User Manual

Ammonitor
Ion-Analyser

Document Ammonitor-01:E5308
12/2008

CERTIFICATE

The TÜV CERT Certification Body
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Analysers AG
Neuköllnische Allee 134
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has established and applies a quality management system for

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measurement-instruments for environmental
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An audit was performed, Report No. **5122**.

Proof has been furnished that the requirements according to

DIN EN ISO 9001:2000

are fulfilled.

The certificate is valid until **2011-05-18**.

Certificate Registration No. **01 100 5122**

Betzdorf, 2008-05-19

First certification 1995

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1.1 Introduction

The Ion-Analyser AMMONITOR is an on-line analyser for batch-wise analysis (sequence of sampling, analysis and result processing).
The Ion-Analyser makes use of potentiometry with Dynamic standard addition method.

Fig. 1 Front view of the Ammonitor

The AMMONITOR Ion - Analyser has a lockable glass door. In the upper part behind the glass door the human interface of the analyser is located. The human interface consists of an alpha numeric display (2 lines, 40 characters each) and a key-board, divided in 3 parts (function keys, numeric keys and a key for Emergency Stop).

In the lower part of the analyser, the wet part of the analyser is situated. The wet part has 9 identical mounting positions for wet part modules, which can be placed in any of the available positions. This results in maximal flexibility for the wet part lay-out for different analysis configurations. The wet part itself as well as the wet part modules are robust, do not have corrosive parts and are constructed according to protection grade. This ensures a strict separation between the wet part and the electrical part of the Ion - Analyser.

To get access to the electrical part of the Ion-Analyser, the lockable wet part door (not the glass door) of the analyzer has to be opened with the special key provided with the analyzer.When this the lockable wet part door is opened the 24 Volts I/O power that feeds the wet part modules falls off automatically. If necessary the 24 Volts I/O power may be switched on while door is opened by pulling a switch at the right hand side inside the cabinet.

The Ion - Analyser is controlled by a Central Computer Board (CCB).
To the CCB all other modules in the analyzer are connected. Also external devices, such as digital inputs, analog outputs, serial connections and relays controls are connected to the CCB.

The ventilator in the top of the cabinet circulates the warm air in the analyzer in order to improve heat exchange to the surroundings.

Note:
Different kind of user data are stored in the memory chip of the CCB, like configuration settings, time programs, results and option settings. If the power supply is turned off, these data will still be stored as well because the memory chip is battery powered when the power supply is turned off.
The battery will discharge when the analyzer is turned off.

The discharge time of a battery is approx. 1 year if the analyzer is not powered.
Check battery voltage regularly in the Utility menu (see OPERATION manual).

The hardware configuration is schematically illustrated in the *Fig. 2*.

1The analyser cabinet inside has

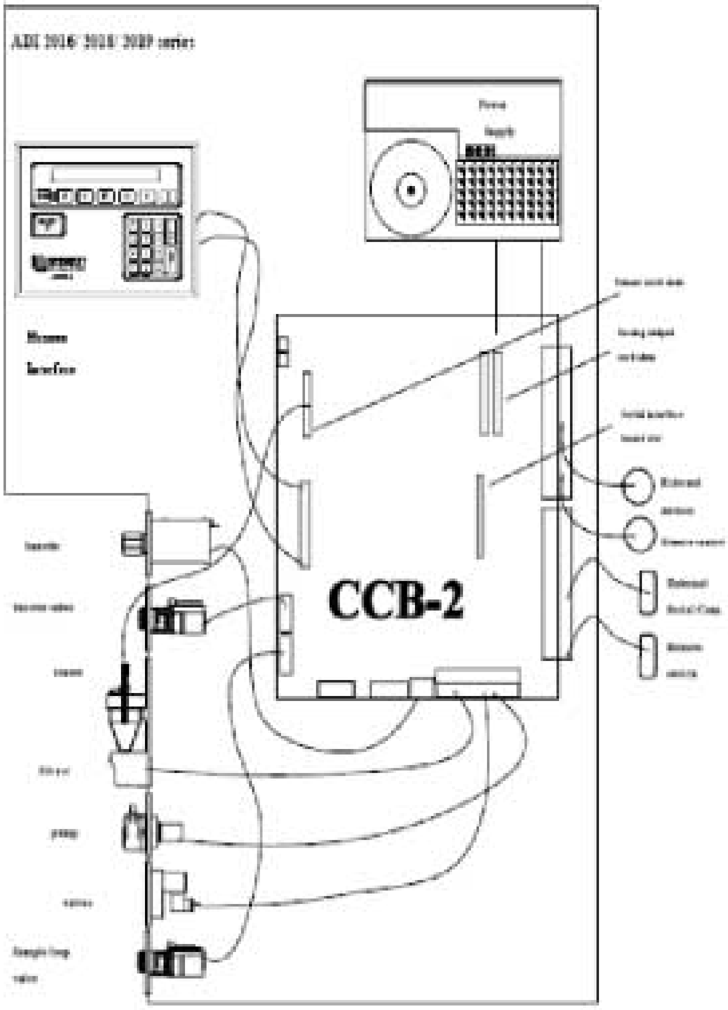


Fig. 2 Screen of Central Computer Board (CCB)

- one trumpet-like cable gland for main supply cable at the left hand side, and
- several cable glands for the cable entree of external devices at the right hand side, and
- one (blinded) hole for the 6.2 mm bulkhead connector to connect instrument air supply, and
- one relief valve of the purge assembly.

The available electronic hardware is described in chapter **2** of this part of the manual, the available wet part modules in chapter **3** and other hardware accessories in chapter **4.** The installation of the Ion - Analyser is described in chapter **5**.

2 Electronic Hardware

To get access to the electrical part of the analyser, the door of the analyser wet part has to be opened.

Make sure that the Process Analyser is powered off and that proper precautions against Electro Static Discharge are taken, when a connection is made/broken, card or module is (de-) installed on the Computer Board. Make sure that the connector of a card or module is placed properly on the connector on the Computer Board, i.e. pins not shifted, this may cause fatal defects on the electronic parts. Applied fuses must comply with IEC 127.

Note:
Realization of electrical connections and service work may only be carried out by qualified personnel.

Useful drawings can be found at the end of this part of the manual.

The electronic parts are protected by a plastic cover that can be removed by carefully pulling it off.

The first time after transport the secure screw has to be removed first.

Fig. 3 Removing of the secure screw

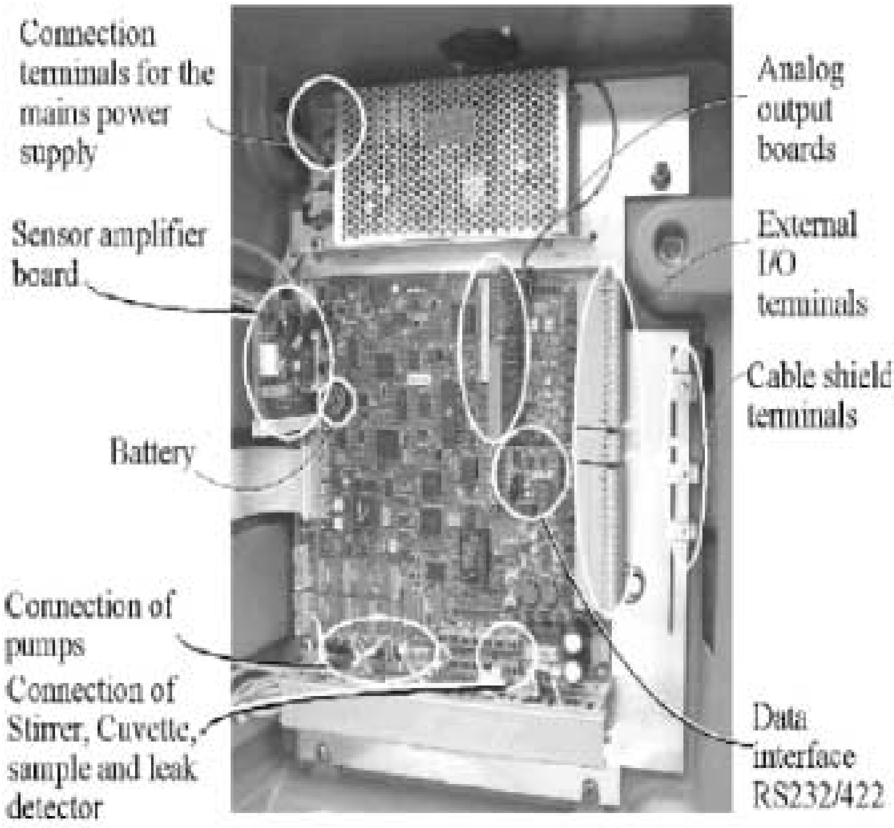


Fig. 4 View of the electrical connections

2.1 Sensor electronics

The Computer Board has a slot for a sensor card. For the conversion of analog sensor signals to a digital value, the Central Computer Board is (CCB) equipped with an A/D convertor.

TEMPERATURE:
The temperature measurement electronics is integrated in the CCB. With (Sensor Pt-100 connector) the Pt-100 sensor can be connected to X9 on the central computer board (left upper part of the CCB).
If a temperature sensor is applied the pH/mV sensor signals are automatically compensated for temperature.

SENSOR CARD pH / mV:
This card is used for pH measurements or for mV/REDOX measurements. The function of the card is set with jumpers on the card.
When a single measuring electrode in combination with a separate reference electrode is applied a separate Sensor Reference Connector has to be used. The Sensor Reference Connector is mounted in the Sensor Connector Module.
When a combined electrode is used, i.e. with an integrated reference electrode, this separate connector is not used. The exact placement of the sensor card pH/mV is like the LED probe card shown in the picture below (electronic components facing inward).

Specifications:

Measuring range: 0 - 14 pH / -2000 - +2000 mV
Tolerance: max + 0.02 pH / + 2 mV
Input impedance: > 1015 ƒ¶

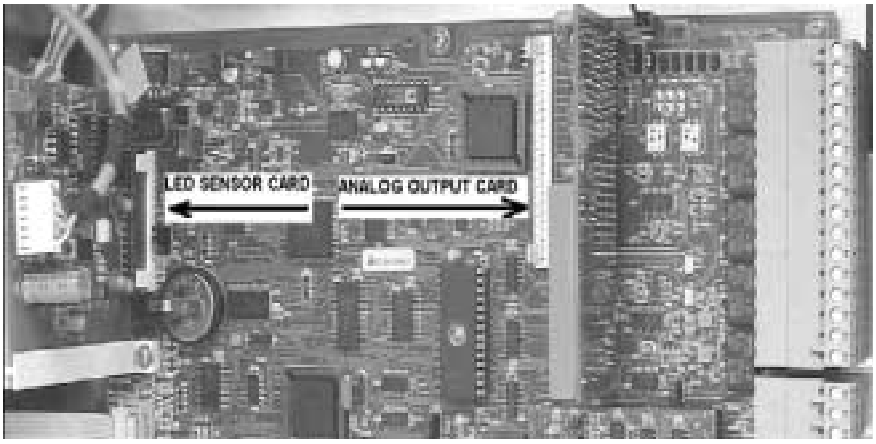


Fig. 5 Analog Output Card

2.2 Analog Output cards

The Computer Board has two slots for Analog Output cards, these are identified as X15 and X18 and are located at the upper right of the CCB. These slots are also identified as ÅeInput1 and Input 2' .
For the conversion of a digital value to analog output signals, the card is equipped with a D/A convertor.
An analog output can be mapped to the analysis result, but also sensor signals can be mapped (see OPERATION reference Part of the manual, chapter Utility).
With jumper settings on the module the output can be set to 0 - 20 mA mode or 4 - 20 mA mode.
The exact placement of the Analog Output card can be seen in the picture at section 2.2; LED probe card (electronic components facing inward).

SPECIFICATIONS:

Output range: As selected (0-20 mA, 4-20 mA)
Resolution: 10 bits
Tolerance: +/- 10 μA
Maximum resistance: 1000 Ω

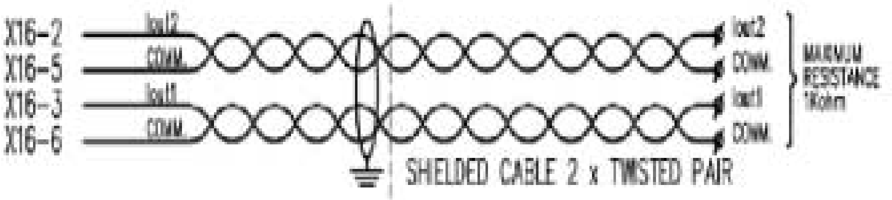


Fig. 6 Placement of the Analog Output card

2.3 External connections to the central computer board

External „recording equipment“ and control devices may be connected to the I/O terminals on the CCB of the analyser. At the right hand side of the analyser there are cable glands (outer cable diameter 6 .. 12 mm). Always use shielded cables for external connections. Inside the analyser cabinet the shielding of the cable must be finished through the shield terminal as illustrated in *Fig. 7*.

Fig. 7 External connection to the I/O terminals

The sheath (insulation) of the cable must therefore be stripped at the clamp.
After connecting the cables, the cable glands must be turned clockwise until the cable is fixed. Shielding terminals are provided with the basic instrument.

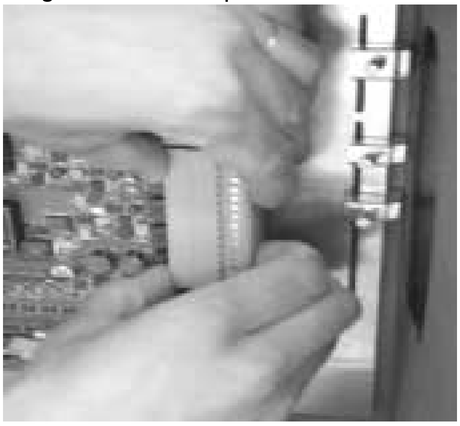


Fig. 8 Internal connection to the I/O terminals

Fixing cables on the I/O terminals is most convenient when they are taken of the CCB.
After fixing the cables on the terminals, they can be placed back on the CCB.
Do not put too much stress on the CCB while pressing the terminal back; give back support with fingers when pressing the terminal on the CCB, see *Fig. 8*.

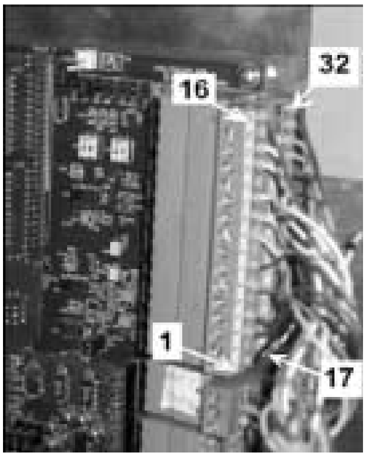


Fig. 9 Numbers of cable connection

Numbering of the Terminal strips X11, X16 and X17.
These terminal strips consist of two layers that can be separate (dis)connected. The numbers of the terminals closest to the CCB are the highest. The counting start at the side of the terminal-strip closest to the bottom of the analyser. Besides; the terminal is labeled, see *Fig. 9*.

2.4 Digital inputs

Several digital inputs are available for various functions: level detectors in containers and remote control options.

Note:
The LEAK and SAMPLE detector have a dedicated power supply connector. These are located at the CCB connectors X20.A and X20.B

2.4.1 Level and leak detector inputs

The Leak detector input: Terminal-strip X17, Terminals 21 and 22.
The Level detectors:
5 inputs are available for connection of level detectors (open/close switch) of re-agent containers.
These detectors must be connected at:

Level detector	Terminal-strip	Terminal
5	X17	23 and 24
4	X17	25 and 26
3	X17	27 and 28
2	X17	29 and 30
1	X17	31 and 32

The associated jumpers (shunts) are JP7, JP8,...JP12

Depending on the jumper setting, the state of the Level detectors (open or closed switch) is taken into account. Only 1 jumper should be used on JP7 to JP12:
–IF the jumper is placed on JP12 AND IF any of the Level detectors 1 ... 5 are open; the Leak/Level alarm output is triggered.

–IF the jumper is placed on JP11 AND IF any of the Level detectors 1 ... 4 are open; the Leak/Level alarm output is triggered. Level detector 5 has no influence anymore (terminal 23 and 24 may be connected or disconnected to each other)
–IF the jumper is placed on JP10 AND IF any of the Level detectors 1 ... 3 are open; the Leak/Level alarm output is triggered. Level detectors 4 and 5 have no influence anymore (terminal 21 to 24 may be connected or disconnected to each other)
–IF the jumper is placed on JP7 ; NONE of the Level detector inputs have any influence anymore on the Leak/Level alarm output (terminal 23 ... 32 may be connected or disconnected)
–Jumper (shunt) JP6 determines if the LEAK detector input has any influence on the Leak/Level alarm output:
–If the shunt is between pin 1 and 2 (at JP6) the Leak detector input has no influence on the Leak/Level alarm output.
–If the shunt is between pin 2 and 3 (at JP6) the Leak detector input will trigger the Leak/Level alarm output (independent of the Level detectors).
–

Note:
- Jumper (shunt) JP6 has no influence on the software-LEAK-alarm (of the 2016HD, 2018HD and 2019HD), the software system options control this.

Optionally the REMOTE_STOP input, see further, may be sacrificed to be used to STOP the analyzer running and generate a ’REAGENT LOW LEVEL’ message on the analyzer display (of the 2016HD, 2018HD and 2019HD).
This can be done by
setting this option active in the software system options, and
connecting the LEAK/LEVEL alarm output to the REMOTE STOP input. (Use the 24 V EXTERN source, terminal-strip X17 terminals 13 and 14, and terminal-strip X11 terminal 19. And set S2 and S1 in the correct position, see *Fig. 10* and *Fig. 11*.

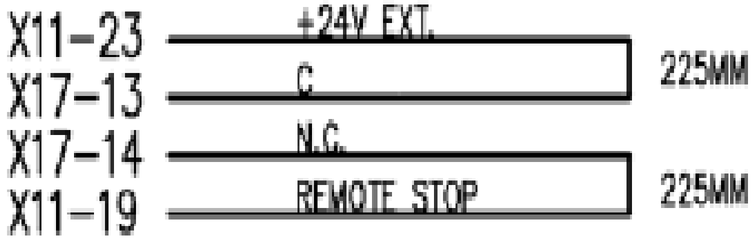


Fig. 10 Connection to LEAK/LEVEL

Note:
Optionally Leak detectors and reagent containers with detectors can be ordered.

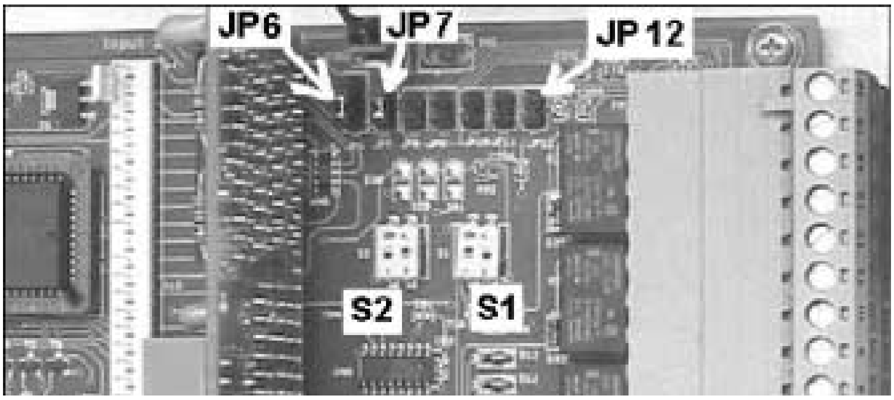


Fig. 11 Connections to REMOTE STOP and EXTERN source

2.4.2 Remote control inputs

This option gives the possibility to remotely operate the process analyyer, i.e. START and STOP running and EMERGENCY STOP (stop immediately all actions).

EMERGENCY STOP
The EMERGENCY STOP input is located at Terminal-strip X11,Terminal 17. If there is **no** between X11 terminal 20 and X11 terminal 17; the analyyer will stop immediately and the PAL-alarm is triggered.

START / CONTINUE
Depending on the position of the switches S1 and S2 on the control board, the digital inputs connected to terminal-strip X11 terminal 18 and 19 will give a different interpretation by the analyser.

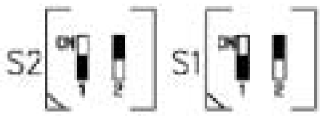


Fig. 12 Switches S1 and S2

The switch-block S1 consists of two separate switches S1.2 and S1.2.(The same for S2; S2.2 and S2.2).

Setting of S1		Function of terminal-strip X11 terminal 18
S1.1	S1.2	
OFF	ON	Remote START
ON	OFF	Remote_CONT

Fig. 13 Function of terminal-strip, Remote Start

- Remote_START:

Connecting X11 terminal 20 and X11 terminal 18 will start the Process analyser while resetting the cycle counter (start sequence according to the programmed ratio).

- Remote_CONT:

Connecting X11 terminal 20 and X11 terminal 18 will continue the Process analyser without resetting the cycle counter.

STOP / 1CYCLE:

Setting of S2		Function of terminal-strip X11 terminal 19
S2.1	S2.2	
OFF	ON	Remote_STOP
ON	OFF	Remote_1CYCLE (until 1 analysis-cycle is done)

Fig. 14 Function of terminal-strip, Remote Stop

- Remote_STOP:

Connecting X11 terminal 20 and X11 terminal 19 will stop the Process analyser at the end of the current cycle.

- Remote_1CYCLE (until 1 analysis-cycle is done):

Connecting X11 terminal 20 and X11 terminal 19 will start the run-ration-selection until one analysis cycle is executed and then stop. This option is especially useful to **operate the Process analyser for off-line.**

2.5 Digital outputs

Several relays are available which can be used for remote indicating purposes for the following functions.
Each relay may be connected as Normally Open (NO) or Normally Closed (NC):

Relays may handle a maximum load of 1 amp. / 24 Volt (Non-inductive).

Running (not 2019HD) : terminal-strip X11 terminals 1, 2 and 3 (1 = common).
Power ON (only 2019HD) : terminal-strip X11 terminals 1, 2 and 3 (1 = common).

PAL(Processing Alarm) : terminal-strip X11 terminals 4, 5 and 6 (4 = common).
RAL-2(Result Alarm-2) : terminal-strip X11 terminals 7, 8 and 9 (7 = common).
RAL-1(Result Alarm-1) : terminal-strip X11 terminals 10, 11 and 12 (10 = common).
Extern-3 : terminal-strip X17 terminals 1, 2 and 3 (1 = common).
Extern-2 : terminal-strip X17 terminals 4, 5 and 6 (4 = common).
Extern-1 : terminal-strip X17 terminals 7, 8 and 9 (7 = common).
Sample-Flow Alarm : terminal-strip X17 terminals 10, 11 and 12 (10 = common).
LEAK/LEVEL alarm : terminal-strip X17 terminals 13, 14 and 15 (13 = common).

- RUNNING:

This relay is de-activated* when the analyzer is executing a program. Jumper JP2 must be set at (upper) position 2-3.

- PROCESSING ALARM (PAL):

his relay is de-activated* when a processing alarm has occurred, i.e. when the analyzer has triggered an alarm because further execution is not possible.
(See OPERATION reference part of the manual for a description of processing alarms).

- RESULT ALARM 2 (RAL):

This relay is de-activated* when a result alarm has occurred. (See OPERATION reference part of the manual for a description of processing alarms).

- RESULT ALARM 1 (RAL):
This relay is de-activated* when a result alarm has occurred. (See OPERATION reference part of the manual for a description of processing alarms).

- EXTERN 3 OUTPUT:
This relay is activated by a program macro or by a manual command, see OPERATION reference part of the manual in chapters PROGRAMMING and MANUAL. It can be used to read the status of the analyzer in an other device (e.g. a PLC), or to drive an indication lamp,buzzer or other small devices. Devices that are demanding more power can be activated indirectly, i.e. with additional signal conditioning hardware.

- EXTERN 2 OUTPUT:
The same as "EXTERN 3".

- EXTERN 1 OUTPUT:
The same as "EXTERN 3".

- SAMPLE FLOW ALARM:
If a sample detector is applied; this relay is electrically de-activated* when NO sample is detected at the moment of sampling in the analysis program of the analyzer. If a sample detector is applied this output is triggered when no sample is detected at the moment of sampling of the analyser.

- LEAK / LEVEL ALARM:
When jumper JP6 is set in the correct position and a LEAK detector is applied: This relay is electrically de-activated* when a leak is detected in the wet part of the analyzer. Also this output can be configured so that; this relay is electrically de-activated* if a LOW LEVEL situation is detected in a reagent container (or a High level in a Drain-Container with level switch assembly). So, this is a combined alarm output, i.e. it can be triggered if a leak is detected, OR a level alarm (in one or more reagent / drain containers).

*** Note:**
-These outputs are used in a so called „Fail Safe“ mode, i.e. in this case the relays are electrically activated if there is NO problem (software status = NO Alarm) and electrically de-activated when there is a problem (software status = Alarm).

2.6 Serial communication RS232/422

This module is plugged on the control board.

The data interface RS232/422 module gives the possibility to perform serial communication according to RS232 or RS422 standards. A serial device can be connected; a printer or computer. Use either the terminals for RS232 communication or for RS422 communication.
The optional board is placed on the controller board. The type of interface should be selected with jumper settings on the module; JP1 en JP2 in RS232 or RS422.
Connection of a serial link is done at the external I/O terminal-strips X 11 and X 16.

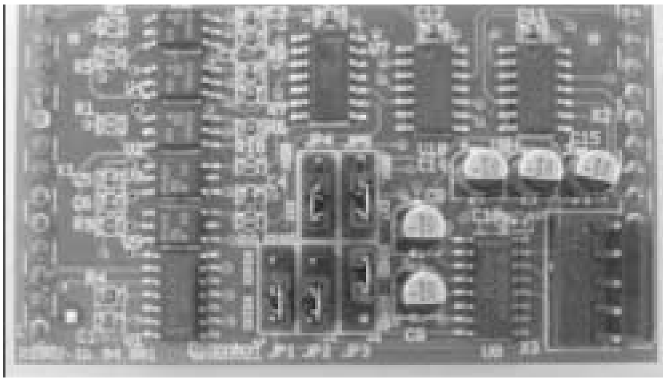


Fig. 15 RS232/422 board

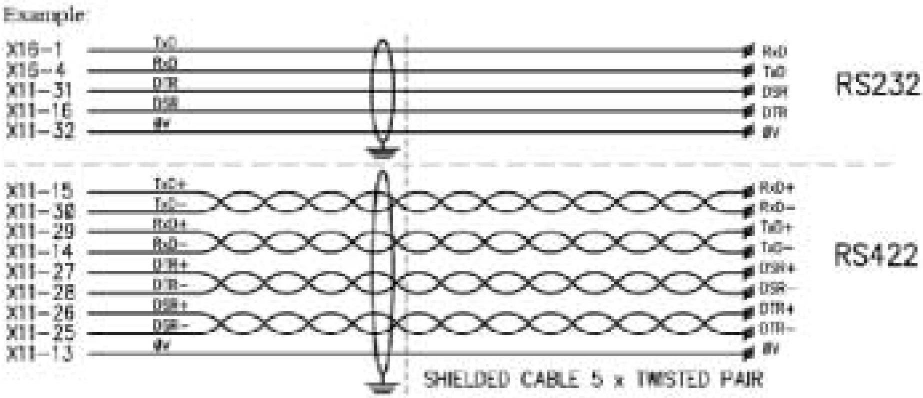


Fig. 16 Connections of RS232 and RS422

3 Wet part modules

Several types of wet part modules are available to be applied in the AMMONITOR Ion-Analyser. This chapter describes the functionality and specifications of the wet part modules.

The functionality and specifications of the following wet part modules is described in this chapter:

- Stirrer/Vessel Holder Module
- Sensor Connector Module
- Solenoid Valve Module (Teflon®)
- Solenoid Valve Module (PEEK / FFKM)
- Tubing Pump Module
- Burette Module
- Burette Valve Module
- Loop type sampling system
- Cuvette module
- Blind Plate Wet Part Position

All of these modules require one wet part position, except for the Stirrer/Vessel Holder module which requires two vertically adjacent positions, while sample pipettes do not take any position. A wet part module can be used for different functions depending on the wet part configuration. For example, a Valve module can be used as an addition valve to add a reagent into the reaction vessel, as a sample selection valve for sample stream selection, or as a Pipette valve. Some wet part modules are combined in one functional group. For example, a Burette and Burette Valve are combined to be a dosing device.
For description of manual operation and programming, refer to the OPERATION reference part of the manual.

Make sure that the Process Analyser is powered off and that proper precautions against Electro Static Discharge are taken, when (dis)connecting the wet part modules.

3.1 Stirrer & Vessel holder module

This module consists of a bottom stirrer and a reaction vessel holder.
The module requires two vertically adjacent positions in the lower region of the wet part of the Ion -Analyser. A reaction vessel of any available volume can be placed in the module by sliding the head plate forwards after loosening the knurled bolts. The head plate seals the vessel from the environment and facilitates the following entries to put in sensors and tubing :

- 4 sensor entries ID = 12 mm: for electrodes
- 9 tubing entries ID = 1/4": for additions and a macro sample pipette.
- 1 tubing entry ID = 3/8": for overflow

The position of the electrode tips in the reaction vessel can be adjusted in a preferable position because the electrode is held in a movable ring. This feature is useful in small reaction vessels.

All unused entries in the head plate have to be closed with blind stoppers to ensure correct functioning of the overflow.
The Stirrer/Vessel Holder Module is provided with a mounting screw for a Macro Sampling Pipette.

Note:
The reaction vessels are delivered with stirrer bars of different size depending on the size of the vessel.

SPECIFICATIONS:
- Liquid contacting material:

borosilicate glass (reaction vessel), PTFE (lid, stirrer bar, blind stoppers, stopper for electrode, tee for rinse/drain connection), FEP (tubing), PCTFE (reaction vessel drain connector), Teflex (seal reaction vessel - lid),
- Temperature:

maximum 90Åã Celsius.
- Stirrer speed:

0-1600 rpm, software adjustable.

3.2 Sensor connector module

The Sensor Connector Module has four positions for sensor connectors for electrodes, LED dipping
probe, heater probe.
Due to the limited length of the sensor cables, this module should be located near the Stirrer/Vessel
Holder Module. All unused positions have to be covered with blind plates.

3.3 Solenoid valve module (Teflon)

The Solenoid Valve Module is can be provided with two plunger valves, but comes standard with one plunger valve. By means of an ADD-ON valve the modules can be expanded.
The module is provided with 1/4" BSP female connectors for which several adapters are available, see Maintenance and Spare parts manual; Mounting materials. PTFE as well as the material of the seal (FFKM) have excellent chemical resistance. The valves can be used as sample, liquid addition or drain valve.

SPECIFICATIONS:

Liquid contacting material:	PTFE (valve housing), FFKM (seal), FEP (O-ring)
Valve type:	Normally Closed
Valve opening:	4.5 mm
Pressure range liquid:	0 - 400 kPa (0 - 4 bar)
Temperature range liquid:	0 - 110°C

3.4 Solenoid valve module (PEEK/ FFKM)

This Solenoid Valve Module is standard provided with one solenoid but can be expanded to 4 solenoid valves. They are all 3/2 way valves, but can be applied as 2/2 way valve when one port is blinded with a blind stopper. The applied material PEEK as well as the material of the seal (FFKM or Kalrez®) have excellent chemical resistance. The valve is provided with female M8 connectors for flaired M8 tubing. Also adapters to flaired M6 tubing and 1/4" tubing are available, see Maintenance and Spare parts manual; Mounting materials. The valves can be used for liquid addition, as sample valve or as drain valve. The 3/2 way configuration is particularly useful as sample valve as part of a fast loop and as valve in a pipette sampling module.

Liquid contacting material:	PEEK, FFKM seal (Kalrez ®)
Valve type:	3/2 way, membrane
Valve opening:	3 mm
Pressure range liquid:	0 - 200 kPa (0 - 2 bar)
Temperature range liquid:	0 - 70°C

3.5 Tubing pump module

The Tubing Pump Module consists of a motor with a peristaltic pump head. The Pump module can be applied for adding reagents, sample or rinse solution, for carrying sample from the Sampling System Loop Module or draining the reaction vessel. For more reproducible reagent additions (i.e. + 2%) , preferably the Tubing Pump 5 ml/min should be used. For all other liquid handling the high flow pumps may be used. If these latter pumps are used for reproducible additions, periodic recalibration is necessary. The flow rate of the tubing pumps is determined by the revolution speed and the tube diameter. Each has its own fixed speed. The tubing used in the tube assemblies is Norprene? Food tubing. This tubing has a long life time and good chemical resistance properties. The tubes can easily be exchanged/replaced, see Maintenance and Spare part manual. M6 flared tubes (for 5 ml/min) or M8 flared tubes (for 40, 120 and 320 ml/min) can be connected directly to the pump head. With adapters also 6mm or 1/4" tubing can be connected, see *Maintenance* and *Spare part manual*; mounting materials.

SPECIFICATIONS:

Liquid contacting material:	Norprene® Food (tubing), PP (connectors)
Temperature range medium:	0 - 90 °C
Pressure range medium:	inlet -20 to 100 kPa (-0.2 - 1 bar)
outlet max.	1 bar
Type connectors:	M8 flared tube (40, 120 and 320 ml/min), M6 flared tube (5 ml/min)
Typical tubing life time:	> 3 months (continuous operation)

3.6 Burette valve module

The Burette Valve Module is a rotary valve with five hydraulic connection ports (m6 flared tube) in the stator (valve head) and two cavities (connection passages) in the rotor. The Burette Valve Module can only be used in combination with the Burette Module. For a further explanation on the operation of this valve, see Burette module.

SPECIFICATIONS:

Liquid contacting materials:	PTFE (rotor), PCTFE (stator)
Temperature range medium:	0 - 70 °C
Type connectors:	M6 flared tube (5x)

Note:
It is advised against operating the module without liquids for longer periods, this may enhance wearing out of certain parts seriously.

3.7 Burette module

The Burette Module consists of a cylinder and a motor controlled piston. The cylinder and piston combination is available in different sizes (2 ml, 10 ml, 20 ml and 50 ml). The piston can move in two directions in order to fill the cylinder or to dose the content of the cylinder. The burette motor makes stepwise movements with a resolution of 16,667 steps per cylinder stroke. A Burette Module operates in combination with a Burette Valve Module to perform titrations or to dose exact standard additions.

The Burette / Burette Valve combination enables the following different actions:
- refilling the cylinder from reagent container.
- dosing to reaction vessel.
- initiating; initially fill cylinder from reagent container.
- recycling cylinder contents back to reagent container.

The Burette Module is hydraulically connected to a Burette Valve by two separate M6 flared tubes. Through one tube the burette cylinder is filled, through the other tube the burette cylinder is emptied. The other 3 connection ports of the Burette Valve are connected to the reaction vessel (1x) and to the reagent container (2x). The above mentioned burette actions are explained in the illustration below. The small circles in *Fig. 17* represent the port connections in the burette valve stator. The bold line represent the connecting passages in the rotor for the specified action.

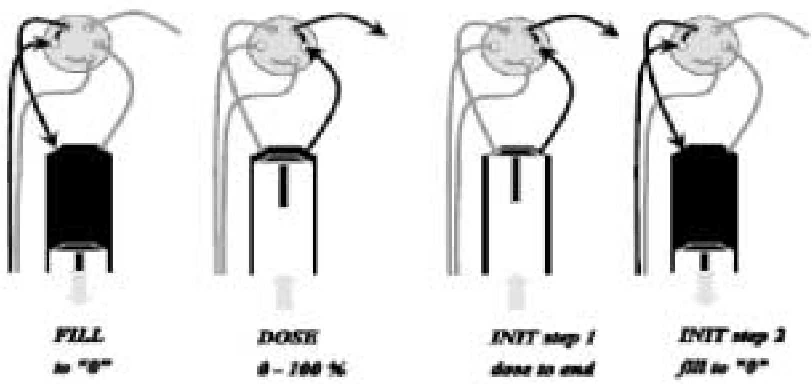


Fig. 17 Fill, dose and init of burette

FILL:
The piston moves back until the lower limit switch is reached, then the piston moves forwards a few steps to nullify any clearance in the transmission from the motor to the piston. This position is the zero position from where steps are counted.

DOSE:
The piston pushes out the contents of the cylinder. Volumes between 0 and 100 % of the burette volume can be dosed.

INIT:
This action is performed in two steps; STEP 1: a DOSE action to 100% position is performed followed by a low speed DOSE action beyond the 100 % position, towards the cylinder head emptying the cylinder completely. STEP 2: the burette cylinder is filled with a FILL action. The INIT function is especially useful for initial filling of the burette cylinder or for complete renewal of the burette cylinder contents.

Note:
- After power up of the Process Analyzer and at the beginning of each analysis run the burette will perform a FILL action.
- The command INIT can only be activated in the Manual commands menu, not in Time Programs (see OPERATION reference part of the manual, Manual menu).

RECYCLE:
This action is performed in four steps as schematically depicted in the figure next page, and is especially useful to remove air-bubbles out of the cylinder. STEP 1 is to discharge the cylinder contents to the reagent container. STEP 2; the burette is filled with a certain amount of liquid from the reagent container. STEP 3; this volume is dosed back to the reagent container again to push all present air-bubbles beyond the Burette Valve. STEP 4; the burette is filled again.

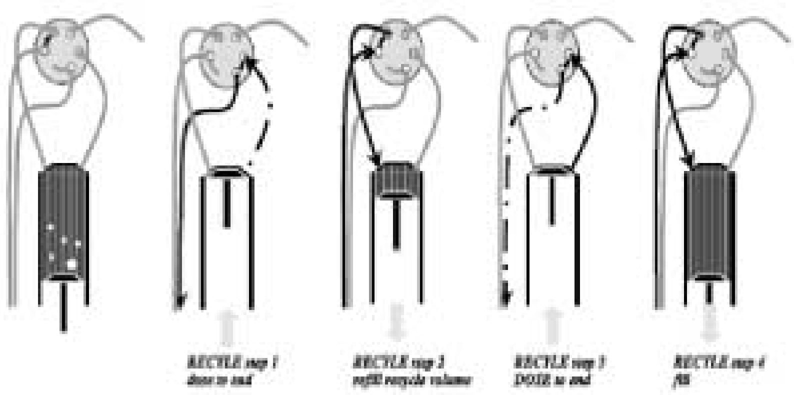


Fig. 18 Recycle of a burette

Note:
- Formed air-bubbles in the burette cylinder have to be removed regularly with the recycle action to avoid erroneous results. This action can be programmed in a time program.
- Formation of air-bubbles in the burette cylinder can be minimized by using degassed reagents and by placing the reagent containers at the same level (or higher) as the Burette.
- The recycle volume in step 2 of the recycle cycle can be set, see OPERATION reference part of the manual, Utility menu.

SPECIFICATIONS:
- Liquid contacting materials:

PTFE(25% C) (burette head), PTFE (piston) borosilicate glass (cylinder)
- Smallest dosing step: 0.01 % of cylinder size
- Inaccuracy: 2 ml cylinder; + 0.3 % , 10 ml cylinder; + 0.2 % (max.vol.), 20 ml cylinder; + 0.15 %, 50 ml cylinder.; + 0.1 % (max.vol.)
- Repeatability: +/-0.1 % (max.vol.)

- Minium inlet pressure: -20 kPa (-0.2 bar)
- Temperature range: 0. . . 40 °C

3.8 Sampling system loop module

These modules are used for highly reproducible closed loop sampling. The Sampling System Loop Module contains a rotary type valve with six hydraulic connection ports (M6 flared tube) in the stator (valve head) and three cavities (connection passages) in the rotor for the 3-WAY version, two cavities for the 2-WAY version. Different connections between the connection ports are made by the cavities in the rotor of the valve. The slider can rotate against the valve head making the different connections possible. The valve has two positions. In the OFF-position sample can flow through the sample loop. In the ON-position, the isolated sample in the sample loop can be transferred to the reaction cell using a proper liquid carrier, i.e. a solvent for the sample. In the 3-way version the sample and carrier can continue to flow in any position, while in the 2-way version only one of the two can flow, either sample during LOAD position or carrier during INJECT position. This is illustrated in the schematic picture following.

In some application it is desirable that the sample stream is constantly flowing. In this case the 3- WAY type valve can be applied. An additional means (valve, pump or burette) is necessary to block the carrier stream for this one is flowing constantly too.

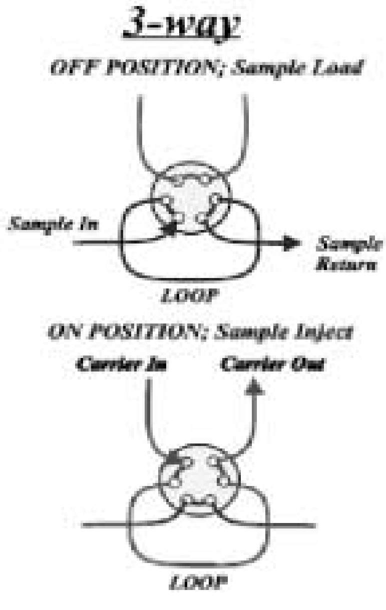


Fig. 19 2-way position of a burette

With a 2-WAY type valve this is not mandatory, i.e. the sampling valve can then be applied without additional means for carrier or sample stream, although in most applications a valve or pump is applied upstream the sample line in order to be able to shut off the sample supply or to do a sample selection in multiple stream applications.

It is advised against operating the module without liquids for longer periods, this may enhance wearing out of the slider part seriously.

Note:
- The exact sample loop volume has to be determined by calibration. This can be performed by analysis of a standard solution.
- The valve type selection (Sampling System Loop Module 3-way or 2-way) is done by Applikon or by your local dealer.

SPECIFICATIONS:
- Liquid contacting material: PTFE, PCTFE
- Type connectors: M6 flared tube (6x)
- Sample volume repeatability: < 0.1% rsd
- Sample temperature range: 0 . . 70 C
- Max. sample pressure: 200 kPa (2 bar)
- Loop diameter (ID): 1.5 mm
- Internal dead volume: 0.1 ml

4 Auxiliary Hardware

In this chapter the functionality and specifications of auxiliary hardware are described.
Drawings can be found at the end of this part of the manual for additional information.
The functionality and specifications of the following auxiliary hardware are described in this chapter:

- Purge Assembly
- Table Stand
- Reagent Containers
- Sample Present Detector Reaction Vessel
- Leak Detector Wet Part
- Electrodes & Sensors
- Heating probe
- Reservoir 2.5 liter with float valve

4.1 Purge assembly ADI201Y

If the Ion-Analyser is installed in a corrosive or humid environment, it is recommended to purge the cabinet part with instrument air, to protect the electronic parts of the analyser. The Purge Assembly consists of a bulkhead connector (for air inlet) and a pressure relief valve. Both parts are mounted in the bottom of the cabinet of the Ion - Analyzer. Inside the cabinet a tube from the top of the cabinet is connected to the bulkhead connector, leading the instrument air to the top of the cabinet to assure good purge performance. The pressure relief valve will open at a positive pressure over 100.7 kPa (0.007 bar).

SPECIFICATIONS:
Type connector : plastic tube, OD 6.2mm/ID 4.0mm
Supply pressure instrument air : 110 kPa (0.1 bar)
Quality instrument air : according to ISA-S7.0.01-1996 Quality standard for Instrument Air

4.2 Table Stand

The AMMONIOR Ion-Analyser can be mounted on a stand which can be placed on a table.

SPECIFICATIONS:
Construction material Stand: Abcite® X1060 coated steel (stand)

4.3 Reagent containers

There are different kind of containers available:

Floor standing containers (without level switch)
These HDPE containers are available in three different volumes, 2.5, 5 and 10 liter. The wet connection to the container is fit for 6 mm or 1/4" tube which should be slipped through a hole in the lid of the container. The tube is guided inside the container to the bottom. For convenience a second lid without a hole is provided which may be used during transport.

4.4 Electrodes & sensors

Different electrodes for performing **potentiometric measurements** with the Ion-Analysers (ADI2016/2018) are available. All electrodes are provided with a special watertight, corrosion free TNC connector (threaded nut connector). These electrodes have to be connected to a Sensor Card pH/mV through a Sensor Connector module. Besides electrodes from the Metrohm® program including ISE's (Ion Selective Electrode), a series of specially designed electrodes for use in low-volume applications in the ADI analysers are available:

For more information concerning application and maintenance of these electrodes, refer to the User Manual of the Ion - Analyser Electrodes (in the electrode box).

5 Installation

In this chapter the various installation steps for the AMMONITOR Ion-Analyser are described:

- Placing the analyser, ambient conditions
- Mounting
- Service switch
- Purging with instrument air
- Connecting of the mains power supply
- Connecting hydraulics; sample and drain

The connecting of external I/O devices, analog output, digital in- and outputs and serial communication is described in chapter 2, electronic hardware. Wet part modules are described in chapter 3, wet part modules. The auxiliary modules purge assembly, table stand, reagent containers, electrodes& sensors are described in chapter 4, auxiliary modules. After all is installed the Start-up procedure in the OPERATION reference part of the manual (Chapter 1, Introduction) should be followed.

5.1 Environmental conditions

- Indoor or at a sheltered location
- Altitude: up to 2000 m
- Maximum relative humidity 80 % for temperatures up to 31 °C, decreasing linearly to 50 % relative humidity at 40 °C
- Temperature: 5 °C to 40 °C

Note:
If the temperature inside of the cabinet exceeds 60°C, the 24 Volt power for the actuators will be shut off. The analyser will be functional again after reset and temperature decrease.

5.2 Mounting

The Ion-Analyser can be wall mounted or mounted on a table stand.
For wall mounting the Ion-Analyser is provided with four brackets at the rear side.

Note:
When installing the Analyser take into account the necessary clearance to the left and right side of the analyser for cable connections and swing space for the door.

5.3 Service switch

When the wet part door of the analyser is opened by means of the special key provided with the analyzer, the 24 Volt I/O power is switched off automatically. This power is feeding all wet part modules and external devices connected to the analyzer. All other voltages are still present.

The 24 Volt I/O power can be switched on while the door is opened by pulling the service switch.

Fig. 20 Pulling of service switch

Beware that devices may be damaged when touched when powered on. Do not connect or disconnect devices with I/O power On. Make sure that proper precautions against Electro Static Discharge are taken.

5.4 Purging with instrument air

If the Analyser is equipped with a Purge Assembly the electronic part of the instrument can be purged with instrument air. Instrument air supply has to be connected to the appropriate bulkhead connector at the bottom of the analyser cabinet (remove blind cap from connector).

A shut-off valve must be installed in the instrument air supply line to the Process Analyser, so the air supply can be shut off during service operations.

This shut-off valve must be marked as "air supply to ADI 201Y". Do not obstruct the purge outlet at the bottom of the analyzer cabinet.

Type connector: plastic tube, OD 6.2mm/ID 4.0mm
Supply pressure instrument air: 110 KPa (0.1 barg)
Quality instrument air: according to ISA-S7.0.01-1996 Quality standard for Instrument Air

The Purge Assembly is further described in chapter 4 on page 29.

5.5 Connection of the main supply

An external mains supply switch (2 poles) must be installed in the proximity of the analyser and within reach of the operator, and be marked as "disconnecting device for analyser". To get access to the electrical part of the analyzer, the door of the analyzer wet part has to be opened.

Beware of electrical hazard of internal parts of the analyser. Switch off mains supply during connection of the mains supply cable.

Realization of electrical connections and service work may only be carried out by qualified personnel.

The Analyser contains delicate electronic components. To prevent damage, make sure that proper safety precautions are taken concerning Electro Static Discharge!

Electrical connections may only be carried out by qualified electricians.

An incorrect power supply voltage can result in damage to the instrument

Applied fuses must comply with IEC 127.

The electronic parts are protected by a plastic cover that can be removed by carefully pulling it off.

The first time after transport the secure screw has to be removed first (*Fig. 21*).

Fig. 21 Removing of the secure screw

The Process Analyser must be connected to the mains supply.
Before connecting the power supply, verify if the voltage tag corresponds to the line voltage and the fuse rate of the mains fuse is correct. The power supply cable has to be connected to the power supply terminals, located at the left side of the power supply module. The power supply module is located in the upper part of the analyszer cabinet.

Attention:
The earth pole at the left side of the cabinet must be connected to a clean earth pole that provides a good earth quality (low impedance, < 1 ohm), using an earth wire braided 10 mm^2

To connect the power supply cable:

- Connect the earth wire (braided),
- open the door of the analyser cabinet with the door key provided with the analyser,
- remove the front cover of the electronic part,

- turn the cable gland at the left hand side of the Process Analyser loose until the cable can be inserted through the gland,
- strip the power supply cable and connect it to the power supply terminal;
  . live wire to terminal L,
  . neutral wire to terminal N,
- he cable gland must now be turned back until the cable is fixed and it functions as a strain relief,
- remount the cover,
- close and lock the wet part door of the Process Analyser.

Note:
The Process Analyser may be delivered with a power supply cable, BUT this power supply cable should be replaced by above described connection.

5.6 Hydraulic connections

Tubing connections are to be made to the various wet part modules (refer to the hydraulic planning sheet in the Application manual, if available):

Take necessary precautions when (dis)connecting tubes to reagent containers and sample and drain point with regards to hazardousness of chemical substances. Consult appropriate safety data sheets before reagent and samples are handled and make sure that appropriate measures are taken.

- Sample streams to sample pumps / valves,
- Reagent containers to corresponding burettes / pumps / valves,
- Drain valve to drain container or waste pipe,
- Any other hydraulic connection that is required to have the Process Analyser working on-line.

Depending on the type of connector and liquid the following tubing is applied:

Teflon® tubing 1/4" FEP	(part no. V0M5219010)
Tubing for air 6.2 mm	(part no. V0P5217000)
M6 flared tubing	(various lengths available)
M8 flared tubing	(various lengths available)
Norprene® Food tubing size 15	(part no. V0M5217040)
Norprene® Food tubing size 18	(part no. V0M5217010)

The tubes are put through the holes at the bottom of the wet part into the wet part where they are connected to the wet part modules.

Take into account that the wet part door can be swung open taking all connected tubing along with it.

For that reason all tubes have to be bundled to the (left) hinge side of the wet part door in such a way that they can twist without consequence when the wet part door is opened.

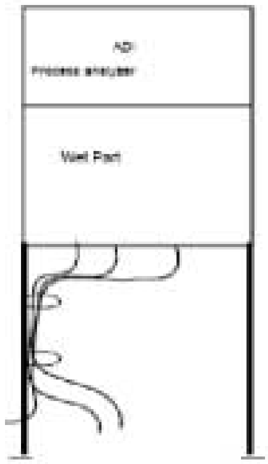


Fig. 22 Connections Wet Part to Reagents

SAMPLE STREAM

The dead time (time elapsing between sampling from the process and the availability of the analysis result) caused by sample transport depends on the total volume of the sample line from sample tap to the analyser and the sample flow rate (sample pump in analyser 120 ml/min). To improve the response time of the analyzer, the dead time has to be minimized. This can be achieved by simply placing the analyser as near to the process as possible, or by applying a fast-loop type to bridge over longer distances.

The sample temperature must not be higher than 60 °C.
The sample pressure must not be lower than -20 kPa (-0.2 bar) or not higher than 50 kPa (0.5 bar).

Note:

In general it is good practice to include a shut off valve in the sample line as depicted in the figure beside. In this way the analyser can be serviced or moved without problems.
If a sample preconditioning unit is applied (e.g. a filter) it should be located near the analyser. Also take into account appropriate conditioning measures for the fast loop, e.g. heat tracing.
An ADI 2018 Ion-analyser may have a second sample line ("Sample 2").

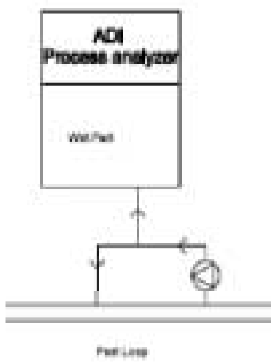


Fig. 23 Connection to waste pipe or waste container

DRAIN CONNECTION
The drain valve/pump must be connected to a drain point near the analyser, this main be a waste pipe or waste container. Make sure that there is no over-pressure on waste point, i.e. that the drain can flow freely and without obstruction in the waste point.

When a DRAIN **VALVE** is applied:

For a proper drain performance, the outlet of the rinse valve has to be connected with a T-connector to the inlet of the drain valve. In this example, the rinse valve may be replaced by a tubing pump!

When 1/4" drain tube is applied, it is recommended to cut the outflow side of the drain tube with an angle of approximately 45°. In this way the surface area of the outlet opening is increased, reducing the flow resistance at the end of the drain tube. (note that FEP tube shows less flow resistance than PE tube and thus better drain function than PE tubing).

Furthermore air locks in the tubing must be avoided. This can be realized by leading the tubing downwards without “goose neck”, as illustrated in the picture. If this is not convenient or when the drain is located more than 2 meter from the analyser, the drain tube should be lengthened with a wider bore tube via a vented adapter. The vent opening should be located at a higher level than the drain tube end!

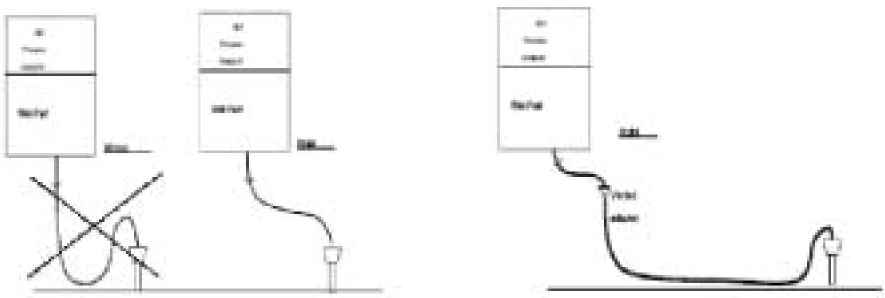


Fig. 24 Correct position of the drain tube

REACTION VESSEL OVERFLOW
The top plate of the Stirrer/Vessel Holder module has one 3/8" hole for the overflow connection of the vessel. One end of a Norprene® Food tubing size 15 should be insert in this hole while the other end has to be connected to a drain. Make sure that air locks in the drain tubing are avoided.

WET PART DRAIN
The wet part of the analyzer has one drain opening in the bottom. This opening has to be connected to a Norprene® Food tubing size 18. The tubing is fixed in the drain opening with a Clamping Bush for Drain Tube. The other end of the wet part drain tubing has to be connected to the drain. Make sure that air locks in the drain tubing are avoided.

6 Operation Part

6.1 Introduction

The AMMONITOR Ion-Analyser is an on-line analyser for batch-wise Ion analyses with Dynamic Standard Addition method (sequence of sampling, analyses and result processing).

The AMMONITOR Ion-Analyser has a lockable glass door. In the upper part behind the glass door the human interface of the analyser is located. The human interface consists of an alpha numeric display (2 lines, 40 characters each) and a key-board, divided in 3 parts (function keys, numeric keys and a key for Emergency Stop). The upper display line presents the status of the software menu, the lower display line explains the meaning of the 5 function keys.

Fig. 25 View of the screen

6.1.1 Using the keyboard

* Press the **F**-key (function key) above the text to select a sub-menu (going down 1 level).

* Press the **EMERGENCY STOP** key to cancel all actions immediately.

* If a value must be entered/edited, this must be done with the numeric key-board:
- press the digits,
- press the ENTER key.

* The key ↑
- Press the key to return to the previous menu (one level up in a menu).
- Press the ↑ key multiple times to go to the Main menu.
- If one does not want to enter/edit a value: escape with the ↑ key.

* The **MAIN** key
- Can be used to quickly return to the Main menu.
- The **MAIN** key will reset any processing- and result alarm and 3.9.x Alarm limits and actions).

It is strongly recommended that the cause of an alarm is solved before proceeding. This is especially the case if the software has detected a leak. The software detects only the change *from dry to wet, it doesn't detect if the detector is wet. The hardware detects if the detector is wet.*

* The **CLEAR** key is used to erase accidentally keyed-in numbers.

6.1.2 Configuration

In the lower part of the analyser, the wet part of the analyser is situated. The wet part has 9 identical mounting positions for wet part modules, which can be placed in any of the available positions. This results in maximal flexibility for the wet part lay-out for different analysis configurations. The wet part itself as well as the wet part modules are robust, do not have corrosive parts and are constructed according to IP65 protection grade. This ensures a strict separation between the wet part and the electrical part of the Analyser.

Fig. 26 Front view of the Ammonitor

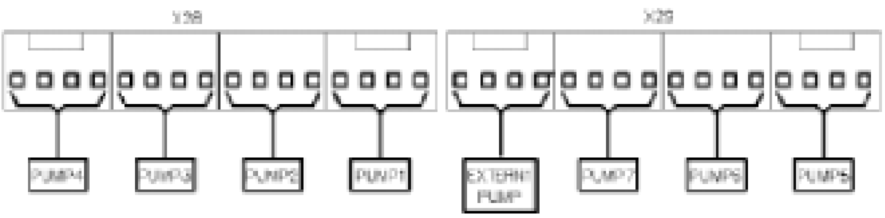
The analyser contains a micro processor system, loaded with flexible software that can perform three different programs for analyses, reference and cleaning. This is realized by activation commands (macro) for the wet part modules which are configured as is schematically depicted in the hydraulic planning sheet of the analyser.

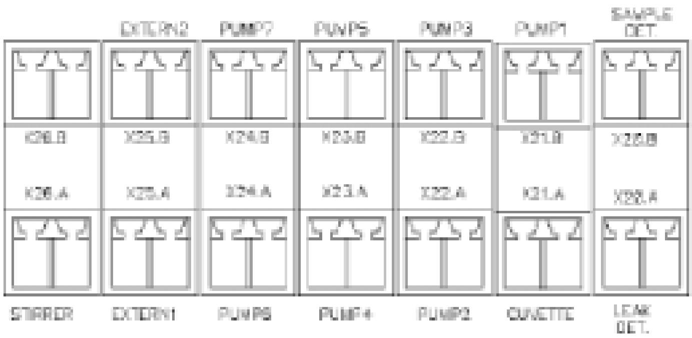
The hydraulic planning sheet of the analyser should be present in the APPLICATION part of the manual. This sheet gives a view of how the analyser is assembled. If this sheet is not present it has to be filled in. In the upper part of the sheet a hydraulic scheme of the wet part is presented. The modules on the 9 wet part positions are indicated with icons. In the lower part of the sheet the same 9 wet part positions are presented but now with additional information on the concerning module of the upper part. The module has to be connected at the correct place on the Central Computer Board, so the software controls the correct module.

The address of a module can be recognized when operating the analyser (see further chapters in this part of the manual), so for example the pump or valve connected to DRAIN on the Central Computer Board is operated by a software activation command called "*DRAIN*" .

- - Rinse: Pump or 2-way valve
- - Drain: Pump or 2-way valve
- - Stirrer: Stirrer
- - Burette: Piston burette motor
- - Burette: Valve Burette slider valve, 3 positions, 5 connections
- - Sample: Pump or 2-way valve
- - Blank Pump or 2-way valve
- - Buffer Pump or 2-way valve

Information is where a particular module must be connected can be found in the HARDWARE & INSTALLATION part of this manual.





CONNECTION	ADI 2016 HD	ADI 2018 HD	ADI 2019 S
PUMP1	RINSE	RINSE	ADD-3
PUMP2	SAMPLE	SAMPLE 1	SAMPLE
PUMP3	STAND	SAMPLE 2	STAND
PUMP4	PIPETTE	PIPETTE	PIPETTE
PUMP5	DRAIN	DRAIN	DRAIN
PUMP6	ADD-2	BUFFER	ADD-2
PUMP7	ADD-1	BLANK	ADD-1

Fig. 27 Electronical connections of pumps, stirrer and burette

Sampling can be done in two ways: With a pipette valve or with a Sampling Loop valve. Both systems require their own configuration. Both sample systems are operated with the same software activation commands addressed as "Pipette", see further chapters in this part of the manual.

6.1.3 System option settings menu

A hidden option menu is available to choose settings concerning optional modules and the log In/Out procedure. The last option is not to be used, the other options are described in this chapter at the concerning modules. To access the OPTION SETTINGS menu be sure that the analyser is in the MAIN menu:

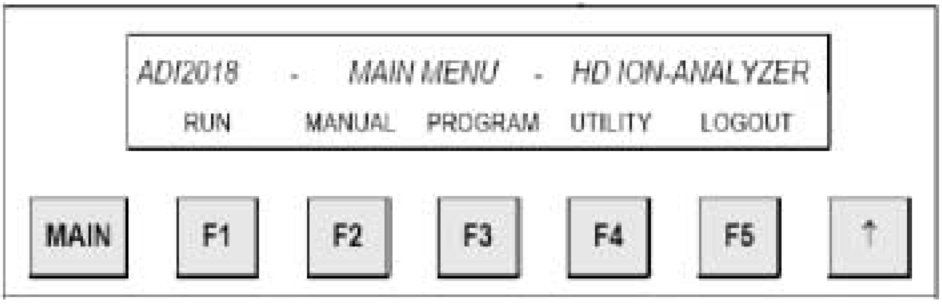


Fig. 28 Main menu

Now press **MAIN** and ↑ key at the same time; the following menu will appear:

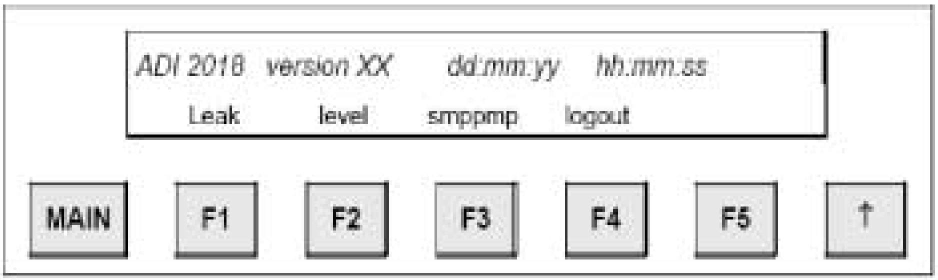


Fig. 29 Date and Time Screen

An option is selected by pressing the concerning key. The option will be shown in uppercase characters when selected **ON**.

The menu can be closed by pressing **MAIN**, the MAIN menu is returned then.

The option is used in case a leak detector is installed.

The option is used in case a reagent level detector is installed.

The option is used in case a Sample Present detector is installed and used to control the sample volume.

The logout option is not to be used.

6.1.4 Starting up

When the power supply cable is connected to the mains, the display shows: 'LAR-ION - CHECKSUM TESTING' , after which the Main menu is presented:

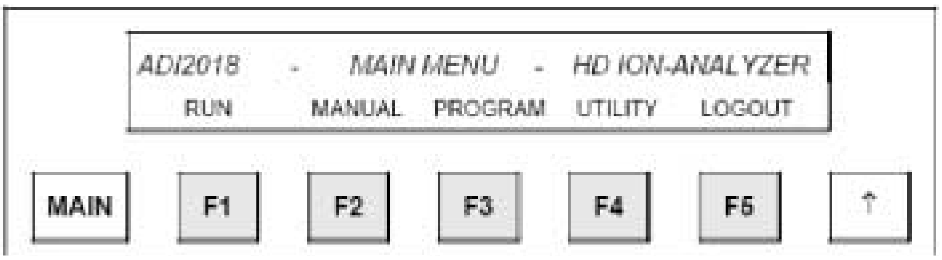


Fig. 30 Main menu

The shaded keys are operational.

With the function keys **F1** - **F5**, the different menus can be selected.

Table 1 .Selection of different menus

Function keys	Meaning
F1 RUN	the Analyser can be started (see chapter 4)
F2 MANUAL	the hardware in the wet part can be activated manually (see chapter 2)
F3 PROGRAM	programs can be inserted or edited for the execution of analysis runs, reference runs (analysis of a standard solution) and cleaning runs (extra cleaning of the reaction cell, see chapter 3)
F4 UTILITY	is used to recall information from a previous run, to program data (like data format and baud rate for a printer) and to carry out diagnostics concerning the electronics and software (see chapter 5).
F5 LOGIN or LOG-OUT	when a pass code is set in the Utility menu, the program can be protected against changes by unauthorized personnel (see Utility p.code menu, chapter 5)

Before entering the Run menu and starting the Analyser, follow the procedure below:

Install the Analyser according to the instructions in the HARDWARE and INSTALLATION part of the manual.

Take necessary precautions when handling chemicals. Consult appropriate safety data sheets before reagent and samples are handled and make sure that appropriate measures are taken.

Prepare the reagent solutions as specified in the APPLICATION part of the manual and connect them to the corresponding wet part modules.

Fill/flush the tubing and modules with the reagents (Use the Manual menu, chapter 2).

When flushing the tubing, make sure that the reaction vessel is not overflowing. This can be done by activating the DRAIN pump sufficiently during activation of the other pumps.

Verify the programs and values of the constants.

Verify if the programmed intervals in the sampling procedures are sufficient; if not, increase the corresponding interval in the Program menu (see program lay-out in the APPLICATION Manual). The manual commands can be used to verify if a programmed interval is long enough; the programming menu must be used to edit intervals.

Now the Analyser can be started (**F1** in the Run menu); take care of regular maintenance (see BASIC MAINTENANCE part of the manual).

6.2 Manual commands

6.2.1 Parts of the manual menu

To execute manual commands: press ↑ until the display does show the Main menu, then press **F2** MANUAL, the display will now show the first part of the Manual menu:

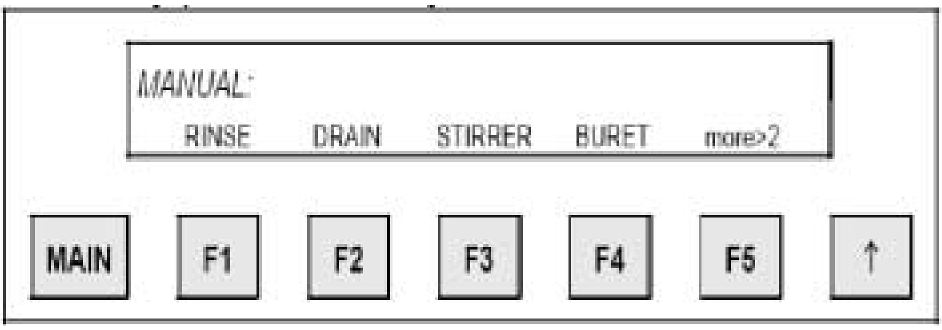


Fig. 31 Manual menu, first part

When **F5** 2 is pressed, the display will show the second part of the Manual menu:

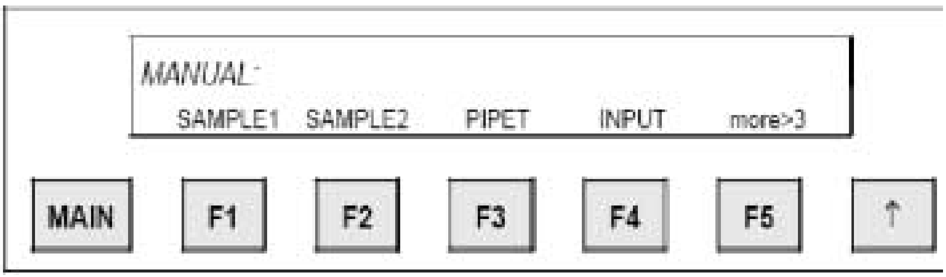


Fig. 32 Manual menu, second part

When **F5** is pressed again, the display will show the third part of the Manual menu:

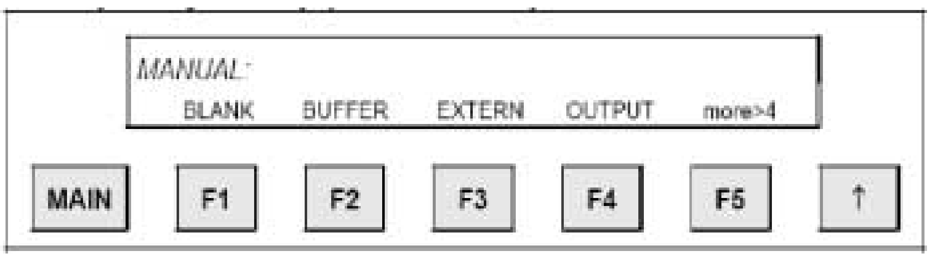


Fig. 33 Manual menu, third part

After pressing **F5**, the fourth part of the Manual menu is presented:

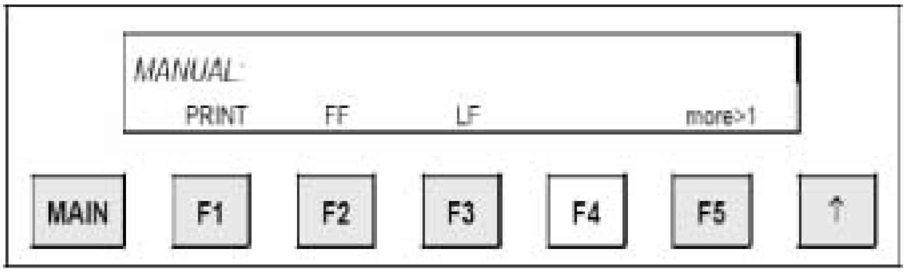


Fig. 34 Manual menu, fourth part

This fourth Manual menu will only be presented if the "printer" interface is selected (Utility serial menu, → *Section 5 on page 31*) When "computer" or "network" is selected, the Manual menu will only consist of three parts.

6.2.2 Explanation of function keys

In the Manual menu, the function keys have the following meaning:

Table 2 Meaning of the function keys

Part	Function keys	Meaning
Part 1	**F1**	operation of the rinse, valve/pump
	F2	operation of the drain valve/pump
	F3	operation of the stirrer, selection of stirrer speed
	F4	operation of the burette
	F5	go to part 2
Part 2	**F1**	operation of the sample valve-1
	F2	operation of the sample valve-2
	F3	operation of the pipette valve
	F4	show sensor signals, calibrate temperature sensor
	F5	go to part 3
Part 3	**F1**	operation of the blank valve/pump
	F2	operation of the buffer valve/pump
	F3	operation of the outputs 'extern1', 'extern2' and 'extern3'. This opens a sub-menu.
	F4	recall output signals, calibrate strip chart
	F5	go to part 4
Part 4	**F1**	print out a selected part of information
	F2	manual form feed command to printer
	F3	manual line feed command to printer
	F4???	????
	F5	go to part 1

6.2.3 Valve, pump and extern operation

All valve/pumps and the extern outputs can be operated in the same way. The manual control of the extern (1-3) goes with an extra sub-menu.
During Manual valve/pump/extern operation the ↑ will not influence the operation. In this way two or more manual commands can be carried out simultaneously by the Analyser.

VALVES AND PUMPS
As an example, the manual operation of the drain valve/pump:
Go to the Manual menu and press the **F**-key DRAIN, the display shows:

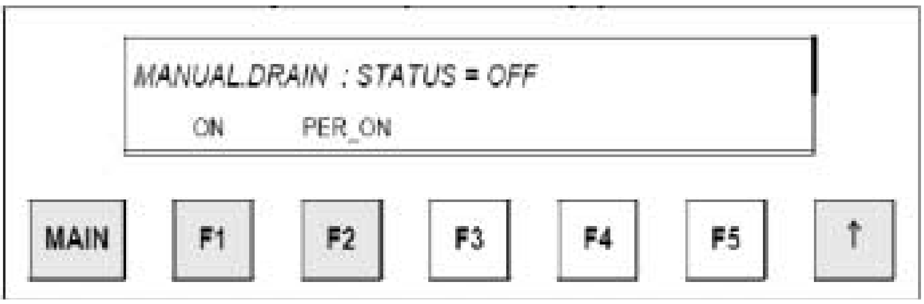


Fig. 35 Manual Drain menu, Status off

The status of the pump is presented, while the action can be selected with **F1** or **F2**. **F1** ON activate the pump for an indefinite* period of time

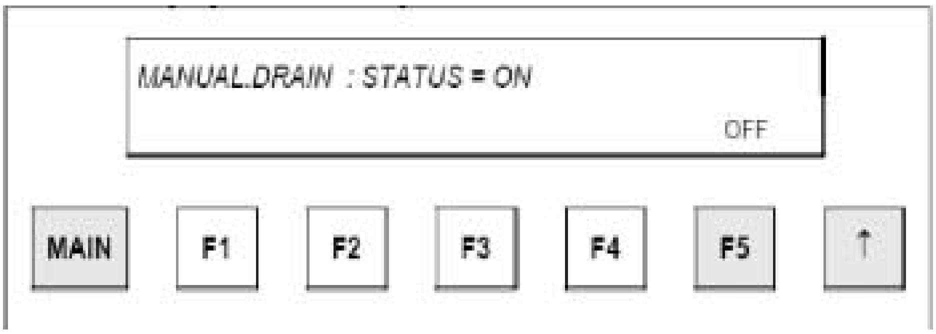


Fig. 36 Manual Drain menu, Status on

Press **F5** to switch off the drain.

*The valves/pumps (not Extern) will switch off automatically when active for 9,999 seconds.
F2 PER_ON will activate the pump for a number of seconds.

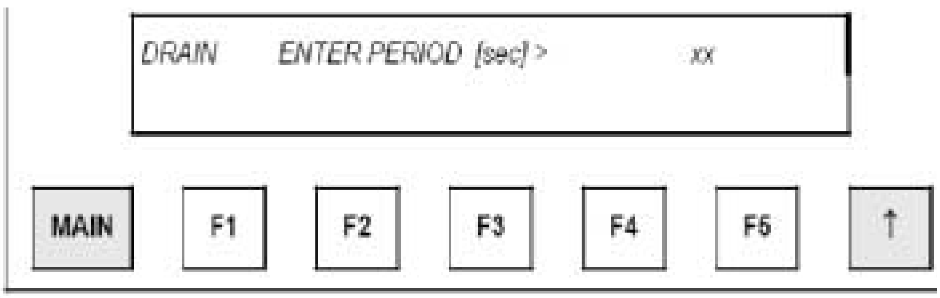


Fig. 37 Manual Drain menu, Period

Enter a number of seconds with the numeric keyboard, then the action is executed.

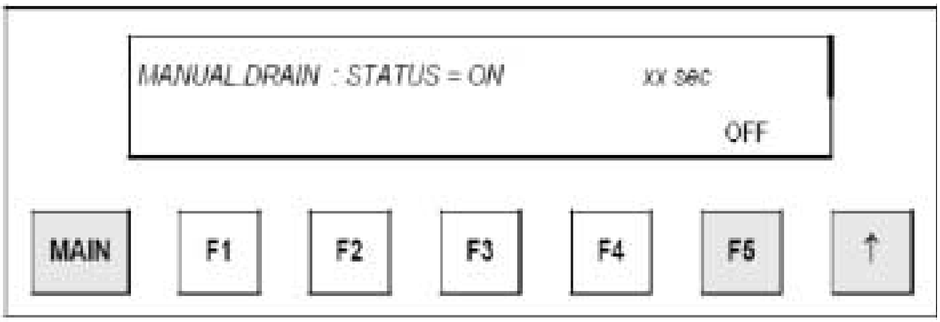


Fig. 38 Running Manual Drain menu

During the action, the time that still remains to be executed, is displayed.
The action can also be interrupted with key **F5** .

EXTERN OUTPUTS

The extern outputs can be operated by selecting the Manual menu. Use **F5** the display shows:

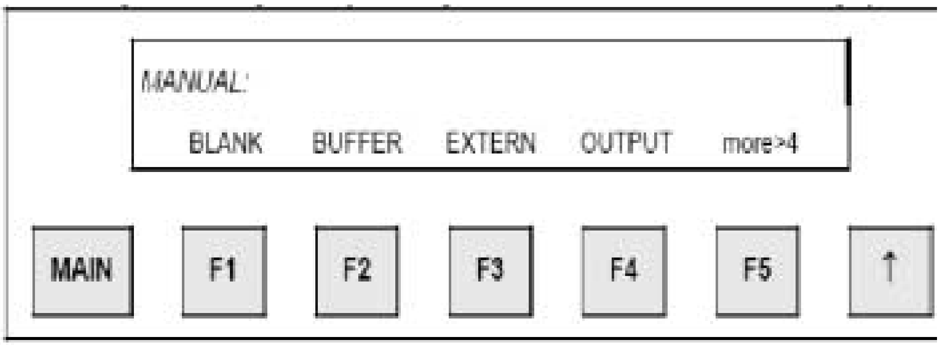


Fig. 39 Manual menu of extern output

Press **F3** to open the sub-menu of the Extern outputs:

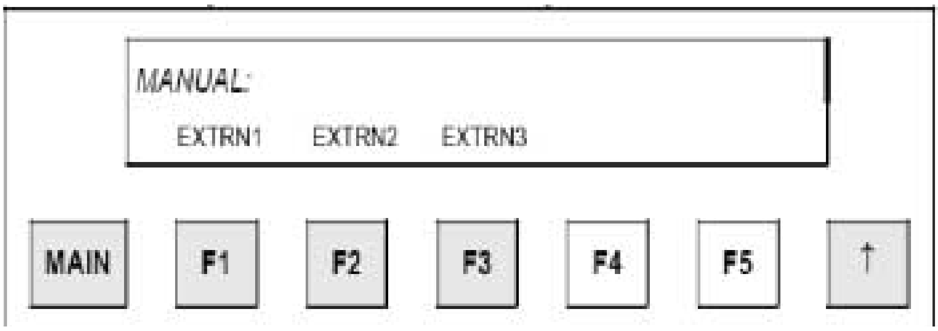


Fig. 40 Sub-menu of extern output

F1, F2 and **F3** a menu in which the Extern outputs can be operated like a pump, as described before.

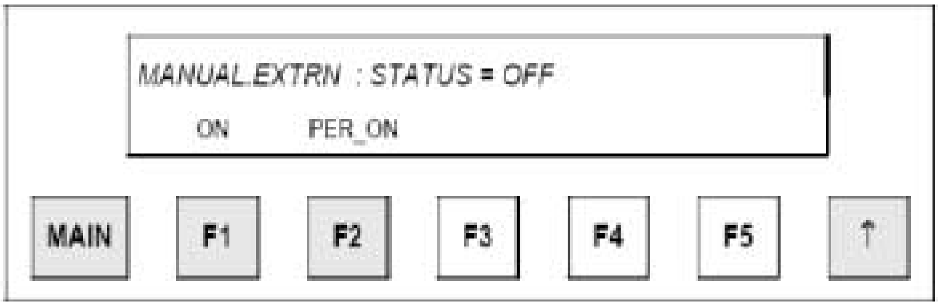


Fig. 41 Sub-menu of extern output, Status off

6.2.4 Stirrer operation

To manually operate the stirrer:
- select the relevant part of the Manual menu
- press key **F3** STIRRER, the display shows:

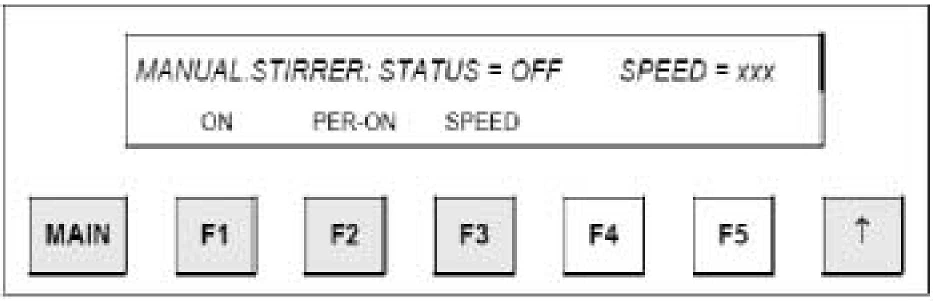


Fig. 42 Manual stirrer

Press **F1** to activate the stirrer.
Press **F2** to activate the stirrer for a number of seconds, see section 2.3 for the display.
Press **F3** to change the stirrer speed, this can be done while the stirrer is on or off.

When **F3** is pressed, the display shows:

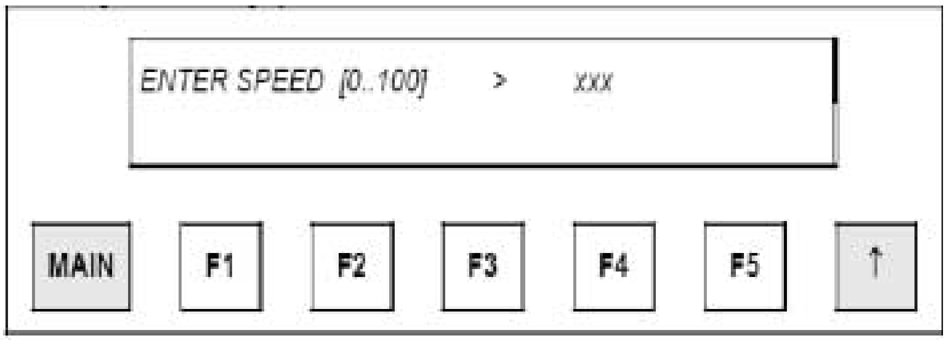


Fig. 43 Sub-menu of Manual stirrer

Enter the stirrer speed with the numeric key-board, or go to the previous level with the ↑ key.
The stirrer speed, selected by this manual command, is also used in the Analysis, Reference and Cleaning program. So, **DO NOT CHANGE THE SPEED UNNECESSARY.**

The original setting can be found in the application description.

Note:
- The stirrer speed can be set between 0 and 100 %.
- The default value of the stirrer speed is 30 % (after total initialization)

6.2.5 Burette operation

The burette can be manually operated in 4 ways: dosing, refilling, initiating (dosing and refilling a number of times) and recycling (recycle and degas cylinder back to reagent container).
In the Utility buret menu (see chapter 6.5 on page 75), the refilling speed and the cylinder size can be selected. In case of a viscous solution, a lower actual speed can be chosen by making the speed value larger.
In case of a viscous solution, a lower actual speed can be chosen by making the speed value larger. The speed can be set from 1 (highest speed) to 100 (slowest speed = highest speed / 100).

Select the Manual menu and the **F**-key BURET. The display shows:

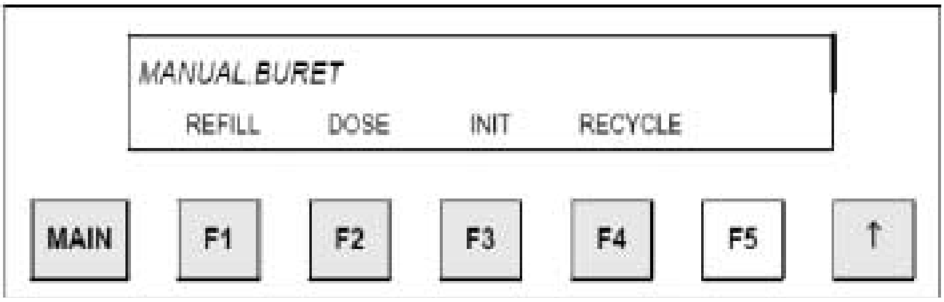


Fig. 44 Manual Buret menu

When pressing **F1** the cylinder is refilled and the display shows:

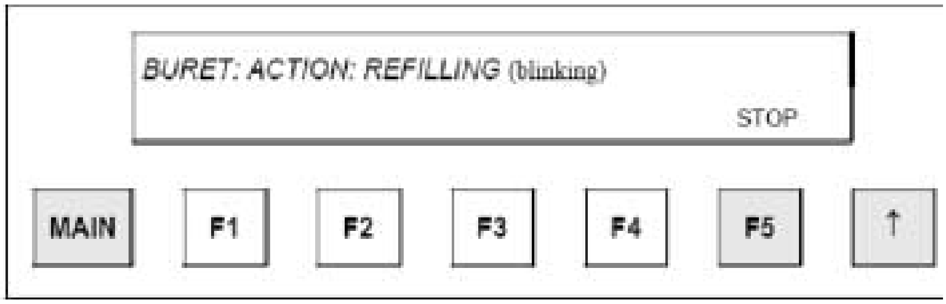


Fig. 45 Sub-menu of manual Buret, Refilling

The refilling action can be interrupted with function key **F5** .
When the refilling action is completed, the display returns to the Manual buret menu.

When pressing F2, a dosing action can be selected; the display shows:

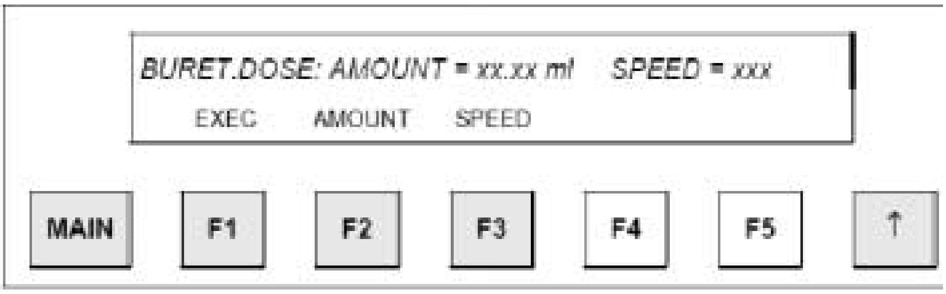


Fig. 46 Sub-menu of manual Buret, Amount

When the displayed amount and speed need to be updated, this can be done using **F2** and **F3.**

SPEED in combination with the numeric key-board.
The amount can be set from 0 ml to one cylinder volume (cylinder volume is set in the Utility menu). When speed and amount are set, press **F1** EXEC(ute); the dosing action will be executed, display shows:

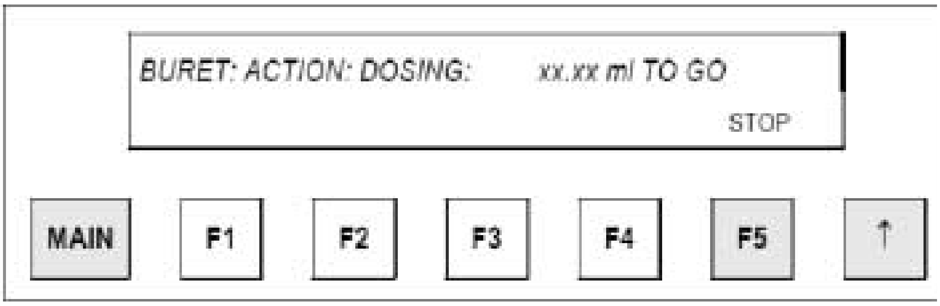


Fig. 47 Sub-menu of manual Buret, Dosing

If required, the dosing action can be interrupted with function key **F5**.

After pressing **F3** in the Manual buret menu, the function can be executed; this function can be used during start-up. Use the numeric key-board to enter the number of cycles of dosing and refilling, after which the action will be executed automatically. The display shows:

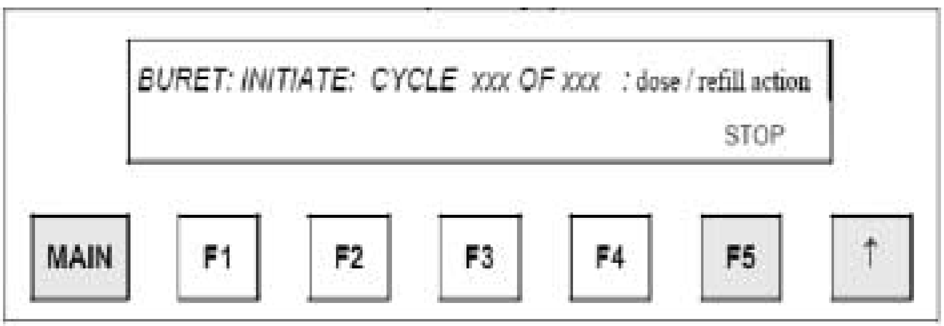


Fig. 48 Sub-menu of manual Buret, Initiate

The dose action will be done to the very end of the burette cylinder, this means that the reagent will be completely renewed without the necessity to dismount the burette cylinder.

During execution of this action, the function key **F5** can be used to interrupt the action.

After pressing **F4** in the Manual buret menu, the function can be executed; this performs a complete sequence of actions to remove air bubbles from the burette cylinder. After pressing **F4** one sequence will be executed automatically. The display shows:

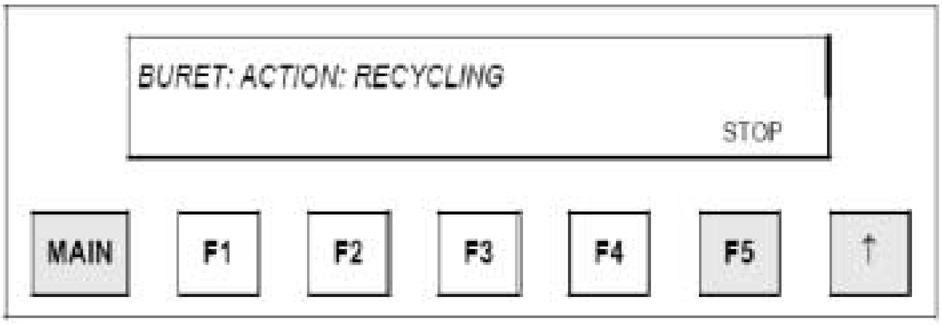


Fig. 49 Sub-menu of manual Buret, Recycling

During execution of this action, the function key **F5** can be used to interrupt the action. The recycle volume can be set in the Utility burette menu.

6.2.6 Input operation

Select the Manual menu and press the **F**-key INPUT. The input menu is now selected and the actual input (electrode) signal is presented in mV and the temperature in degrees Celsius is presented. When no temperature sensor is installed, a constant temperature is shown.
The input range of the mV-input is -2000 .. +2000 mV, of the Temp-input -50 °C .. 150 °C.

When a mV-amplifier is installed, the display will show:

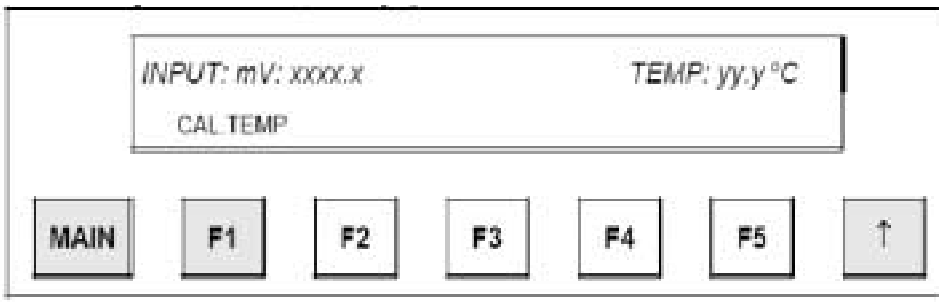


Fig. 50 Input menu

The mV-input signal and the temperature are displayed.
With the function key **F1** TEMP the offset of the temperature sensor can be calibrated. The mVinput can not be calibrated.
The mV-value depends on temperature (Nernst-law).

With **F1** TEMP the temperature sensor can be calibrated. This is actually nothing more than adjusting the offset of the temperature sensor. The following menu will now be displayed:

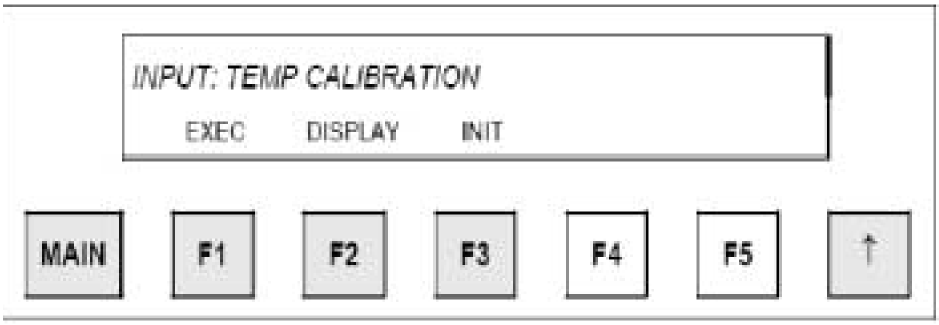


Fig. 51 Sub-menu Input, Temp Calibration

F1 will start the calibration of the temperature probe.
F2 will display the calibration data (offset); (after this; use the ↑ to return.)
F3 will set the offset to 0.0 (default value).

When **F1** pressed the current temperature is asked for, use the numeric key-board. The actual measured temperature is displayed. When a stable signal is detected the offset is calculated and presented, now use the ↑ to go to the Manual menu.

Note:
- When the input signal is not stable within 120 sec., the display presents the error message: ’ UNSTABLE PROBE, CALIBRATION ABORTED ’.

6.2.7 Output operation

Select the Manual menu and press **F4** OUTPUT. The output menu is now selected and the actual values of the analog outputs 1 and 2 are presented in the display (only when both data interfaces are installed):

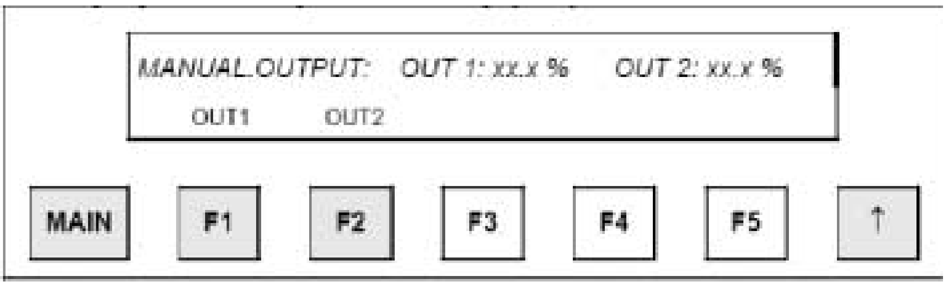


Fig. 52 Manual Output menu

When no data interfaces are installed, the message: *’NO OUTPUTS AVAILABLE’* will be displayed.
When only 1 data interface is installed, only the actual value of this output is displayed.
When **F1** or **F2** is pressed, the actual output value can be updated; enter the new value in %, using the numeric key-board.

0 % will result in an output of 0 or 4 mA (depending on the settings of switches), 100 % will result in an output of 20 mA.
This procedure can be used to calibrate any recording device, that is connected to the analog output. Use the ↑ key to return to the Manual menu.

Note:
When the actual output value is updated, the time that is required to reach the new value depends on the output Adjust pace setting, see Utility adjust menu.

6.2.8 Print operation

In order to use this sub-menu, the interface selection it the Utility serial menu must be set to Printer.
Select the Manual menu and press **F1** PRINT. The Manual print menu is now selected and one of the five possible data blocks can be printed:

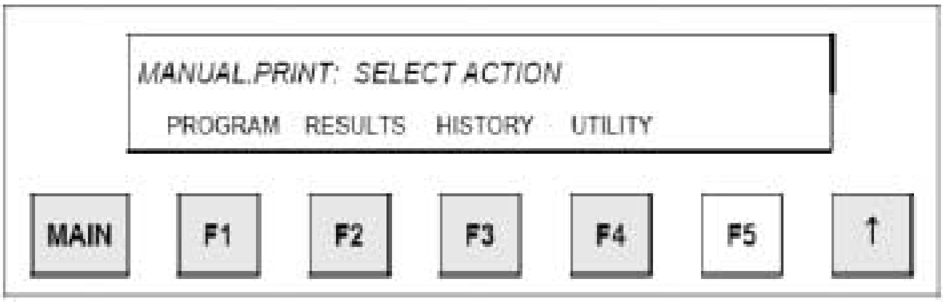
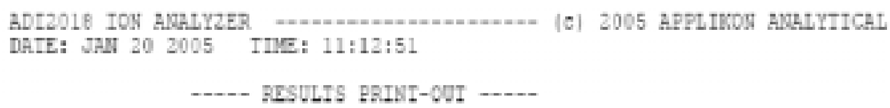


Fig. 53 Manual Print menu

F1 result in the print-out of the user program (Analysis, Reference and Cleaning program, together any Run Select Ratios, Cycle Time and stirrer speed).

F2 will print the results of the previous run, together with any alarm message. This command is mainly used during start-up (optimization purposes); the print-out will have the following format:


ADI2018 ION ANALYZER ---------------------- (c) 2005 APPLIKON ANALYTICAL
DATE: JAN 20 2005 TIME: 11:12:51

----- RESULTS PRINT-OUT -----

Fig. 54 Format of the print-out - neues Bild wg. APPLIKON??? oder weglassen?

- *Analysis results with any alarm message:*

Existing results for sample 1 and 2) together with the initial and final measured mV-value and the amount of standard that is dosed. The engineering unit is selected in the Utility const menu. Also the existing history data is printed (mean result and standard deviation).
- *Reference results with any alarm message:*

Results of the last executed Calib-macro in the Reference Run (in mV/decade), together with all measured mV-values.
- *Mean reference results:*

Mean slope values, found during the last run sequence (expressed in mV/decade). These slope values are actually used to calculate the current analysis result.
- *Calibrated range:*

This shows the range over which the calibration of the Ion Selective Electrode is carried out. That is; the lowest and highest concentration in the reaction cell expressed as sample concentration in the selected Engineering unit (see chapter 6.5 on page 75) and calculated with use of the Engineering factor.

F3 will print the same heading and the results of the last calculations (i.e. each last calculation programmed in the Output macros, → *Section 3 on page 21*). This History is also available in the Utility stats menu.

F4 will print the utility settings: the loaded software version, the burette cylinder size, refilling speed, recycle volume, the constants, the stirrer speed, data format of serial interface, analog output mapping plus limits and the calibration parameter of the temperature sensor.

Use the ↑ key to return to the Manual menu.

Note:
The Analyser will generate a "form-feed" command every 66 lines that are printed. Analyser and printer can be synchronized by reset the line counter by resetting the Analyser (Utility init reset menu) and setting the printer at the top of the page after switching it on. Pressing the command (Manual menu) will also reset the line counter since the Analyser expects the printer to be at the top of the page after this command.

Other menus can be used while a print action is performed. The actual printing is executed on the background (using a 2 kByte output buffer).

6.3 Programming

6.3.1 Program menu

In the Main menu, pressing **F3** will show the Program menu:

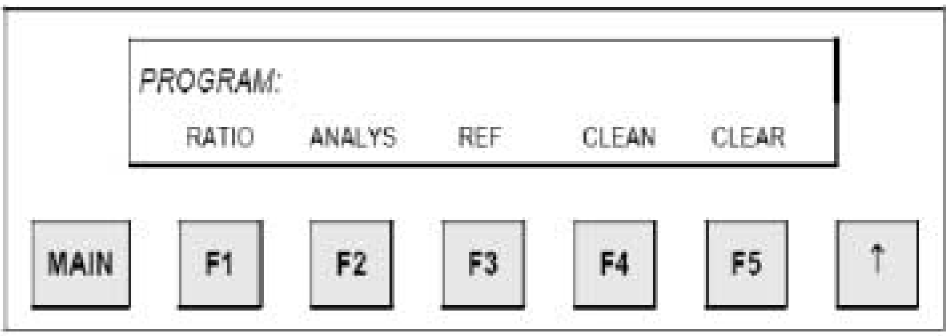


Fig. 55 Program menu

F1 = the ratios of the different runs and cycle time,
F2 = program the analysis run,
F3 = program the reference run,
F4 = program the cleaning run,
F5 = delete (one of) the programs.

In the analysis run the concentration of analyte in the sample is determined by the dynamic standard addition method. The obtained standard consumption is used to calculate the concentration of analyte.

The reference run has a double function:

1) The reference run can be used to calibrate the slope of the Ion Selective Electrode with the blank and the standard solution.

2) The reference run can also be used to analyse the concentration of the standard solution to check if the analyzer still works properly, this is also called **diagnose**.

The cleaning run can be used to perform extra cleaning actions in the reaction cell.

The analysis run, reference run and cleaning run can be combined in a sequence, this is called the run selection ratio.

6.3.2 Ratio selection

The ratio selection can be programmed by selecting **F1** RATIO the Program menu:

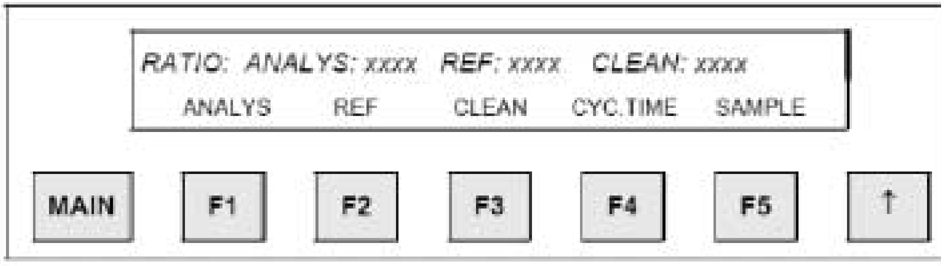


Fig. 56 Sub-menu Program, Ratio

Function keys F1 ... F3 (run-select ratios)
With these function keys a sequence of extra cleaning, analyzing a reference solution and analyzing the sample(s) can be programmed.

F1 : to program the analysis ratio; press **F1** enter the desired value.
F2 : to program the reference ratio; press **F2** enter the desired value.
F3 : to program the clean ratio; press **F3** enter the desired value.

When all three ratios have a value larger than zero, the sequence of actions after giving the START command (see Run menu) will be:

execution cleaning run (x times), execution reference run (y times), execution analysis runs (z times)

Where: x = ratio value of cleaning run,
y = ratio value of reference run,
z = ratio value of analysis run.

Note:
- When the ratio of a run is set to 0, this run will not be executed in the run selection sequence.
- Ratio values can be set between 0 and 9999.
- When all three ratios are set to 0, the START in the Run menu will generate the processing alarm *'ALL RUN-SELECT RATIOS ZERO '*.
- The Run menu has also the option to start the execution of one of the three runs without using the run select options, see chapter 6.4 on page 70.

- When y (ratio value of the reference run) = 1 or higher, the average value of the reference results is calculated and used in the calculation of the result of the sample.

Function key F4 TIME
In the run select menu, also the minimum cycle time of the analysis run can be set; in this way the analysis frequency can be programmed. Press TIME in the ratio menu and the display will show the cycle time status (*'OFF '* or *'xxx minutes'*). With the function keys **F1** or **F2** , the cycle time can be set on/off and the duration can be entered on the numeric key-board (in minutes, max. 1440).

The cycle time is only used for the analysis run. When the actions in the analysis run are completed within the duration of the cycle time, the Analyser will switch to an *'IDLE'* until the programmed cycle time is completed.
When the actions in the analysis run are not completed within the programmed cycle time, the cycle time will be overruled by the programmed actions in the run. When a run-selection is used (ratios for cleaning or reference run > 0), the cleaning and reference runs are part of the cycle time (see *Fig. 57*):

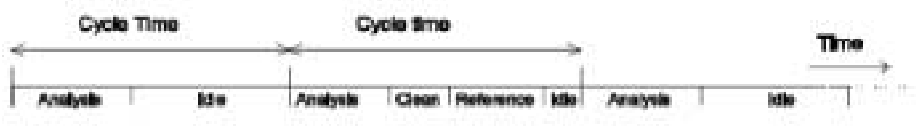


Fig. 57 View of the cycle time

The programmed cycle time is ignored in the following cases:
- in case of analysis cycle 1,
- in case a run is interrupted () and restarted (),
- in case the result of (one of) the sample(s) exceeds the programmed alarm limits.

Function key **F5**
The function key can be used to program sample selection ratios for the two sample streams that can be analyzed. After pressing , the programmed sample selection is displayed, while function keys.

F1 SAMPLE-1 and **F2** can be used to change the current ratios.
The sample selection procedure is identical to the run selection procedure; example:

- ratio of sample 1 = 3
- ratio of sample 2 = 2
analysis run 1: sample 1,
analysis run 2: sample 1,
analysis run 3: sample 1,
analysis run 4: sample 2,
analysis run 5: sample 2,
analysis run 6: sample 1, etc.

6.3.3 Programming macros

Programs for cleaning, reference and analysis run are composed by entering a sequence of standard actions, called MACROS. For the three different runs, the following macros are available:

Table 3 Function of macros

Macro name	Analysis run	Reference run	Cleaning run
WAIT	x	x	x
RINSE	x	x	x
DRAIN	x	x	x
BUFFER	x	x	x
MEASURE	x		
CALIB		x	
OUTPUT	x	x	
SAMPLE	x		
BLANK		x	x
FLUSH	x	x	x
EXTRN1	x	x	x
EXTRN2	x	x	x
EXTRN3	x	x	x
BURET	x	x	x

Below, the function of each macro is described:

WAIT-macro
The WAIT macro contains a waiting time; during this interval, the stirrer action can be set on or off.

RINSE-macro
The RINSE macro opens the rinse valve/pump for the programmed number of seconds; during the second half of the programmed period, also the stirrer is activated.

DRAIN-macro
The DRAIN macro opens/starts the drain valve/pump for the programmed number of seconds; during the first 2 sec. of this drain interval, the rinse valve/pump is activated. During the first half period of the drain interval, the stirrer is activated.

BUFFER-macro
The BUFFER macro is used to add the Total Ionic Strength Adjustment Buffer (TISAB) to the reaction cell. The required interval is programmed in seconds. The BUFFER macro is automatically extended with a 5 sec. period; during this period, the solution in the reaction cell is homogenized since the stirrer is activated during the buffer macro.

MEASURE-macro
The MEASURE macro (analysis run) is used to analyse the sample, using the standard addition method; in this MEASURE macro, the maximum measure time and some parameters must be programmed. During the MEASURE macro, the stirrer is activated (stirrer speed is set in Manual menu).

CALIBration-macro
The CALIB macro (reference run) is used to calibrate the slope of the electrode over one to four concentration ranges. The number of concentration ranges must be selected.

OUTPUT-macro
The OUTPUT macro in the analysis and reference run is used to carry out result verification and data transfer. The OUTPUT macro consists of two actions:
–- specification of result alarm limits (and for the analysis run also alarm actions),
–- selection of the print action (result with or without measured mV value or off)

SAMPLE-macro
The SAMPLE macro contains two individual periods; one period for opening one of the sample valves (pipette is filled with sample) and a second period for opening the pipette valve (contents of the pipette is transferred to the reaction cell). Between these two periods, the macro is paused for five seconds. When this macro is recalled or edited, the total macro time will be the sum of "both valve intervals plus 5 sec.".

BLANK-macro
The BLANK macro is identical to the SAMPLE macro, however in this case the blank valve is operated.

FLUSH-macro
Like the SAMPLE macro, the flush macro consists of two periods: a "flush period" (sample line and pipette can be flushed with fresh sample/standard; the drain valve, sample/standard valve and the pipette valve are opened) and a "pipette period" (sample/standard valve is closed while the drain and pipette valve are still open, so the contents of the pipette can be drained).
If this macro is recalled or edited, the sum of both flush time and pipette time is presented in the display.

Note:
- At the beginning of the pipette period, the rinse valve/pump will be activated automatically for 2 sec.

EXTRN1/EXTRN2/EXTRN3-macro
The EXTRN macro is used to activate an external device for a programmable number of seconds; unlike all other macros, this macro is shortly displayed and is immediately followed by the next macro, but during this programmed interval a relay is switched at a "Extern" terminal. This relay can be used to switch 24 V. For EXTRN1 and EXTRN2 also a separate 24 V output is controlled.

BURET-macro
The BURET macro can be used in the reference and analysis runs. This option is maybe useful in case a cycle time is used (e.g. one analysis per hour); just before the analysis run is completed, the reaction cell can be drained and filled with an electrode-conditioning solution (mixture of rinse water andstandard). In this way, the electrode lifetime maybe increased. During the BURET macro, the stirrer is activated.

6.3.4 Rules in using macros

- Each run (analysis, reference and cleaning) can contain a maximum of 30 macros.

- The measure macro can only be programmed once during the analysis run.
- The calibration macro can only be programmed once during the reference run.
- The analysis run and reference run only can contain one output macro each.

6.3.5 Inserting macros in a program

In order to create programs for the analysis, reference and cleaning runs, macros must be inserted in the Program menu. Select this menu (**F3** in the Main menu).
Select **F2** ANALYS create an analysis run.
Select **F3** REF create a reference run.
Select **F4** CLEAN create a cleaning run.
When no analysis program is yet inserted (or the program is deleted), after selecting **F2** ANALYS display shows:

Fig. 58 Sub-menu Program, Analysis, part 1

Press **F3** in order to enter the insertion menu, which consists of three parts:

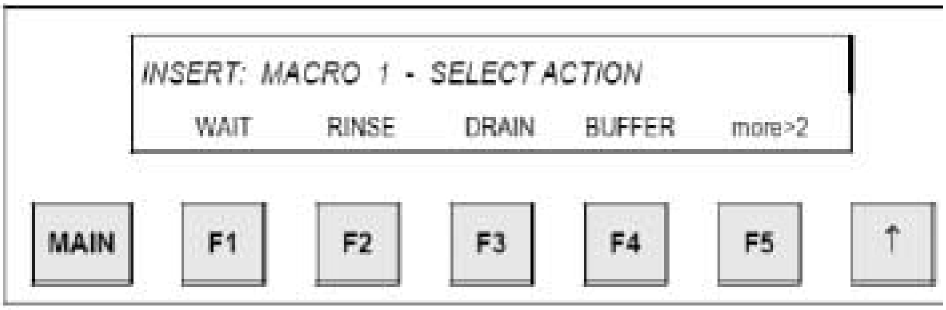


Fig. 59 Sub-menu Program, Insert, part 2

When **F5** 2 is pressed, the display will show the second part of the insertion menu:

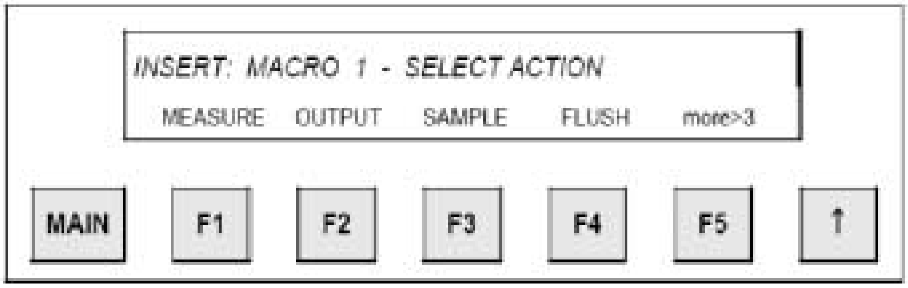


Fig. 60 Sub-menu Program, Insert, part 3

In the reference menu, the SAMPLE macro is replaced by the BLANK macro, while the MEASURE macro is replaced by the CALIB macro. The cleaning menu also consists of three parts but a MEASURE or OUTPUT macro are not present and the SAMPLE macro is replaced by the BLANK macro.

When **F5** 3 is pressed, you will enter the third part of the insert menu:

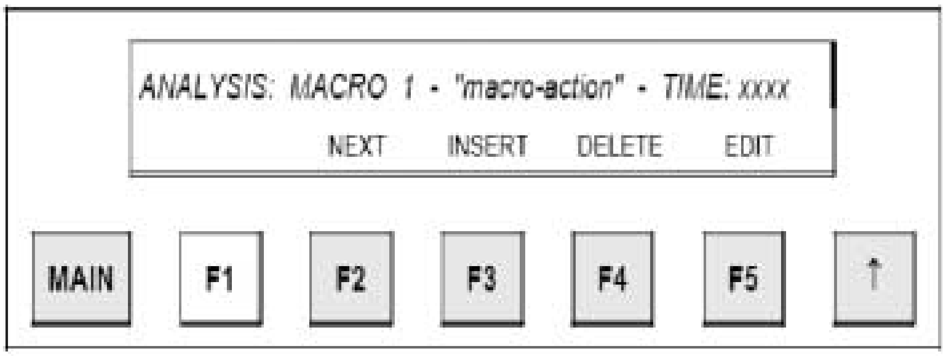


Fig. 61 Sub-menu Program, Analysis run

A sequence of actions can now be composed by selecting actions from the insert menu.

The macro requires a waiting time to be entered (in seconds) on the numeric key-board after which the stirrer action must be specified:

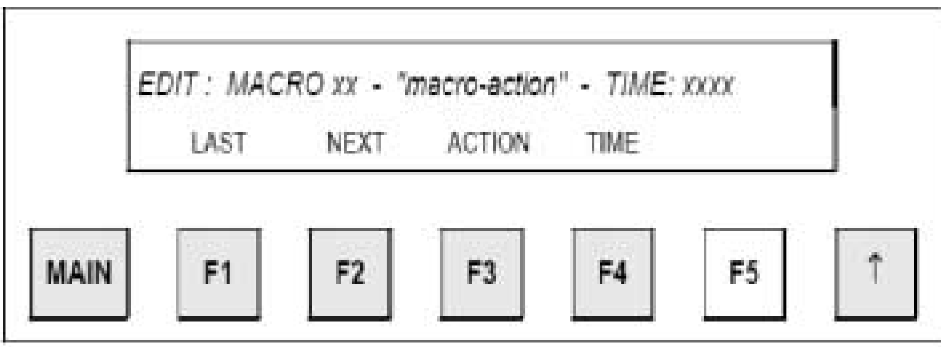


Fig. 62 Sub-menu Program, Edit macro, part 1

The macros RINSE, DRAIN, BUFFER, FLASH, SAMPLE, BLANK and EXTRN only require a period of time entered (in seconds) on the numeric key-board (the

flush, sample and blank macro require a period for opening the sample/blank valve and a period for opening the pipette valve).
The macro BURET requires a dosing speed (1 = highest speed, 2 = half speed, etc.) and an amount (in ml) to be entered on the numeric key-board. If these items are set to “0", only a RECYCLE action is performed while an additional DOSE action is omitted (only in CLEAN run).

Note:
- The minimum amount that can be dosed in a macro is 0.01 % of the cylinder volume.

The macro in the analyses run requires a maximum measuring time, an electrode drift criterion and a "sample out of range" action (→ *Section 6.3.8 on page 61*).

The macro in the reference run requires a selection of the number of concentration ranges for the calibration of the slope of the electrode and the same parameters as used in the macro.

In the macro, the alarm and print (on/off) setting is programmed. In the analysis run, the alarm setting means: lower and upper alarm limit, alarm action (RAL1, RAL2 or off) and diagnostics (TEST1, TEST2 or off) for each sample stream.

In the reference run, lower and upper alarm limits of the electrode slope can be specified for each concentration range (if the alarm limits are exceeded, a Processing Alarm is triggered). For detailed information concerning the output macro → *Section 6.3.9 on page 65*.

Note:
When during the insertion of an action the ↑ key is pressed, the insertion is interrupted.

6.3.6 Editing macros in a program

When the analysis, reference and cleaning runs are programmed, the programmed macros can be edited very easily. Select the Program menu and the run that needs to be edited. In the following procedure, the analysis run is edited as an example:

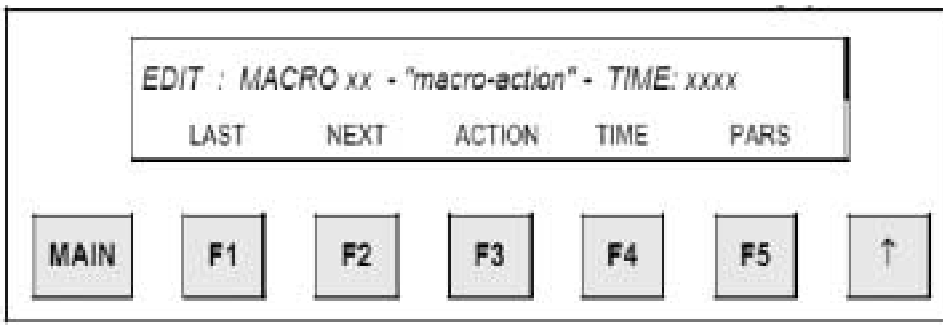


Fig. 63 Sub-menu Program, Edit macro, part 2

The function key **F2** can be used to step through the program.
When **F2** is pressed once, the function key **F1** will be the key.
When, using key **F2**, the final macro in the sequence is reached, key **F2** becomes functionless.
Press the key **F5** and search the macro to be edited with **F1** or **F2**.

When a valve/pump/relay action (DRAIN, BUFFER, FLUSH, SAMPLE, BLANK or EXTRN) is edited, the display shows:

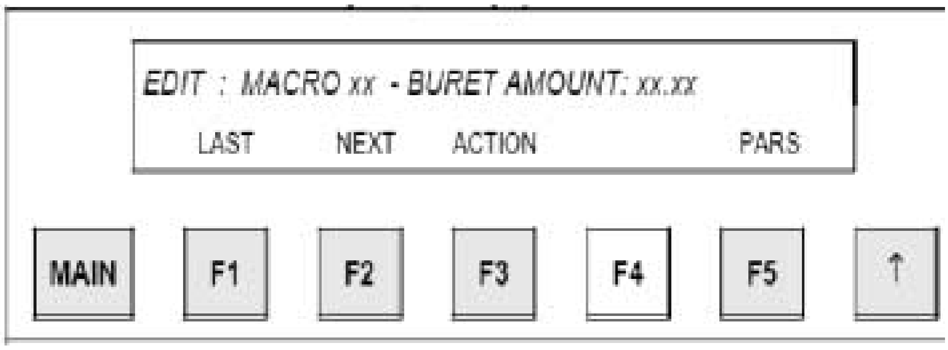


Fig. 64 Sub-menu Program, Edit macro, part 3

The type of action can be edited with **F3**.
The action-time can be edited with **F4**.
And the parameters can be edited with **F5**:
- the parameters of the **WAIT** macro mean the stirrer action: on or off,
- for more information about the measure and calibration parameters → *Section 6.3 on page 52*.

Editing an macro is very similar to editing a macro; both the action (**F3**) and the parameters (**F5**) can be selected to be edited with the function keys. Function key **F4** however is not present. See → *Section 6.3.9 on page 65* for more information about the output parameters.

When a macro needs to be updated, the display shows:

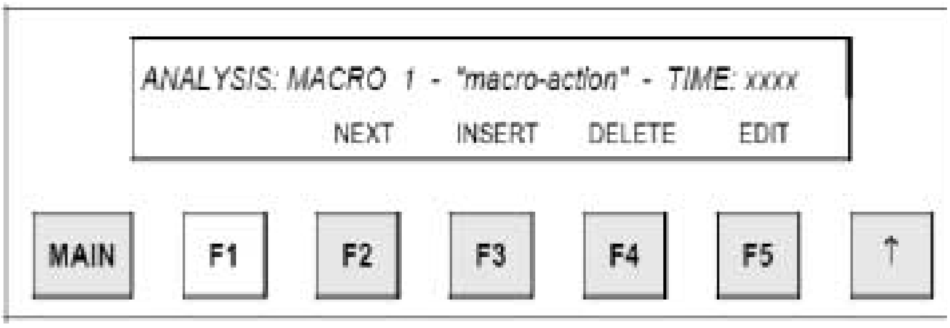


Fig. 65 Sub-menu Program, Analysis, Deleting macros, part 1

The function key **F3** can be used to edit the action (see previous example).
With **F5** both the burette speed and dosing amount can be edited.

Note:
- It is also possible to add actions to the program; select the macro menu and go to the position where the new action needs to be inserted using **F2** (or **F1**). Now press **F3** and the new action can be inserted.

6.3.7 Deleting macros from a program

Deleting macros can be performed in the following manner: select the Program menu and run (analysis, reference or cleaning) that needs to be updated.
When the analysis run is selected, the display shows:

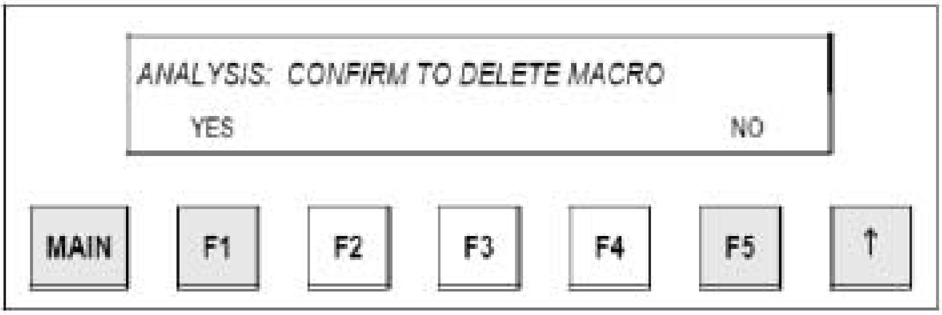


Fig. 66 Sub-menu Program, Analysis, Deleting macros, part 2

Use function key F2 to go to the macro that needs to be deleted. When F4 is pressed, the display shows:

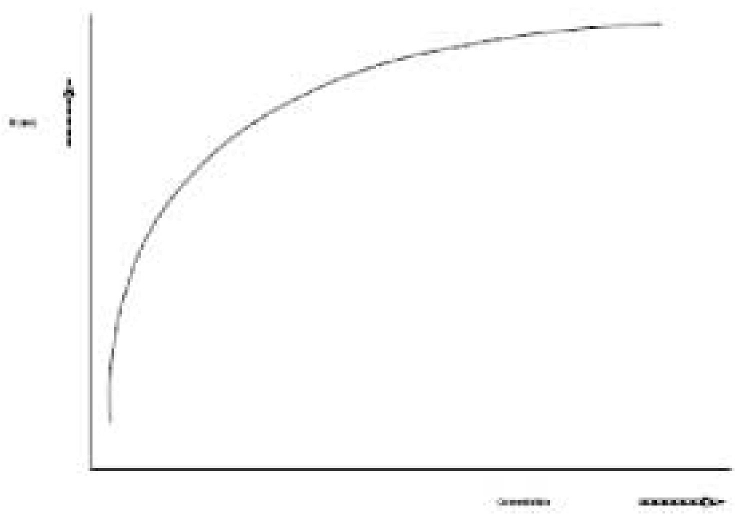


Fig. 67 Measuring signal

Pressing **F1** will delete this macro, pressing **F5** will return to the macro menu.

Note:
- The complete program can be deleted by using function key **F5** in the Program menu (→ *Section 6.3.10 on page 69*).

6.3.8 Measure/calibration parameters

MEASURING: (analysis run) In the measuring macro, the Ion-Analyser uses a dynamic standard addition method in order to determine the ion concentration in the sample. Since the potential shift that is caused by a standard addition depends on the original sample concentration (logarithmic function, see figure), the ion concentration in the sample can be calculated.

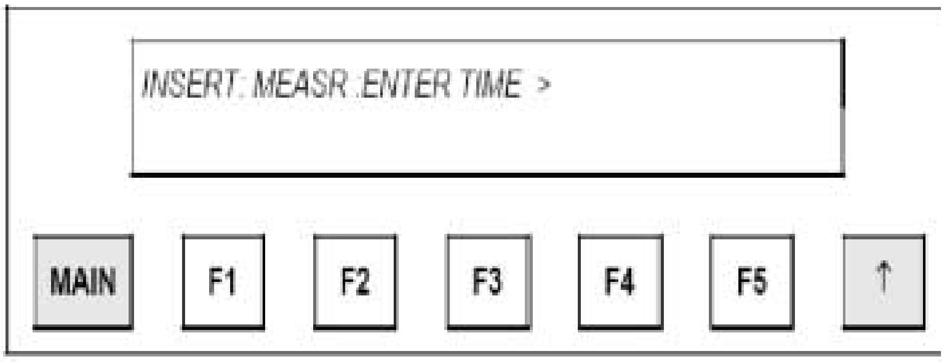


Fig. 68 Sub-menu Program, Insert, part 1

The standard addition is carried out by the precision burette of the Ion – Analyser. Because of this standard addition method, the results will not be effected by electrode drift or matrix effects of the sample. In order to obtain maximum accuracy, the Analyser aims to increase the concentration of the measured ion approx. with a factor of three.

Maximum standard addition volume: 100 % of the cylinder size.

When programming a measuring macro, two parameter values must be set:

- *a maximum measurement time*

The maximum measurement time must be entered in seconds; when no analysis result could be found within this period, the processing alarm (PAL) will be generate, with the message: 'ANALYSIS TIME-OUT **PAL**'.

- *a drift criterion of the electrode signal*

The drift criterion is used to verify if the electrode signal is stable; when the measured electrode drift over 5 seconds is smaller than the programmed criterion, the actual electrode potential is accepted and the measuring macro will be proceeded (carrying out another standard addition or calculating the final result).

Note:
- During the measuring macro, the electrode signal is measured continuously. During the first 15 sec. After each addition, the actual value is displayed; after this, the mean value is displayed every second until the drift criterion is met.
- When the ion concentration of the sample is higher than the concentration of the standard, the error message *' SAMPLE OUT-OF-RANGE '* is presented.

When a measuring macro is inserted, the display shows:

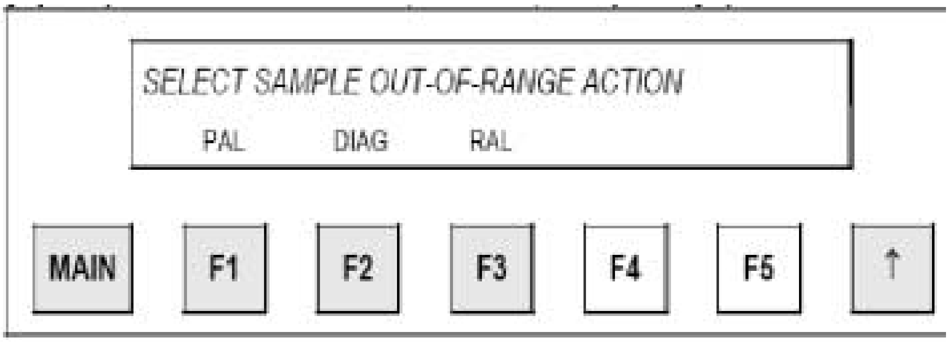


Fig. 69 Sub-menu Program, Insert, part 2

After having entered the maximum measurement time (in seconds), using the numeric keyboard, the display asks you to enter the drift criterion (in mV/5 sec). Finally the display shows:

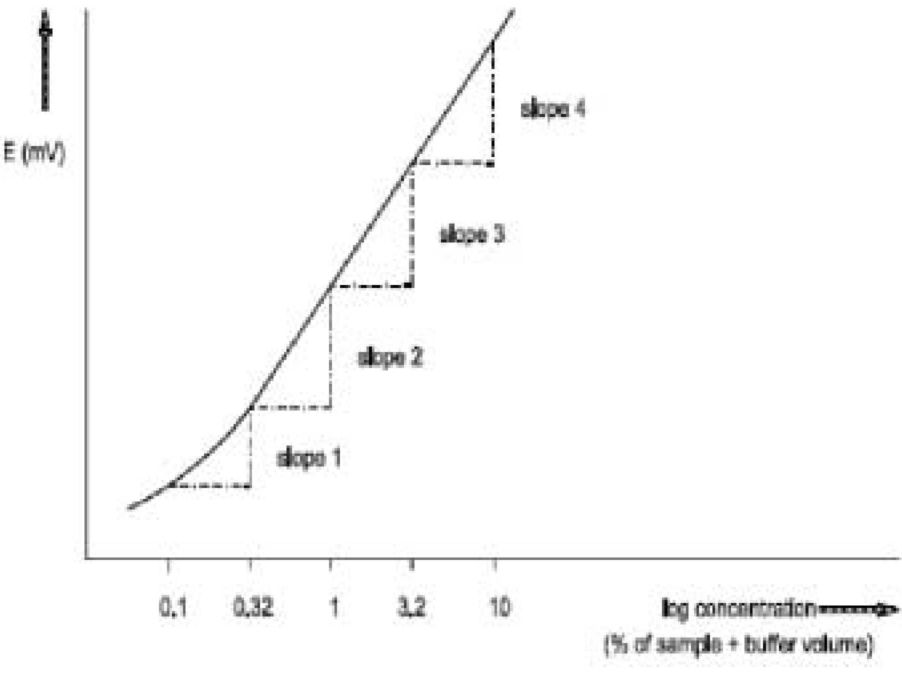


Fig. 70 Calibration of the slope of the electrode

When **F1** is pressed, a processing alarm will be triggered in case of sample-out-of-range.
When **F2** is pressed, a diagnostic action will be performed (Section on page 67, output parameters).
When **F3** is pressed, both result alarms will be triggered.

Note:
- Refer to the Application Manual for initial parameter settings.
- Only one measure macro can be programmed in the analysis program.
- In order to obtain an accurate result, all mV values are internally corrected for the measured temperature.

CALIBRATING (reference run)
In the calibrating macro of the reference run, the Analyzer is calibrating the slope of the Ion Selective Electrode over a user selectable range (maximum: 2 decades). The sensitivity of the analysis depends on the concentration of the standard that is added in the measure and calibration macro (see specification list in the Application Manual). The calbration of the slope of the electrode can be devided into a maximum of 4 ranges (5 individual additions), see figure.

If required (e.g. to save time), a lower number of slopes can be selected as well; in this case, the number and volume of the additions can be found in the table below (the volumes are given in % of the sample + buffer volume):

Table 4 Slope of the electrode

	1 slope	2 slopes	3 slopes (lo)	3 slopes (hi)	4 slopes
first add.	1 %	0.1 %	0.1 %	0.1 %	0.1 %
sec. add.	10 %	1 %	0.3 %	1.0 %	0.3 %
third add.	-	10 %	1.0 %	3.1 %	1.0 %
fourth add.	-	-	10.0 %	10.0 %	3.1 %
fifth add.	-	-	-	-	10.0 %

The calibrated slope values are stored in memory and can be printed, using the output macro.
If the run selection ratio for the reference run is 2 or higher, the mean slope values are taken into account in order to calculate the analyses results.
When no reference run is carried out, the analyser will use the theoretical Nernst potential (default value, corrected for the measured temperature).

When programming a calibration macro, three parameter values must be set:

- *a maximum time of the calibration macro:*

The maximum time must be entered in seconds (like in the measuring macro); when the calibration macro could not be completed within the programmed time, the processing alarm (PAL) *' CALIBRATE TIME OUT '* will be generated.

- *the number of slopes to be determined (1 - 4):*

The number of slopes to be determined can be set between 1 and 4; *Table 4* (*S. 64*).

- *a drift criterion of the electrode signal:*

The drift criterion is used in the same way as in the measure macro: as soon as the measured electrode drift over 5 seconds is smaller than the programmed value, the actual electrode potential is accepted.

When a calibration macro is inserted, the display shows:

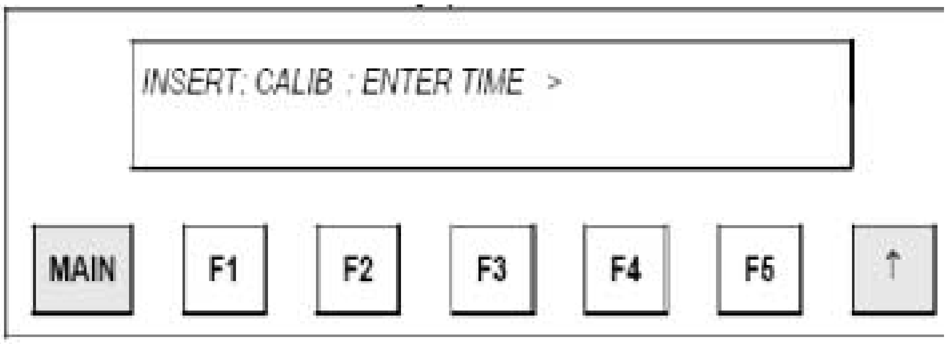


Fig. 71 Sub-menu Program, Insert Calib, part 1

After entering the maximum time on the numeric keyboard, the display shows:

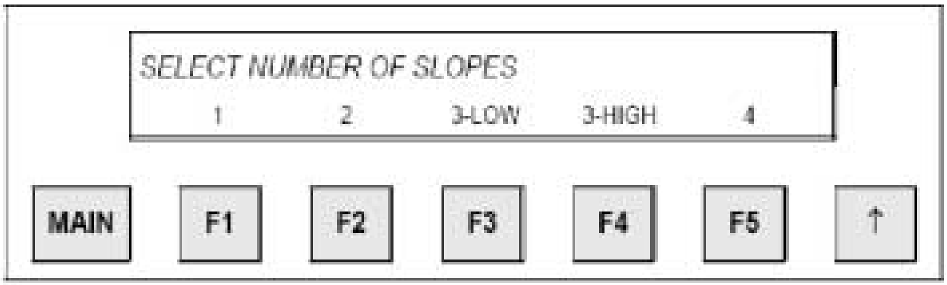


Fig. 72 Sub-menu Program, Insert Calib, part 2

After having selected one of the function keys and programmed a drift criterion, the insertion of the
calibration macro is completed.

Note:
- For the relation between the standard concentration and sample range, refer to the Application Manual.
- Only one calibration macro can be programmed in the reference run.
- In order to obtain accurate slope values, the measured mV values are internally corrected for the measured temperature.

6.3.9 Output parameters

In both the analysis and reference run an output macro can be programmed; this macro is used to direct the result(s) of the executed run to the analog and/or digital outputs and to specify any alarm limits (the calculation formula is described in → *Section 6.5 on page 75*: the Utility const menu).

When programming an output macro, the display shows:

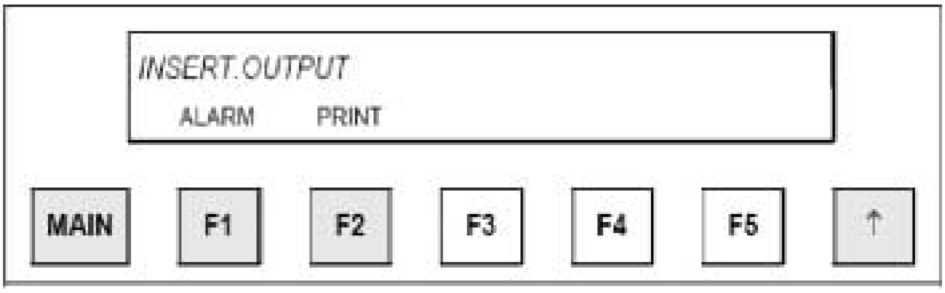


Fig. 73 Sub menu Program, Insert Output, part 1

6.3.9.1 Print option

When function key **F2** PRINT selected, the display shows:

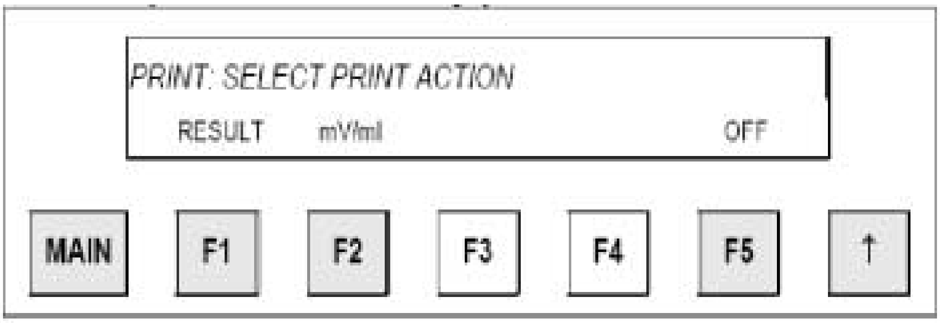


Fig. 74 Sub-menu Program, Insert Output, part 2

With the function keys **F1**, **F2** and **F5** a print action can be selected (do not forget to set the print format and baud rate in the Utility menu).

When **F1** is selected, the obtained result is printed (ion concentration or slope values); when **F2** ml is selected, the result including the measured mV values and dosed standard volume are printed (in the reference run, this option is called mV since in this case the dosed volumes are not stored).

Each print-out page will start with a header; example:

----- LAR - ION Nbr 4 DATE: DEC 08 2008 TIME: 13:39:13 -----
CYCLE TIME RESULT VALUE ERROR EXCEEDING ACTION mV

Per cycle, the result(s) will be printed in columns.

When a reference run is programmed, the mean reference results are printed at the last reference run of the current sequence.

Make sure that the Analyzer and printer are synchronized: reset the analyzer (Utility init reset menu), switch on the printer and set it at the top of the page; after each 66 lines, the analyzer will generate a form feed command.

Note:
- When the serial data interface board is installed and the interface type "computer" or "network" is selected (Utility serial I-face menu), the print action will be omitted since in this case the "host" will request the data.

- The actual printing is executed in a sub-routine (on the background, using a 2 kByte output buffer); the print action will therefore not take more than 1 sec.
- Make sure that the receiving device (printer etc.) is ready to receive data.
- Before executing a diagnostic action, the print-out will present the message *'di-agnostic '*
- If the diagnostic/reference result **is** within limits, the Analyser will return to its normal procedure and the print-out routine of the original run will be completed.
- If the diagnostic/reference result **is not** within limits, the Analyser will generate a processing alarm (PAL-error) and stop.

The display shows: ***'PAL: REFERENCE RESULT ERROR'*.**
The printout: Time SAMPLE-1: 61.039 ppm **TOO HIGH: DIAGNOSTICS**
Time SLOPE: -56.738mV/dec **TOO LOW** : 'the deviation' **PAL**

6.3.9.2 Alarm limits and actions (Analysis)

In the analysis run, the output macro can be used to set alarm limits, to specify which alarm relay should be triggered and to select a diagnostic action.

After pressing function key **F1** in the output-insertion menu, the low and high alarm limit for sample 1 can be entered using the numeric key-board.

Next the display shows:

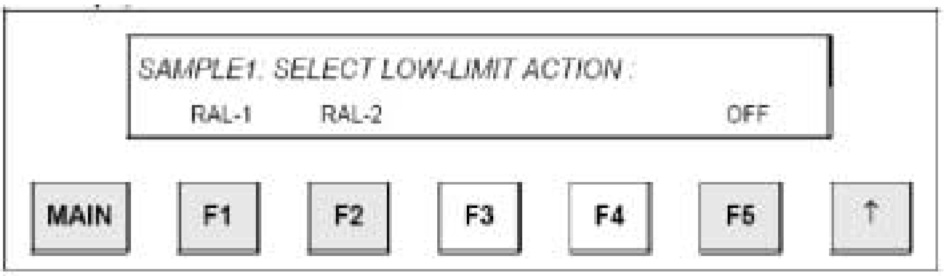


Fig. 75 Sub-menu Program, Insert, RAL, part 1

The low limit alarm action can now be selected.
F1 will switch RAL-relay 1 when the low limit is exceeded.
F2 will switch RAL-relay 2 when the low limit is exceeded.
F5 will cancel any relay action on this alarm limit.
After selecting the action for the low limit, the procedure is repeated for the high limit action.

Finally the display shows you the diagnostics option:

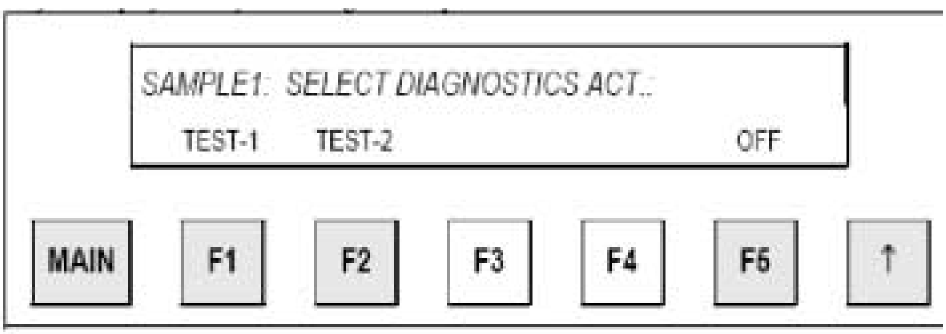


Fig. 76 Sub-menu Program, Insert, RAL, part 2

With **F1** or **F2** one of the diagnostic options can be selected. **F5** will switch off the diagnostic action. When one of the diagnostics is selected, the occurrence of a result alarm will interrupt the analysis run and start the execution of test-1 or test-2.
Before executing a diagnostic action, the print-out will present the message ’diagnostic’
F1 Test-1 will start the diagnostics/reference run; when the result(s) of this run is(are) not exceeding the alarm limits of the diagnostics/reference run, the result of the analysis run and the triggered alarm relays are printed and the normal procedure will be continued.

Note:
- The cycletime is ignored until a ‘normal’ analysis result is found for the same sample.
- When in the diagnostics/reference run also a result alarm is detected (e.g. because of a malfunctioning electrode), a processing alarm is triggered (all processing is cancelled) and the display shows: ’ REFERENCE RESULT ERROR ’ **.**

F2 Test-2 executes both the cleaning and diag./refer. run on occurrence of a result alarm in the analysis run; the results, obtained in the diagnostics/reference run, are handled in the same way as in test-1.
F5 OFF will switch off the diagnostic action; when a result alarm occurs, only the specified RAL relay will be triggered. This RAL relay will be switched back as soon as a result is found within the alarm limits.

When sample stream 2 is also connected, the cycletime is ignored until a ‘normal’ analysis result is found for the same sample, the whole procedure will now be repeated for sample 2. If the second sample stream is not connected, the alarm setting routine can be interrupted with the ↑ key.

When alarm data needs to be updated, use the edit-procedure (see also → *Section 6.3.6 on page 59*); the display will show the following message:

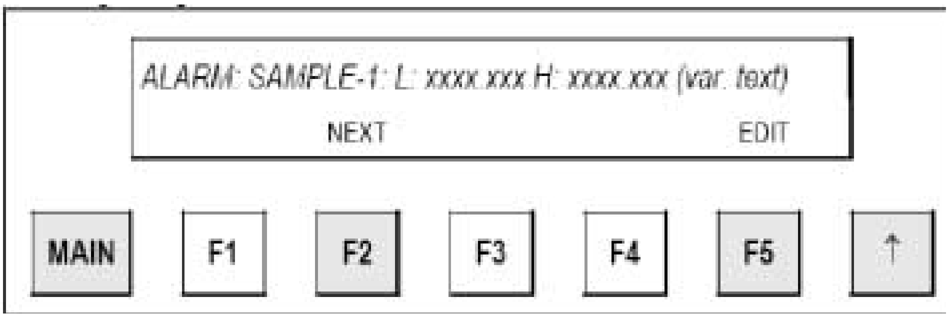


Fig. 77 Sub menu Program, Insert, RAL, part 3

The variable text in the upper display line shows (in a 3 sec. interval):
L: xxxx.xxx H: xxxx.xxx, meaning values of low and high limits,
L.ACT: xxxx H.ACT: xxxx, meaning specified alarm actions,
DIAGNOSTICS ACT. : xxxx, meaning type of diagnostic,

The function key **F2** can be used to recall the alarm data of sample 2.
The function key **F5** can be used to update alarm limits, actions or diagnostics.

Note:
- Execution of a diagnostic action will not interfere with any run selection ratio and the result of the reference run will not be used in the calculation of the next analysis run. However, when a run selection is used, the diagnostic action can be performed only once during one sequence.
- When an alarm limit is exceeded, the programmed cycle time is ignored.

6.3.9.3 Alarm limits (Reference)

For each slope that is specified in the calibration macro, a low and high alarm limit can be set (for negative slope values the low alarm limit is the most negative one).

The insertion procedure of an output macro in the reference run is identical to the one in the analysis run; the display now shows:

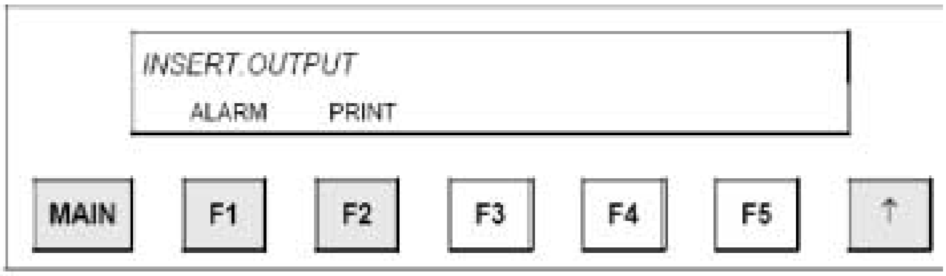


Fig. 78 Sub-menu Program, Insert, Alarm, part 1

After pressing **F1** , the low and high limit for each slope value can be entered, using the numeric key-board.
When the alarm limits are already programmed, pressing **F1** will recall these data:

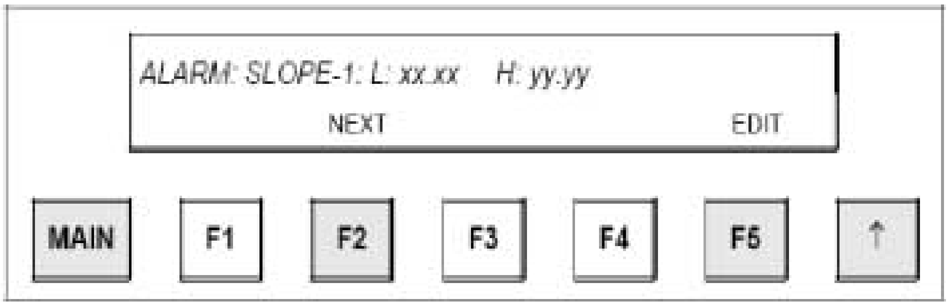


Fig. 79 Sub-menu Program, Insert, Alarm, part 2

Use function key **F2** to recall the alarm limits of other slopes.

Note:
- When (one of) the slope value(s) exceeds the corresponding alarm limit, the processing alarm "reference result error" will be generated and the Analyser will cancel all actions.

6.3.10 Clearing (part of) the program

Select the Program menu and press **F5** CLEAR. The display will now show:

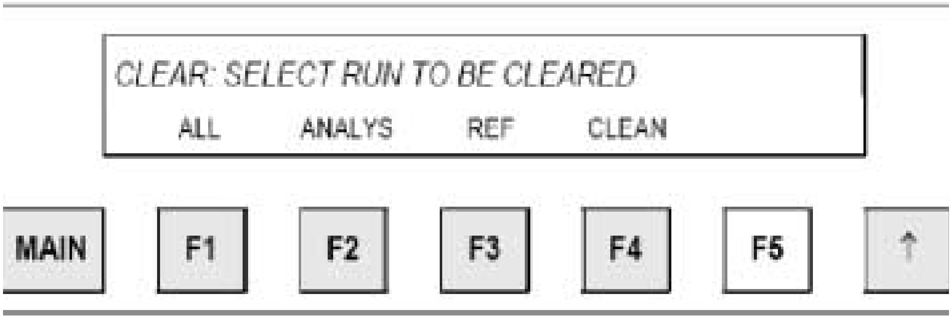


Fig. 80 Sub-menu Program, Clear, part 1

With the function keys **F1** through **F4**, the part of the program can be selected after which the clearing confirmation is required before clearing is executed. If for instance **F4** is pressed, the display shows:

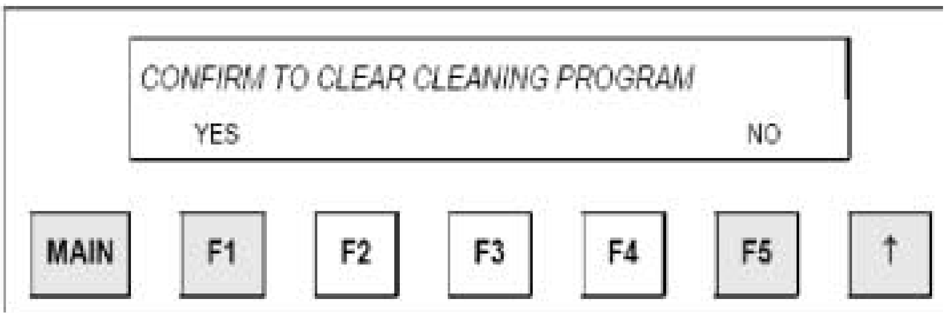


Fig. 81 Sub-menu Program, Clear, part 2

When **F5** is pressed, the Program menu will be presented again in the display. When **F1** is pressed, the clearing will be executed.

Note:
- If only one or more macros need to be deleted from a run, this can be done in the edit menu, → *Section 6.3.7 on page 61*. When **F1** ALL is selected, the constant-setting is also cleared.

6.4 Running

6.4.1 Run menu status

When the Run menu is selected from the Main menu (press **F1** in the Main menu), the run status is displayed. If no previous run (after power-up) was executed, the display shows:

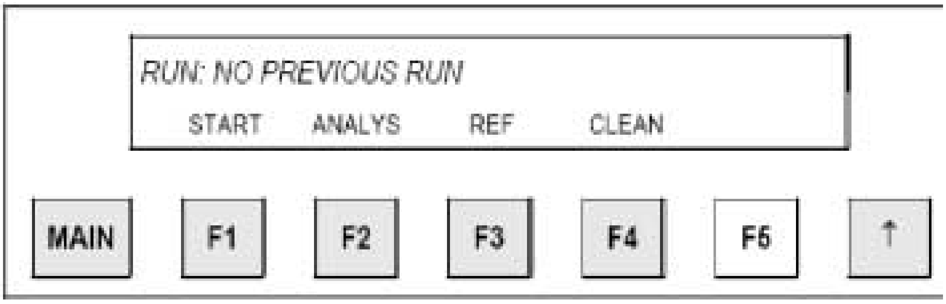


Fig. 82 Main menu Run, part 1

The upper display line can present 4 other status messages, like:

1) ***'RUN: RUN STOPPED, CYCLE COUNT: xxxxx '***
This message means that the Analyser is stopped manually, the function key **F5** can be used to continue.
2) ***'RUN: CYCLE-LIMIT REACHED xxxxx '***
The programmed number of cycles is executed, the Analyser can be started again according to the normal procedure.
3) ' ***RUN: RUN ABORTED BY EMERGENCY-STOP '***
The Analyser is interrupted by a manual or remote Emergency Stop. The function key **F5** can now be used as a option, see section 4.3 .
4) ' ***RUN: RUN ABORTED BY PROCESSING-ALARM*** '
The Analyser is interrupted by a processing alarm. Like in the previous case, function key **F5** can be used as a option.

The Analyser can now be started with the function **F1** through **F4**.
F1 START will start the execution of the programmed sequence of cleaning, reference and analysis runs (run ratio, see → *Section 6.3 on page 52*).
F2 ANALYS is used to start the execution of one or more analysis runs.
F3 REF is used to start the execution of one or more reference runs.
F4 CLEAN is used to start the execution of one or more cleaning runs.

When one of the function keys is selected to start a run or a run selection ratio (sequence of runs), the display will ask you to enter the maximum number of cycles to be executed (each type on run has its own cycle limit):

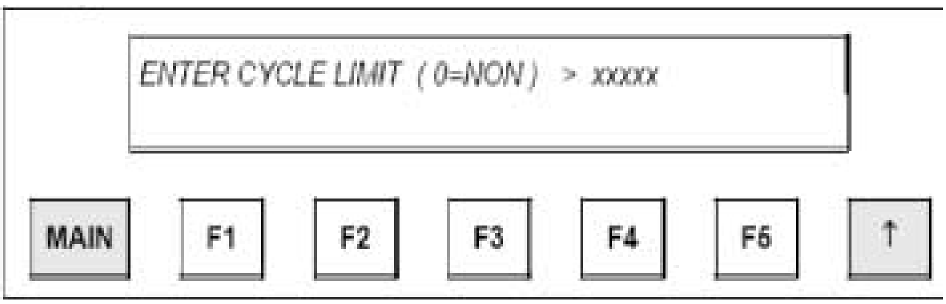


Fig. 83 Main menu Run, part 2

The value xxxxx is the default or previously entered value. If no cycle limit is required, enter the value 0 on the numeric keyboard.

As soon as the cycle limit is entered, the selected (sequence of) run(s) will be executed for the programmed number of cycles.

6.4.2 Display during running

The upper display line will now show the actual running information:

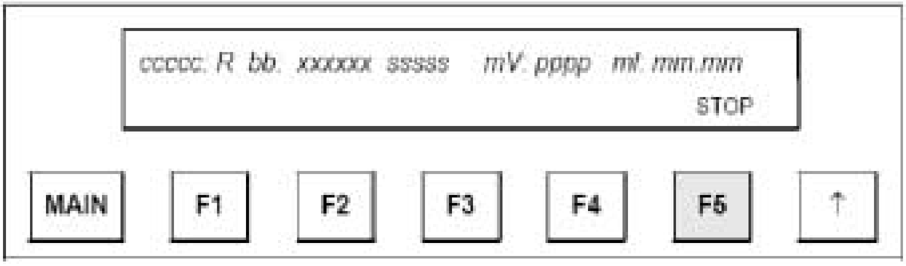


Fig. 84 Main menu Run, part 3

Table 5 Running information

Where	Meaning
ccccc	**Current cycle number**
R	**Run type: A1 = analysis run, sample 1** **A2 = analysis run, sample 2** **R = reference run (blinking in diagnostic action)** **C = cleaning run (blinking in diagnostic action)**
bb	**Macro number**
xxxxxx	**Actual macro type (→ *Section 6.3.6 on page 59*)**
sssss	**Number of seconds to go in this macro, or that this macro is active**
pppp	**Measured mV value (only during measure/calibration)**
mm.mm	**Added amount of standard (measure, calibrate and buret macro)**

6.4.3 Stopping a run

When the Analyser is running, it can only be interrupted in 2 ways:

1) F5:
When F5 (STOP) is pressed (STOP display will now be blinking), the current cycle will be completed, after which the Analyser will stop, displaying the Run menu. Function key **F5** has the CONTfunction.

2) E-STOP:
A run is interrupted immediately when the red EMERGENCY STOP is pressed. In this case all processing is cancelled and the PAL-relay is triggered. If there is no other problem like leakage; use the **MAIN** to reset this PAL status.

ATTENTION:
The MAIN key will reset any software-alarm, it is strongly recommended that the cause of an alarm is solved before proceeding.

6.4.4 View option

When a processing alarm (PAL) has occurred (for some reason a macro could not be completed), the option (**F5**) can be used to obtain additional information about the type of PAL and the moment of occurrence.
The PAL status can be reset by pressing the **MAIN**
Select the Run menu (press **F1** RUN); The upper display line will show:

’ RUN: RUN ABORTED BY PROCESSING ALARM ’

When **F5** VIEW pressed, the type of processing alarm will be presented, e.g.:

’ PAL: MEASUREMENT TIME-OUT ’

When **F5** VIEW pressed again, the moment of the processing alarm occurrence (the cycle nr., macro nr. and time to go) will be displayed.
When **F5** VIEW pressed for the third time, you will return to the run status menu.

6.4.5 Power failure indication

In case of a power failure during running, this will be indicated in the following manner:
When the power supply is back to normal, the Analyzer will generate the processing alarm:

’ POWER FAILURE OCCURRED ’ (after checksum testing).

If there is no other problem like liquid leakage, use the **MAIN** to reset this processing alarm.
Now the view option can be used to recall additional information.

6.4.6 PAL messages

Table 6 Overview PAL messages

Description	Meaning
EMERGENCY STOP OCCURRED	A manual, serial or remote **EMERGENCY STOP** command is given.
BURETTE VALVE FAILURE	The burette valve is not in the correct position within 5 sec. after the burette valve was activated.
BURETTE END LIMIT REACHED	The piston of the burette is in highest position while a DOSE was executed. Program might be incorrect.
BURETTE TIME OUT	The burette action could not be completed within the allowed time interval. The burette drive might have failed.

Table 6 Overview PAL messages

Description	Meaning
LEAK DETECTED	The Leak Detection input is active during more then 1 second
ANALYSIS TIME-OUT	The MEASR macro could not be completed within the programmed time interval. Verify the electrode stability and the measurement parameters.
MEASURE INPUT NOT AVAILABLE	No mV/pH sensor card found.
CALIBRATION TIME OUT	The CALIB macro could not be completed within the programmed time interval; verify the electrode stability and the calibration parameters.
SAMPLE OUT-OF-RANGE	The MEASR-macro detects that the concentration of the sample is higher than the concentration of the standard and the programmed action for this is PAL. Is the slope factor is properly set ? (see utility chapter)
ARITHMETIC FATAL ERROR	*A*n internal arithmetic error has occurred. Carry out an EPROM (checksum) and RAM test (see Utility menu). Verify the constant settings in the Utility menu. Any division by zero?
REFERENCE RESULT ERROR	The reference run has found a result outside the specified alarm limits (output macro).
PRINTER TIME-OUT	The Analyser can not send its information to the printer; verify if the printer is on-line.
POWER FAILURE OCCURRED	The power supply has been interrupted while the analyser was running.
ALL RUN-SELECT RATIOS ZERO	All run select ratios are zero while the RUN-START command is entered. Program the run ratios (→ *Section 6.3.2 on page 53*).
NO ANALYSIS PROGRAM	The analysis run is started while it does not exist.
NO REFERENCE PROGRAM	The reference run is started while it does not exist.
NO CLEANING PROGRAM	The cleaning run is started while it does not exist.
ALL SAMPLE-SELECTS ZERO	At the start of the ANALYSIS program are the Selection Ratio's for both Sample-Streams zero.
ILLEGAL CONSTANTS VALUES	At least one of the constants has an illegal value (like 0)

When a processing alarm is generated, the lower display line will automatically show the Main menu, while the in the right hand corner of the upper display line the word *' *** **PAL** *** '* is blinking.

6.5 Utilities

6.5.1 Utility menu

The Utility menu contains a number of settings that are not a part of the programmed runs, but are essential for the proper functioning of the Analyzer. This menu consists of 4 parts, all on the same level. The Utility menu can be selected from the Main menu by pressing **F4** . The display will show the first part of this menu (see → *Section 6.5.2 on page 76* for detailed information):

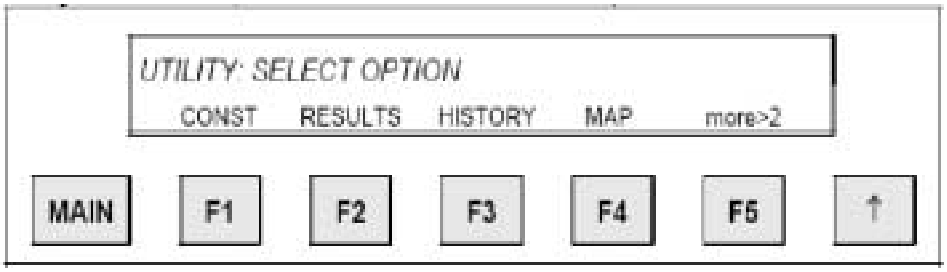


Fig. 85 Main menu Utility, part 1

When **F5** is pressed, the second part will be displayed (→ *Section 6.5.3 on page 79* for detailed information):

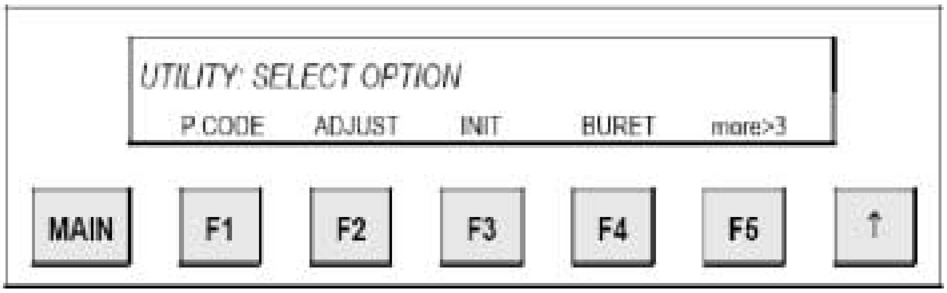


Fig. 86 Main menu Utility, part 2

Use **F5** again to reach part 3 (→ *Section 6.5.4 on page 81* for detailed information):

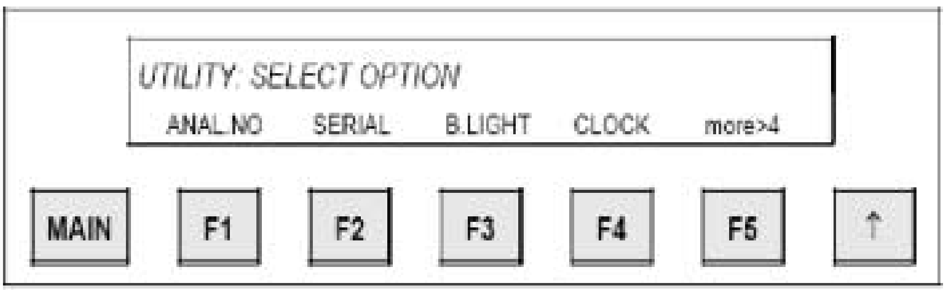


Fig. 87 Main menu Utility, part 3

And finally part 4 will be displayed after pressing **F5** (→ *Section 6.5.5 on page 84* for detailed information):

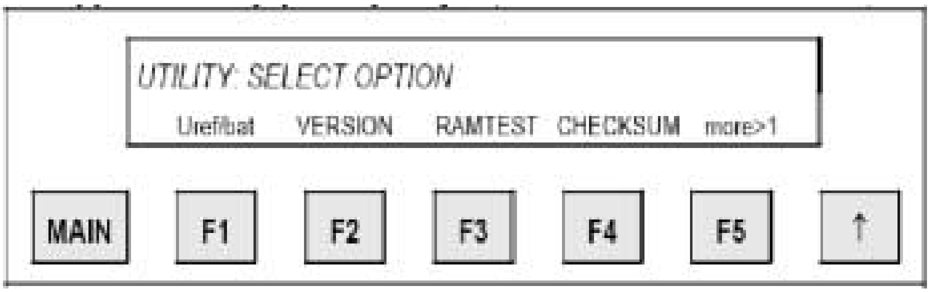


Fig. 88 Main menu Utility, part 4

6.5.2 Utility part 1

6.5.2.1 Constants

F1 CONST the possibility to set or edit the values of the five constants that are needed to calculate the analysis result.

INITIAL VALUE OF THE CONSTANTS
When the constants have no value yet (never have been set or after initiation of the EPROM), the values are requested in the following sequence:

- Sample volume (ml),
- Buffer volume (ml),
- Conc. of standard (This constant is the concentration of the undiluted standard solution, normally same engineering unit as the sample concentration),
- Slope factor (is used to specify the valency and type of ion).
- Engineering factor (is used to convert the analysis result to another Engineering Unit)

Finally the Engineering Unit can be selected (none, mol/l, mmol/l, g/l;mg/l , micro g/l, ppm , ppb and %).

EDITING CONSTANTS
When the constants are already set but need to be edited, pressing F1 present the next display:

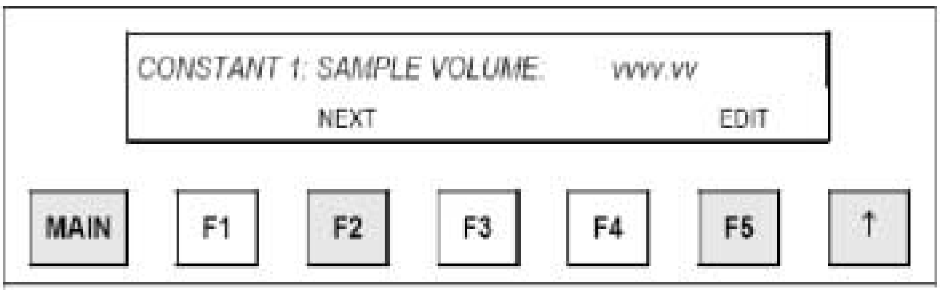


Fig. 89 Main menu Utility, Constant

After pressing **F2** once, **F1** will have the function .
Use **F2** or **F1** to select the constant number to be edited and use **F5** to update the value (use numeric key-board to enter the new value).

Note:
- The sample and buffer volumes are factory set to the values that are listed in the application description; these volumes can be verified by weighing.
- The analysis result is calculated according to the following formula:

$$\text{Analysis result} = \frac{D_f \cdot C_a \cdot E_f}{\frac{V_0 + V_a}{V_a} \cdot 10^{\frac{\Delta E}{S}} - \frac{V_0}{V_a}}$$

Fig. 90 Calculation of Analysis result

where:
Df = Dilution factor ({Volume of sample + buffer}/ Volume of sample) = ({C1 + C2} / C1),
Ca = Concentration of the standard (C3, mg/ l),
Ef = Engineering factor, can be used to present the result in a different dimension (C4).
Vo = Volume of sample + buffer (C1 + C2, ml),
Va = Volume of standard addition (calculated by the Ion-Analyzer, ml),
ΔE = Potential change, caused by standard addition (analysis run, mV),
S = Slope of the electrode (reference run, mV/decade).

6.5.2.2 Results

F2 RESULTS be used to recall the results from previous analyses and reference runs. After pressing this function key, the display shows:

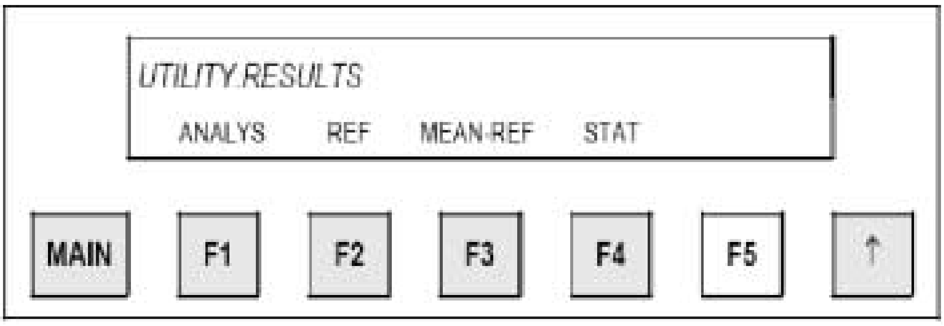


Fig. 91 Main menu Utility, Results

F1 ANALYS the results of the former analysis (sample 1/2, together with any triggered result alarm and alarm action). Use the function keys toggle between sample 1 and 2. When a recalled result is not present, the display will show: *' ? NO DATA ? '* .

F2 REF the results of the former reference run (slope values of each concentration range, together with any occurred alarm and alarm action). Use the function keys scroll through the available reference results.
When a recalled result is not present, the display will show:*' ? NO DATA ? ' .*

F3 MEAN-REF the mean results of former reference runs executed in one sequence (see section 3.2); when the reference ratio is set to 1, the reference results are identical to the mean reference results.
The "mean-ref" values for the different concentration ranges are used to calculate the final result ("S" in the equation on the previous page).
An obtained "mean-ref" value will exist until it is replaced by a new one or until in this menu **F3** () is pressed; in the latter case, the mean value of the slope will be reset to the "Nernst potential divided by the valency of the ion" at 20 °C (default value).

F4 STAT the statistics-option regarding the "History" (→ *Section 6.5.2.3 on page 78*).
This menu presents the average result of sample 1/2 together with the standard deviation and the number of present results. The function keys and toggle between sample 1 and 2.
When the "History" is initiated (cleared), the average and standard deviation are not available.

6.5.2.3 History

F3 HISTORY used to recall previous results from the "data base" of the Analyzer. 250 analysis results can be stored based on the principle "first-in-first-out".
When the History is recalled, the display presents:

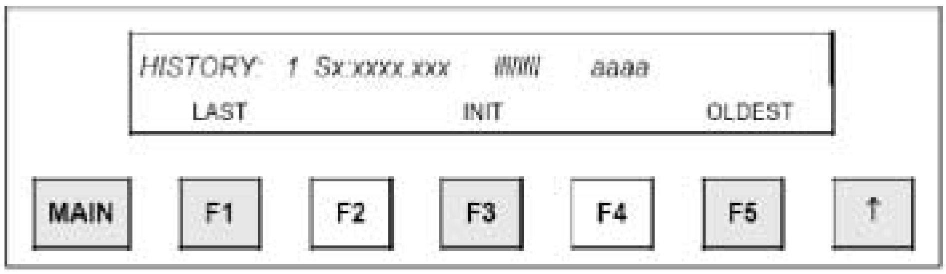


Fig. 92 Main menu Utility, History, part 1

When entering the History, the newest result (number 1) will be presented; this may be the result of sample 1 or 2. *IIIIIIII* presents any exceeded alarm limit, aaaa presents any related action.
When **F1** is pressed, the former History result is presented:

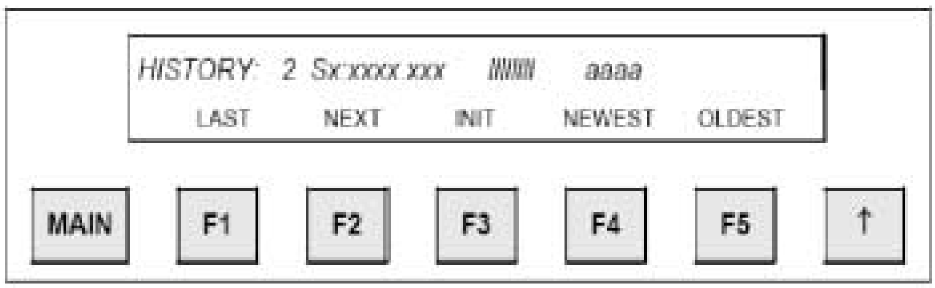


Fig. 93 Main menu Utility, History, part 2

Using the function keys **F1** and **F2** you can scroll through all history results. When reaching the last history result, **F1** looses its function.

Using the function keys **F4** and **F5** you can jump to one one the extremes in the list.

Pressing **F4** will return to the previous display. After pressing **F4** , this key will loose its function.

Using the function key **F3** , the contents of the data base can be deleted (cleared). This option has no special security, so when the Analyzer is logged-in, anyone may do so.

6.5.2.4 Map

F4 MAP used to assign an analog 0/4 - 20 mA output to either an analysis result or an input signal (active during measuring/calibr. and manual recalling of input signal); available input signals: mV-value of the ISE, temperature-value of Pt-100 (if installed) and the reference value of the A/D-converter (→ *Section 6.5.5.1 on page 84*).

The map menu presents:

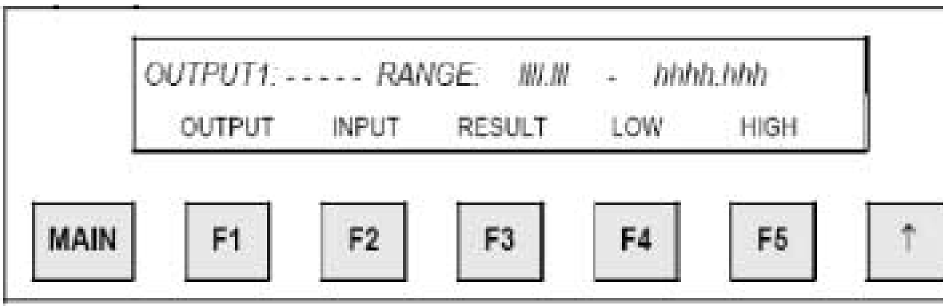


Fig. 94 Main menu Utility, Map, part 1

F1 OUTPUT used to specify the output nbr. (toggles between nbr. 1 and 2).

F2 INPUT the output to one of the inputs (mV, temp. and Uref.); by pressing this function key more than once, you scroll to the list of available inputs (- - - - - means "no input").

F3 RESULT the output to the result of one of the 2 sample streams; next the sample number is requested. Use the numeric key-board to specify it. Mapping of the results take place during the execution of the OUTPUT macro

F4 LOW used to set the low range (value that should correspond with 0/4 mA).

F5 HIGH used to set the high range (value that should correspond with 20 mA).

The low and high range of the output must be entered on the numeric key-board and specified in the
engineering units of the recorded value.
When analog output 1/2 is not installed, the message *' OUTPUTX: NOT AVAILABLE '* displayed.

Note:
- When an input is mapped, the output will be active when the input is measured in the Manual input menu or during execution of a MEASURE or CALIB macro.

6.5.3 Utility part 2

The second utility part offers the following possibilities:

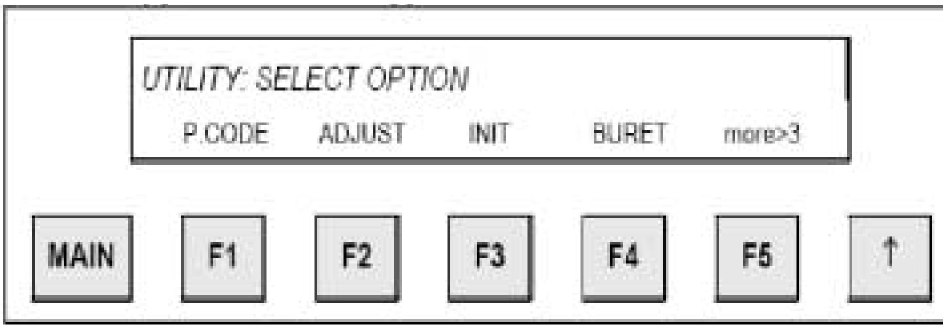


Fig. 95 Main menu Utility, Map, part 2

6.5.3.1 Passcode

F1 P.CODE be used to protect the Analyzer program and Utility settings against changes by unauthorized personnel. The default value of the pass-code = 0 and the status is "logged-in".

A new pass-code can be entered by
- first entering the old pass-code,
- enter a new number of max. 4 numbers, this will be displayed as *

In the Main menu, you can use this new pass-code to LOGOUT **F5.** this "logged-out" status, not everything can be changed anymore. When during updating the pass-code the wrong "old pass-code" is entered, the display will show ’ WRONG PASSCODE ENTERED ’ and Utility menu will be presented on the lower display line. The pass-code will be reset to its default value after replacing the firmware EPROM.

Note:
- The constant setting is NOT protected in the "logout-mode".
- The pass code is not reset by initiating the controller board (F3).

6.5.3.2 Adjust pace

F2 ADJUST the opportunity to slow down the reaction of the analog outputs after an update by an output macro. If the adjust pace is set to 0, the analog output will accept a new result immediately (stepwise changes on the recording unit). When these steps need to be modified in more smooth changes, the adjust pace can be set to a value of 1 **-** 100 (use edit key **F5** enter the new value). The analog output signal will now be updated completely after:

$$T = \text{adjust pace} \times \text{signal change (in \%)} \times 0.050 \text{ sec.}$$

Example:

Adjust pace = 20 ; signal change (difference between previous and actual value) = 15%

In this case it will take 20 x 15 x 0.050 = 15 sec before the output signal reaches the new value.

This adjust pace is only valid when the output is assigned to the result; when the output is assigned to an input, the actual measured signal is directed immediately to the analog output.

6.5.3.3 Initialize

F3 INIT be used to initiate the Analyzer (only when you are "logged-in"). When this key is pressed, you can select **F1** ALL **F2** RESET.

When **F1** selected, first you need to enter the pass-code since this is action will clear all settings, including the programs.

When **F2** selected, all internal software counters (like cycle counters and the number of lines printed since the last form feed) are reset; this action can be compared with switching on the power again. This function can be used to synchronize the Analyzer and printing device. (→ *Section 2 on page 11*, Print operation)

6.5.3.4 Burette settings

F4 BURET be used to specify the cylinder volume and refilling speed of the (optional) burette. When this key is pressed, the display shows the cylinder size (default = 2 ml) and the burette refilling speed (default = 1).

Now with:

F1 SIZE: cylinder size can be selected (select the new size with one of the function keys).

F2 SPEED: burette refilling and recycling speed can be updated. The speed can be set from 1 (highest speed) to 100 (highest speed / 100). In case of a viscous solution, a lower actual speed can be chosen by making the speed value larger. For a 2 and 10 ml Burette the highest refilling speed is 1, for the 20 ml Burette 2 and for the 50 ml cylinder 3.

F3 REC.VOL: recycle volume in ml can be set. Usually 2 ml is sufficient for every burette size.

For explanation of this volume, see HARDWARE & INSTALLATION part of the manual.

6.5.4 Utility part 3

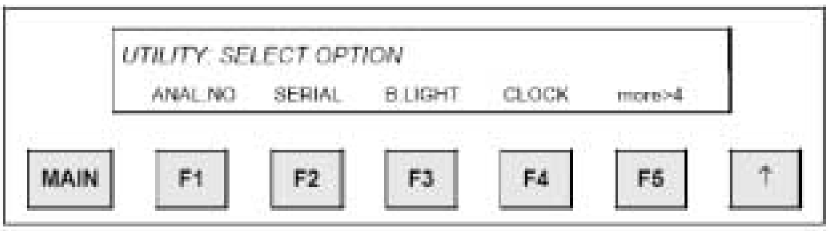


Fig. 96 Main menu Utility, Map, part 3

6.5.4.1 Analyser number

F1 ANAL.NO be used to give each Analyser an individual number between 0 and 99. This option is especially useful when the Analyser is connected to a host computer, using serial network communication.
When the analyser number is > 0 (default = 0), it will also be presented at every print-out. After pressing this key, select **F5** EDIT enter the analyser number.

Note:
- The (communication) node number is the anal.no.

6.5.4.2 Serial interface settings

The serial-interface option NETWORK is not functional.

F2 SERIAL used to set the format/data rate and selection of interface-type for printer or computer connection.

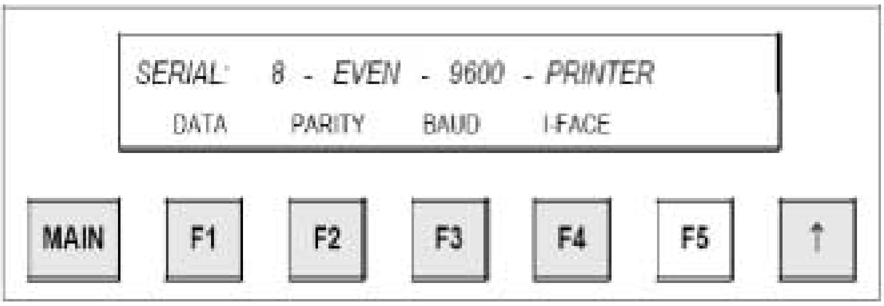


Fig. 97 Main menu Utility, Serial, part 1

In this serial menu, the function keys **F1** - **F4** are used to select the number of data-bits **F1**, parity **F2**, baud-rate **F3**, and the type of serial-interface **F4**. When a function key is pressed, the lower display line shows the possible options that can be selected by use of the function keys. The (hidden) default setting of stop-bits is 1.

Note:
- When "computer" or "network" is selected in the interface menu, the print option in the Manual menu will disappear and print commands in the output macro during running will not be performed. The checksum for serial communication can be set on or off.
- To receive the micro character in microgram/litre the number of data-bits must be 8.

Unlock the communication (after power failure with empty back-up battery or firmware-update)
- Press **F4** (the type of serial-interface), the display shows:

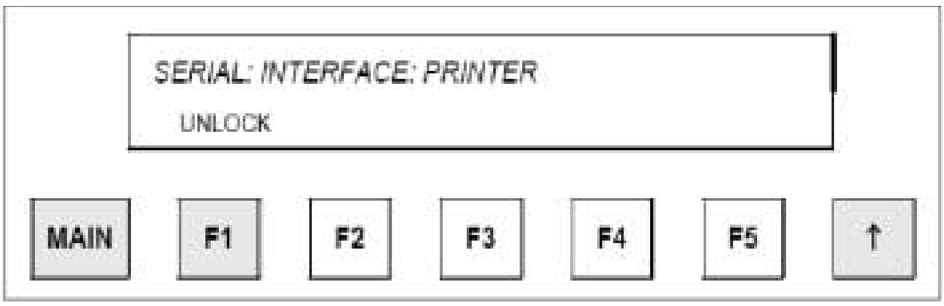


Fig. 98 Main menu Utility, Serial, part 2

- Press **F1** and enter the digits of the following code: 45502
- Disconnect the analyzer from the mains power supply for several seconds,
- Go to the Utility serial menu and press **F4** ACE , the display shows:

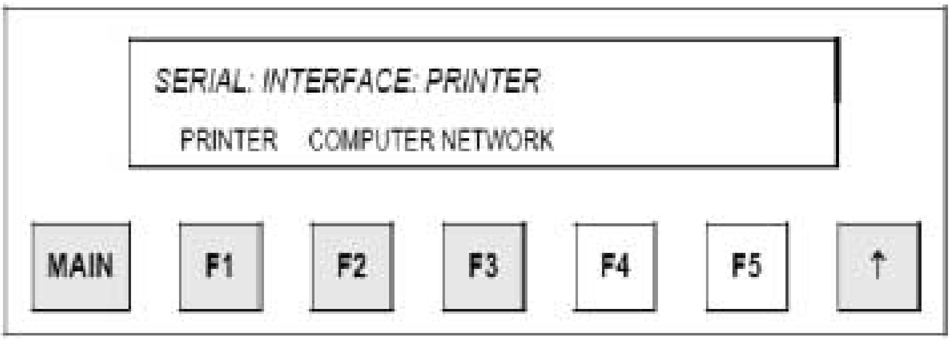


Fig. 99 Main menu Utility, Serial, part 3

6.5.4.3 Backlight

F3 B.LIGHT can be used to switch the display back-light ON or OFF. The default setting is ON. When this key is pressed, the function key F5 can be used to switch it OFF or function key F1 can be used to switch it ON.

6.5.4.4 Clock

F4 CLOCK used to set and/or recall the Real-time-clock. This clock has a battery-backup, so it will
not be interrupted by switching-off the power of the Analyzer.
After selecting, the display shows:

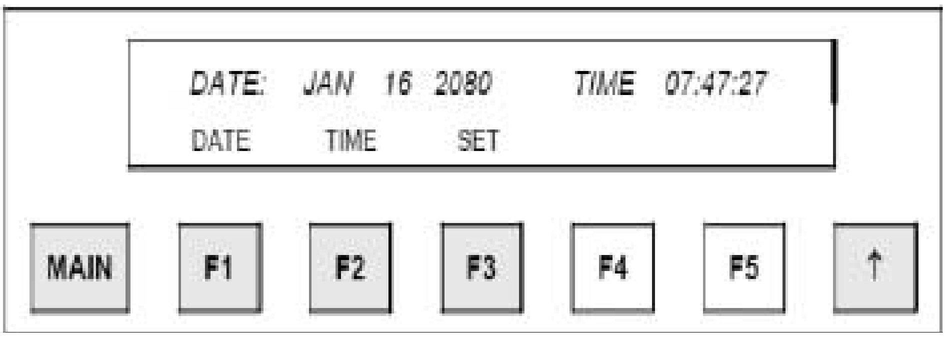


Fig. 100 Main menu Utility, Clock, part 1

F1 DATE be used to change the date.

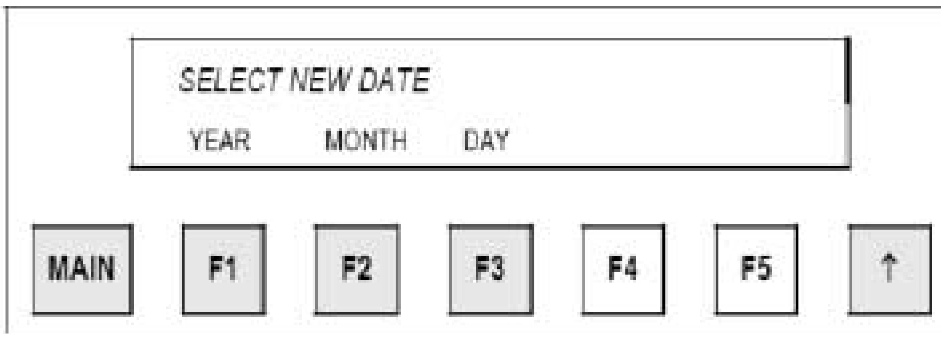


Fig. 101 Main menu Utility, Clock, part 2

Function keys **F1 - F3** must be used to select the part of the date, the new value can be entered.
F2 TIME can be used to update the time.

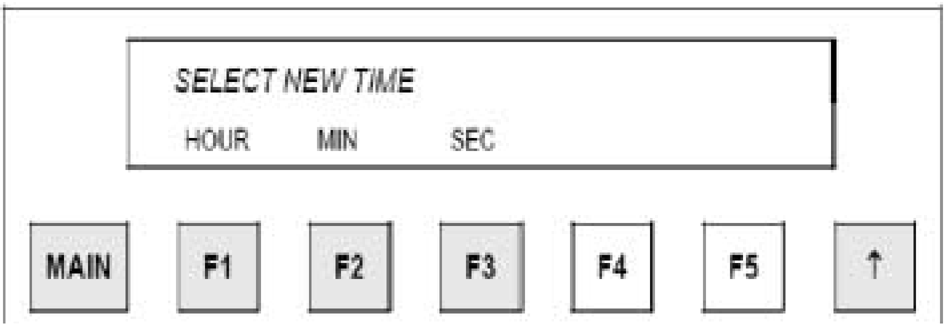


Fig. 102 Main menu Utility, Clock, part 3

Function keys **F1 - F3** must be used to select the part of the time, the new value can be entered.

F3 SET When a new time or date is set, the clock is stopped; press **F3** SET in the Utility clock menu to start counting of the clock.

6.5.5 Utility part 4

The fourth part of the Utility menu contains test functions.

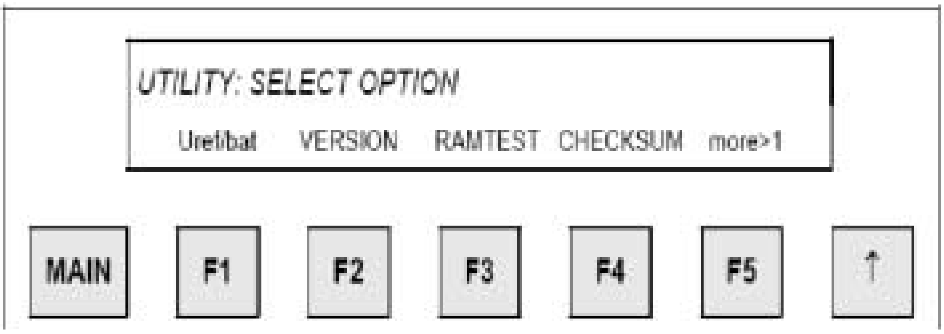


Fig. 103 Main menu Utility, Select Option, part 1

6.5.5.1 Reference/battery voltage

F1 Uref/bat both the reference potential that is used to calibrate the A/D-conversion of the input signal and the battery-level. When this key is pressed, the display will show:

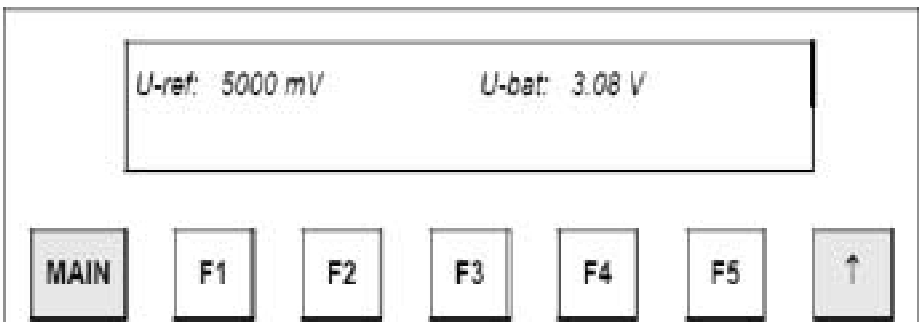


Fig. 104 Main menu Utility, part 2

When the reference value exceeds the range between 4998 and 5002 mV, it will be blinking. This deviation from 5000 mV can be caused by a malfunction in the A/D Conversion circuitry. The battery-level should be above 2.9 V. When under 2.8 Volt, the end of the battery lifetime is reached (last 5 %).

Note:
- Different kind of user data are stored in the memory chips of the Controller Board, like configuration settings, time programs, results and option settings. If the power supply is turned off, these data will still be stored, for the memory chips are battery powered when the power supply is turned off. The battery will discharge when the analyser is turned off.

Check the voltage regularly.

If the battery is low and the main power is shutdown the programs and settings are lost. When the battery-level is too low (value is blinking), the Analyser has probably been switched-off for a long period; replace the battery. The discharge time of a battery is approx. 1 year, i.e. if the analyser is not powered.

6.5.5.2 Software version

F2 VERSION be used to recall the loaded software version.

6.5.5.3 Ramtest

F3 RAMTEST used to execute a RAM-test. The RAM contains the user program. When this key is pressed, the test is performed.

If the RAM is found OK, the display shows: *'UTILITY.RAMTEST: PASSED: FFFF'* (FFFF = final RAM address).

If the RAM fails, he display shows: *'UTILITY.RAMTEST: FAILED: xxxx'* (xxxx = failing RAM address) call the nearest service office for RAM-replacement.

6.5.5.4 Checksum

F4 CHECKSUM used to test the EPROM. The EPROM contains the analyzer software. When this key is pressed, the test is performed; the calculated checksum is compared with the programmed one.

If the EPROM is found OK, the display shows: *'UTILITY.CHECKSUM: PASSED: cccc'* (cccc = calculated checksum).

If the EPROM fails, the display shows: *'UTILITY.CHECKSUM: FAILED: cccc'* call the nearest service office for EPROM-replacement.

7 Application Part

7.1 Analysis

Method:
The AMMONITOR Ion Analyzer uses a Ammonia Ion Selective Electrode for quick. Simple and accurate analysis of small amounts of Ammonia.

Reagents:
It is advisable to clean all containers with diluted (0.1 M) Hydrochloric acid solution. For maximum accuracy the reagents should be degassed and kept at ***constant temperature.***

Reagent–A TISAB Buffer solution:
Dissolve approx. 100 g Sodium hydroxide (NaOH) and 18.6 g Disodium– EDTA ($C_{10}H_{14}N_2Na_2O_8 \cdot 2H_2O$) in 400 ml deionized water. Add deionized water up to 1 L.

Note:
The EDTA is added to prevent precipitation of metals as their hydroxides, if there is a high concentration of metals or the water hardness is very high, the EDTA concentration can be increased.

This solution is stable for at least 4 weeks.

Ammonia Standard solution:
The concentration of the standard solution must be 10 times higher than the required measuring range.

For example: a ammonia standard of 100 mg/l N-NH_4 will lead to a calibrated range of 0 – 10.0 mg/l N-NH4 .

Dissolve 0.382 g ammonium chloride (NH_4Cl) in 400 ml deionized water, using a volumetric flask of 1 l. Fill up to the mark grade with deionized water.

For example: a ammonia standard of 50 mg/l N-NH_4 will lead to a calibrated range of 0 – 5.0 mg/l N-NH_4 .

Dissolve 0.191 g ammonium chloride (NH_4Cl) in 400 ml deionized water, using a volumetric flask of 1 l. Fill up to the mark grade with deionized water.

This solution is stable for at least 4 weeks.

Blank / rinse water:
Use deionized water for calibration (reference run) and rinse purposes.

Note:
- For preparation of the described reagents: use analytical grade chemicals.

7.2 Program description

For the determination of ammonia concentration, at least 2 time programs have to be set: a reference program and an analysis program. Frequently, a cleaning program will be activated to recycle the burette.

The first time program – the reference time program – will perform slope determination using a suitable ammonium chloride standardsolution. The Analyzer is calibrated by performing three (3) measurements on five (5) different standardsolutions with the following concentrations; 1 %, 3 %, 10 %, 31 %, 100 % of the maximum mea suring range. Calibration is performed by sequential additions of known concentrated standardsolution to a blank solution. Additions are made using a precision burette.
After each addition the mV and temperature are measured. A maximum of 4 slopes can be determined over times higher than the required range.

The ammonia standard burette is refilled and the sampling device is flushed until fresh blank solution (deionized water) is obtained. During the flush action old blank or sample solution will be removed from the tubing between the sampling device and the analysis vessel. The analysis vessel is drained and rinsed several times with deionized water. The total content of the sampling device is transferred to the analysis vessel (see Note 2).

Approximately 1 ml TISAB solution (BUFFER) is added. After respecting a stirring period of approx. 15 seconds, the first standardvolume dosage ammonium chloride - equal to 0.1 % of the sample volume – is added accurately with the use of a burette. For the determination of 4 slopes, 5 additions of standardsolution are needed. Wait a short time for the electrode to respond, before performing measurement. The measure ment is done until the signal is within the set drift criterion. The last measured poten tial value is stored. After all addition of standard, calculation of the slope values are done by dividing the measured potential differences with the corresponding ammonia concentration increases. Also the correcting factor – to be used when estimating the signal of the second addition in the procedure – are calculated. Finally, the calibrated slopes are stored in memory.

The electrode is calibrated daily using the reference program in order to correct for any loss of sensitivity due to pollution or aging.

After activation of the analysis time program, the standard burette is refilled and the sampling device is flushed for a pre-set time of 60 seconds to obtain fresh sample solution (see Note 1). Meanwhile, old sample solution is removed from the tubing between the analysis vessel and the sampling device.

The analysis vessel is drained and rinsed several times with deionized water. The content of the sampling device is transferred to the analysis vessel (see Note 2) and approx. 1 ml TISAB solution is added. After the drift criterion is met, the initial potential is measured. Now the proper addition of volume has to be added, using a burette.

In order to find the proper volume, a tryout volume is dosed which would be the proper addition volume when the concentration of the sample would be the same as the lowest point of the calibration range; 0.1 % of the Standardconcentration. This tryout volume will be 0.316 % of the sample volume being half a decade. When the signal is stable according to the drift criterion, again the electrode potential is measured. The difference between the initial and the “tryout” potential is now evaluated to determine the range, which is compared with the concentration of the sample.

When an indication is available, an addition can be selected so that the eventual poten tial difference after the addition will be approx. - 59 mV / decade at 20 °C.

By frequently performing the cleaning program, possible left or formed air bubbles will be removed (recycle): a fixed – free programmable – small amount of the burette solution is pushed back to the reagent container. Beside recycling of the burette, additional cleaning can be performed with a suitable solution to remove possible formed precipitation. It is recommendable to recycle the burette – Clean Program – before performing the calibration of the electrode (reference program).

The expressed result is given as mg/l N-NH_4 . If the results are required as a different unit, the engineering factor should be adjusted. This factor can be found from the

MAIN menu by selecting **UTILITY – CONST.**

Note:
1.The default-preset time of 60 seconds should be adapted after installation in order to get optimal analysis results. The required time should be long enough to flush 3 – 5 times the volume of the sample lines with fresh sample solution.

2.In case a sample loop is used as sampling device, the total amount of sample solution is transferred to the analysis vessel with deionized water as carrier.

3.The above mentioned amounts dosed after sampling, are of interest when total volume of sample solution, reagents and dilution water – present in the analysis vessel – is equal to approximately 10 ml. If the amount of sample increases or if due to requested dilution of the sample solution the content of dilution water increases , the volume of reagent solutions also have to be increased.

7.3 Maintenance

*I*n general, the best way of keeping electrodes in good shape is to use two identical sets of electrodes, and to exchange them regularly (e.g. every week). One set can be cleaned and reconditioned, while the other set is installed in the Analyzer. Clean and/ or recondition the electrodes according to the instructions, supplied in the electrode box.

For general information about maintenance please refer to the User Manual of the Analyzer, part “Basic Maintenance”.

7.4 Example Time Program

The following program can be used to perform the ammonia analysis: it may be necessary to change the activation time of the different valves and/ or pumps.

Program Listing

RUN SELECT RATIO - ANALYSIS : 48
– REFERENCE : 3
– CLEANING : 1
–
– CYCLE-TIME : 30 min
–
SAMPLE SELECT RATIOS - SAMPLE – 1 : 1

STIRRED SPEED : 30 %

Table 7 Program - Analysis Run

Macro	Action	Time/ Parameters
1	DRAIN	PERIOD: 20 sec
2	FLUSH	PERIOD: 40 sec FLUSH-TIME: 20 sec PIPET-TIME: 20 sec
3	SAMPLE	PERIOD: 20 sec
4	DRAIN	PERIOD: 20 sec
5	SAMPLE	PERIOD: 20 sec
6	DRAIN	PERIOD: 20 sec
7	SAMPLE	PERIOD: 45 sec SAMPLE-TIME: 20 sec PIPET-TIME: 20 sec
8	BUFFER	PERIOD: 11 sec
9	WAIT	PERIOD: 40 sec STIRRED ACTION: ON
10	MEASURE	PERIOD: 1000_sec DRIFT: 0.5 mV/ 5 sec SAMPLE OUT OF RANGE ACTION: RAL
11	OUTPUT	RESULT PRINT-OUT: OFF ALARMS: NOT USED

Table 8 Program - Reference Run

Macro	Action	Time/ Parameters
1	DRAIN	PERIOD: 20 sec
2	FLUSH	PERIOD: 40 sec FLUSH-TIME: 20 sec PIPET-TIME: 20 sec
3	BLANK	PERIOD: 20 sec
4	DRAIN	PERIOD: 20 sec
5	BLANK	PERIOD: 20 sec
6	DRAIN	PERIOD: 20 sec
7	BLANK	PERIOD: 45 sec SAMPLE-TIME: 20 sec PIPET-TIME: 20 sec
8	BUFFER	PERIOD: 11 sec

Table 8 Program - Reference Run

Macro	Action	Time/ Parameters
9	WAIT	PERIOD: 40 sec STIRRED ACTION: ON
10	MEASURE	PERIOD: 1000 sec DRIFT: 0.5 mV/5 sec SAMPLE OUT OF RANGE ACTION: RAL
11	OUTPUT	RESULT PRINT-OUT: OFF ALARMS: NOT USED

Table 9 Program - Cleaning Run

Macro	Action	Time/ Parameters
1	BURET	VOLUME: 2 ml SPEED: 2

Table 10 Utilities

SOFTWARE VERSION LOADED: HD V 1.00		
BURETTE	REFILL SPEED SIZE RECL:VOLUME	2 ml 2 ml
CONSTANT	1. Sample volume 2. Buffer volume 3. Conc. Standard 4. Slope factor 5. Eng. factor 6. Unit	10 1.0 100 (50) -1 1 mg/l
STIRRER	SPEED	30 %
SERIAL INTERFACE	DATABITS STOPBITS PARITY BAUDRATE INTERFACE	8 1 EVEN 1200 PRINTER
OUTPUT MAPPING:		
OUTPUT 1:	DIRECTED TO LOW LIMIT HIGH LIMIT	SAMPLE-1 SAMPLE-2 0 100
OUTPUT 2:	NOT AVAILABLE ADJUST PACE	
CALIBRATION PARAMETERS:		
	DEFAULT TEMPERATURE	20 °C

8 Serial Communication

8.1 Introduction

The Analyser has a serial-interface that can be used for several purposes:

1) Connection with a PRINTER, print-out results, program, etc.
2) Connection with a COMPUTER, reading results, changing settings, etc.
3) Connection with a NETWORK, this option is NOT functional.

The serial-interface option NETWORK and the RS485 are not functional.

The option PRINTER is discussed in the OPERATION-part of the manual. The option COMPUTER provides a bidirectional communication link between the analyzer and a HOST (e.g. PC). The serial-interface should be set to COMPUTER (see Utility.serial menu in the operation manual) in order to communicate with a HOST. Note that the interface-selection in the Utility.serial menu only selects the software-interface (i.e the way the software handles the serial-interface), the hardware-selection is done on the RS-xxx interface.

When the serial-interface is set to COMPUTER, the analyser can communicate with a HOST (single HOST). The hardware-interface should be a full-duplex interface (i.e. separate transmit- and receivelines). This can be the RS-232 interface or the RS-422 interface. When the RS-232 interface is used, only a one-to-one connection can be made (single Analyser, single HOST); when the RS-422 interface is used, up to 10 analyzers can be connected to a single HOST. When the RS-422 interface is used with multiple analyzers, a strict master-slave mechanism should be used; the host should not send a next command before the answer to the previous command is returned, else (undetectable) data-collision occurs.

In order to communicate with the analyser over the serial-line, a protocol has been defined which is used for all ADI instruments, hence this is called the ADI-protocol. With this protocol the host can address several functions inside the analyser. These functions can represent simple numbers (e.g. the constants) or they can be complex commands (e.g. start a run).

8.2 Command-string

The ADI-protocol uses the following format:

Table 11 Format of the ADI-protocol

STX	**N** ***to,from***	***Mmodule***	**F*function*** **B*block*** **L*list***	**U*unit***	**C** **A** **E**	***data*** ***data*** ***error***	***/check-sum***	**CR** **[LF]**
	Node	Module	Instruction	Unit	Com-mand	Data	Check-sum	

Note that no spaces are used in the command-string.
The command-string always starts with a <STX> character, this is the ASCII-character 02_{hex}.

The NODE-section is optional; if it is used, it is announced with a N character, followed by the TO-node and FROM-node. The TO-node is the node to which the command is send, the FROM-node is the node from who the command is. The TO-node and FROM-node are always separated by a comma.The Node-section is to be used when more than one ADI-instrument is connected to the serial-line (i.e. when using RS422).

The MODULE-section is optional, it is used for those ADI-instruments that may have more than one Module inside (e.g. the ADI1020). The ADI201Y analyzers all have only one module, so the Module-Section will be ignored when received.

The INSTRUCTION-section must always be used, it holds the function(s) that are requested or commanded. The Instruction-Section consists of one of the 3 characters F, B or L followed by the Function-Code, Block-Code or List-Number respectively. The Mode-Character (F, B or L) selects one of the 3 modes: Function-Mode, Block-Mode and List-Mode. The analyser will only allow the Function-mode.

The UNIT-section is optional and is used when more than one data-section is needed to transfer all the information specified by the instruction.

The Command-separator is always used and has 3 forms: the C character, the A character and the E character. When the command-string is send by the HOST, the C character is used to denote a COMMAND (this can be a request for data or command). When the instrument replies to the command, it uses the A character when it returns the requested data or when it acknowledges to the command; it replies the E character when an error has occurred. The DATA-section holds the data to be used for the function(s). When the HOST sends data to the instrument, it uses the Data-section to transport it; when the HOST requests data from the instrument the Data-section must be empty (in fact, an empty data-section marks a request). When a function is an implicit command (i.e. a function that doesn't need data to perform some action) the Data-Section is also empty.

The CHECKSUM-section is optional and holds both the Checksum-separator '/' and the checksum it self. The checksum consists of two characters which represent a byte-value. This byte-value is the checksum of the transmitted data.

The command-string is always ended by a <CR>, the use of a <LF> is optional.

8.2.1 Node-section

As shortly explained in the previous chapter, the Node-Section uses the format: Nto,from. The TO- and FROM-node are numbers in the range [0..99] and are ASCII-coded (readable). The range is rather academic since only 10 connections are allowed using RS-422 and 32 connections using RS-485. Therefore it is advised to use a node-number in the range [0..9] or [0..31].

Although the Node-section is not intended for a single-connection interface (RS-232), it will be checked when received (and transmitted).

When using the RS-422 interface, the firmware relies on the master (the host) to address only one instrument at a time, and not send another command before the reply of the previous command has been received.

8.2.2 Instruction-section

The instruction-section is the section that addresses a specific function or a group of functions inside the analyzer. Therefore this section should always be used. The Instruction-Section starts with the Mode-Character (F, B or L) which selects the mode to be used.

The analyser will only allow the FUNCTION-mode.

8.2.2.1 Function-mode

The FUNCTION-Mode is the primary-mode used by the ADI-protocol, all other modes are supersets ofthe Function-Mode. All information that is retrieved from or send to the Analyzer uses the Function-Code to address a specific function.
The Function-Code is build hierarchical, formed by several base-groups.

These base-groups are: 0 - utilities
1 - input
2 - input-control
3 - algorithm
4 - output-control
5 - output
6 - run-control

The base-groups are divided into several sub-groups. These are discussed later → *Section 8.3 on page 99*.

These groups and sub-groups are addressed using numbers, together these numbers form the Function-Code. All numbers are separated by periods, creating the format: **F*n.m.o.p ... z*** (e.g. F3.3.1)
The maximum number of sub-groups (or items) is not defined by the protocol itself; the ADI201x analysers all have a maximum of 4 items.

When a function-code is not available, an error will be returned:

example:
command: *<STX>*2.3C*<CR>* (request Node-Number, not available on ADI201x)
reply: *<STX>*2.3**E32***<CR>* (error-32)

The <STX> and <CR> character will be omitted in the examples from now on.

The separate functions (their behaviour) are discussed in detail further on in this manual.

8.2.2.2 Unit-mode/ Unit-section

As described earlier, the reply of the analyser is split-up in UNITS when the length of the data-section exceeds the maximum length. The maximum length of the data-section is not specified explicitly, only the maximum length of the entire command-strings is. The maximum length of the command- (or reply) string is 128 characters, including the <STX> and <CR>; the maximum length for the data-section can be derived from maximum command-length by counting how many characters are needed for the other sections.

When the analyser creates a reply-string that contains more than 128 characters, it automatically splits it into UNITs. Then only the first unit is sent:

example:
command: F3.1C (request Program-Array)
reply: F3.1**U1**A**0**@ .. **0**@**0**@ (reply the first UNIT)

the host must now acknowledge this first unit:
command: F3.1U1C (acknowledge Unit-1)
reply: F3.1U2A**0**@**0**@ **..** **0**@**0**@ (reply second Unit)

this process continues until the last Unit is replied by the analyser:

command: F3.1U20C (acknowledge Unit-20)
reply: F3.1**U0**A**0**@**0**@**0**@**0**@ (reply last Unit, Unit-0)

the last unit is always marked as Unit-0, so the receiver can see that this is the last unit. The host should not acknowledge the last unit.

When the host does not acknowledge the UNIT but requests another function immediately, the analyser sends an error-message (error-39). Whenever the analyser sends error-39, the internal UNIT-mode mechanism is reset, so other functions can be used after an error message. If the host needs to reset the UNIT-mode mechanism without generating an error, it should send the function-code F0 (reset communication).

The UNIT-mode also has another extension to the ADI-protocol, it can use the REPEAT command to request the last unit one more time. In that case the analyser simply replies the same unit again; examples:

command: F3.1U3C (acknowledge Unit-3)
reply: F3.1U4A**0**@**0**@ **..** **0**@**0**@ (reply unit-4)

command: F3.1U4C**R** (repeat Unit-4)
reply: F3.1U4A**0**@**0**@ **..** **0**@**0**@ (reply unit-4 again)

8.2.3 Command separator

The command-separator is always used in the command-strings and has 3 forms: the **C** character, the **A** character or the **E** character. When the command-string is sent by the HOST, the **C** character is used to denote a COMMAND (this can be a request for data or command). When the instrument replies to the command, it uses the **A** character when it returns the requested data or when it acknowledges to the command; it replies the **E** character when an error has occurred. The command-separator can also be lower-case (except the **E**), this denotes that the data is send (or should be returned) using the fast-float notation (see next chapter).

8.2.4 Fast-float-mode

Whenever data is requested, the value of the requested parameter is converted into a string. This conversion takes a certain amount of processing-time. In most cases the requesting device (the HOST) must convert the string back into a numerical value, so two conversions are done that are actually not needed. The ADI-protocol provides the use of another conversion (i.e data-representation) that takes considerably less processing-time than the string-conversion; this is called the FAST-FLOAT conversion. The fast-float conversion takes the memory-bytes (i.e. the bytes that represent the number in memory) starting with the byte lowest in memory and converts these bytes into an 8-character string. This 8- character string is returned as the numerical value. The conversion takes all 4 bytes (a real number in the ADI20XX analysers always consists of 4 bytes) of the number and converts each byte into 2-character. The low-nibble (i.e. 4 lowest bits) of a byte is converted into a character in the range [0..?] (this is the ASCII-range [30hex..3Fhex]), the low-nibble value of the first character is the same as the low-nibble value of the program-byte. This character is then followed by a character that represents the high-nibble (i.e. 4 highest bits), this character is in the range [@..O] (this is the ASCII-range [40hex..4Fhex]), the low-nibble value of the second character is the same as the high-nibble value of the program-byte.

The fast-float mode is marked (indicated) by a lowercase command-separator (i.e. **c** instead of **C**, **a** instead of **A**).

example:
command: F3.3.1**c** (request constant-1 in fast-float)
reply: F3.3.1**a**0@0@0@0@ (return constant-1 in fast-float)

Some parameters are a string by nature (e.g. time and date) and can therefore not be requested in fast-float notation.
Other parameters are integers; requesting them in fast-float notation will first convert these integer to floating-point and then convert the floating-point into a fast-float. Because of the extra conversion, no real gain will be obtained by using the fast-float notation.

8.2.5 Data-section

The DATA-section holds the data to be used for the function(s). When the HOST sends data to the analyser, it uses the Data-section to transport it; when the HOST requests data from the analyser, the Data-section must be empty (in fact, an empty data-section marks a request).
Note that when a function is an implicit command (i.e. a function that doesn't need data to perform some action) the Data-Section is also empty.

When the command-separator indicates an error, the data-section contains the error-code. The error-code is a 2-digit number representing the type of error; see → *Section 8.5 on page 130*.

The contents of the data-section can be numeric (digits) as well as alpha-numeric (characters and digits), depending on the function. The fast-float notation is an alpha-numeric notation of numeric-data.
The length of the data-sections is restricted by the maximum length of the command-string which is 128 bytes. When all sections in the command-string are used to the maximum, only 92 characters remain for the data-section; not using the module-section and not padding with 0's (e.g. F000.001.001, which is legal) leaves 100 characters to the data-section in worst-case.
However, the up/download function (F3.1) expects to have 110 characters available.

The characters in the data-sections should all be readable 7-bits ASCII-characters (to be precise, ASCII only defines 7-bits characters). Readable means that

the first 32 ASCII-characters (which are *controlcharacters*, like <CR> or <TAB>) should not be used.
The IBM-extension on the ASCII-definition is not supported; this means that the degree Celsius sign ('o'), which is both available in the analyzer and the IBM-characterset, can not be transmitted by the ADIprotocol. When for example the contents of the display is requested, all non ASCII-characters are replaced by a hash ('#').

The number of characters returned for a numeric-value depends on the function that is requested. The total number of digits (including the minus and decimal-point) is always restricted to 8. The number of digits on the right-side of the decimal-point depends on the function. Some functions are integer by nature (e.g. macro-number), others have a fixed number of decimals and some have a floating number of decimals (e.g. constants). However, the maximum number of decimals is restricted to 3. When the magnitude of the numeric-value is too large to be represented using its predefined format, first the number of decimals is diminished. If the magnitude is still too large, the digits are replaced by the *overflow* notation '>>>>>>>>'; the number of greater-than signs is equal to the maximum number of characters.
When the numeric-value has an underflow (e.i. too low to be represented using the maximum number of decimals), the overflow-notation is also used.
Leading spaces are not transmitted, so a value of 0 for constant-1 will be transmitted as '0.000', not as ' 0.000'; the trailing zero's, however, are not removed.

Some function-codes can not be commanded since they are read-only. When an attempt is made to command such a function, error-36 (incorrect command data setting) is returned.
If a function can be commanded, the firmware of the analyzer specifies (for all functions but one) that the analyzer should be in the MAIN- or RUN-menu. If the analyzer (human-interface) is not in the MAINor RUN-menu when the command is send, error-57 (command data only allowed in main/run) is returned.
The only function that can be commanded while the analyzer is in a menu other than the MAIN- or RUNmenu, is the keyboard emulation functions (F0.4.2). To be actually useful, this function is allowed in all menus, so it can be used together with the display-request functions (F0.4.1.1 and F0.4.1.2) to provide a remote human-interface.
The keyboard emulation function (F0.4.2) is also the only one that is command only (all other functions that can be commanded can also be requested); when function F0.4.2 is requested, error-37 (parameter data error) is returned.

Some functions are (implicit) commands by nature, they expect no command data since the command is obvious (e.g. F6.1.2 = Emergency-Stop); when command-data is received anyway, error-36 (incorrect command data settings) is returned.
The implicit-command can also be used in the MAIN-and RUN-menu only, except for two: the Emergency-Stop command and the Stop-Running command can also be used during running for obvious reasons.

The functions can always be requested (all menus and during running), except for the ones that demand the analyser to be running (RUN-status functions, F6.3.3.x) or the analyser not to be running (run-status at the moment PAL was generated, F6.3.1.x).

8.2.6 Checksum-section

The CHECKSUM-section is optional and holds both the Checksum-separator '***/***' and the checksum itself. The checksum consists of two characters which represent a byte-value. This byte-value is the checksum of the transmitted data, starting with the <STX>-character and ending at the Checksum-separator. The checksum is calculated by adding all ASCII-values of the characters (e.g A = 65) discarding the carry (overflow when the sum exceeds 255, result is the remainder of sum / 256). The checksum is transmitted using a method like the ADI-fastfloat notation, in this case the *fastbyte* notation. First the low-nibble (lowest 4-bits) of the byte-value is converted into a character on the range [0..?], second the high-nibble is converted into a character in the range [@..O] (see Fast-Float mode for more details). The transmitted checksum (the checksum in the checksum-section) should be equal to the checksum of the received characters (calculated by the receiver); if the checksum is not equal, the analyzer returns error-24 (checksum error).

The use of the checksum is defined by the serial-settings in the Utility.Serial menu. If the checksumoption is set ON, the host **must** send the checksum; if the checksum-section is empty the analyzer returns error-25 (checksum expected). On the other hand, if the checksum-section is set to OFF, the host should **not** send the checksum; if the checksum-section is filled, the analyser returns error-25 (checksum not expected).

example of checksum calculation:
command: *<STX>*F0.1.1C/

byte-values: 2 + 70 + 48 + 46 + 49 + 46 + 49 + 67 + 47
sum: 424
checksum: 424 mod 256 = 168
low-nibble: 168 mod 16 = 8 character = '8'
high-nibble: 168 div 16 = 10 character = 'J'

command-string: *<STX>*1.1C/8J*<CR>*

8.3 Function Codes

The <STX> before and <CR> after any functioncode with all other characters are NOT shown in the following examples.

Note:
- The data sections in the following examples can have ’random’ content.

8.3.1 Function group 0: Instrument level

F0 - Cancel ALL
To reset the Serial communication of the analyzer.
This function-code sends no additional data and nothing is send back.
Example:
A Cancel All is send to the analyzer, this command is performed without answering:
PC: F0C
Analyser:

F0.0.0.0 - Silent Ping
To send a Silent Ping to the analyser.

When data is send together with the Ping, the analyser will send this data unchanged back. When no data is send, the analyser will send back an analyser-model-specific text.

Example:
A silent-ping with text is send, the same text will be send back as answer:
PC: F0.0.0.0CHallo Analyser
Analyser: F0.0.0.0AHallo Analyser
Or without data:
PC: F0.0.0.0C
Analyser: F0.0.0.0AADI2018 Pinging

F0.0.0.1 - Noisy Ping
To send a Noisy Ping to the analyzer.
When data is send together with it, the analyzer will send this data unchanged back.
When no data is send, the analyzer will send back an analyzer-specific text and if the analyzer is in the Main menu then this text also appears in the display.
So, when the analyzer is NOT in the Main menu the Noisy Ping behaves as the Silent Ping (F0.0.0.0).

Example:
A noisy-ping with text is send to the analyser:
PC: F0.0.0.1CHallo Analyser
Analyser: F0.0.0.1AHallo Analyser the text is shown in the display
Without data:
PC: F0.0.0.1C
Analyser: F0.0.0.1AADI2018 Pinging the display remains as it was

F0.1.1 - Uref (the value of the reference for the A/D Conversion)
This reference voltage (Uref) is factory-adjusted to 5000 milliVolt. The measured value should not differ much. A large difference can be caused by a malfunction in the A/D Conversion circuitry.

Example: Uref = 5000.12 mV
ASCII-coding:
PC: F0.1.1C
Analyser: F0.1.1A5000.12
Fast-Float:
PC: F0.1.1c
Analyser: F0.1.1a6O0D<I5D

F0.1.2 - Ubat (the battery voltage in Volts)
Ubat is about 3 Volt for a full battery. When under 2.8 Volt, the last 5% of the battery lifetime is reached.

Example: Ubat = 3.01 V
ASCII-coding:
PC: F0.1.2C
Analyser: F0.1.2A3.01
Fast-Float:
PC: F0.1.2c
Analyser: F0.1.2a7M3J0D0D

F0.2.1 - Device-Code
This function-code returns the device-code of the instrument.

Example: The Device-Code is asked at an ADI 2003 with ASCII-coding:
PC: F0.2.1C
Analyser: F0.2.1A2003

F0.2.2 - Software Version
This function returns the version of the installed firmware.

Example:
ASCII-coding:
PC: F0.2.2C
Analyser: F0.2.2AV1.00

F0.2.3 - Analyser-Number
The chosen Analyser Number of the Analyser is asked.

Example, the Analyser-Number is 1:
ASCII-coding:
PC: F0.2.3C
Analyser: F0.2.3A1
Fast-Float:
PC: F0.2.3c
Analyser: F0.2.3a1@

F0.2.4 - Checksum Tested OK?
The result of the Checksum-Test is asked. If the Checksum Test at the start-up of the analyser has been successful a Åe1' is send back, if Checksum Test Failed then a '0' is sent back.

Example:
ASCII-coding:
PC: F0.2.4C
Analyser: F0.2.4A1

F0.2.5 - Software System Options Flags
These flags show which Software System Options are activated.

Table 12 System Options Flags

bit-7	bit-6	bit-5	bit-4	bit-3	bit-2	bit-1	bit-0
n/a	n/a	n/a	n/a	n/a	Sample-Pump Inhibit	Level Detector	Leak Detector

Leak Detector
This option determines if the change in State of the Leak Detector input (from ’no leak' to ’leak detected' results in a PAL (Processing Alarm); the running analyser-program is terminated immediately and the Main-menu becomes active with the message ’LEAK DETECTED'.

Level Detector
This option must be set when the Leak/Level Output is physically connected with the Remote Stop input. With this option set; a logical high at the Remote Stop input will stop the presently running analyser-program AFTER the cycle is finished. After the analyser has stopped, the message ’REAGENS LEVEL TOO LOW' will be shown on the display.

Sample-Pump Inhibit
This option must be set if the Sample-Pump Inhibit input is used.

Example: the Leak Detector and Sample-Pump Inhibit options are set:
ASCII-coding:
PC: F0.2.5C
Analyser: F0.2.5A5
Fast-Float:
PC: F0.2.5c
Analyser: F0.2.5a5@

F0.3 - Date & Time
To ask or change the date/time in the Real-Time Clock on the Controller Board. Changing the date/time is only possible when the analyser is in the Main menu or Run menu. If not, Error 57 is send back. Asking the date/time is always possible. When the string for setting the date/time has not the correct format, Error 37 is send back.

Table 13 Format of the day/ time

0	1	2	3	4	5	6	7	8	9
dd		-	mm		-	yyyy			

10	11	12	13	14	15	16	17	18	19
		hh		:	nn		:	ss	

With:
dd the day of the month, range 1-31
mm the month of the year, range 1-12
yyyy the year, range 2000 - 2099
hh the hour, range 0-23
nn the number of minutes, range 0-59
ss the number of seconds, range 0-59

Example:
Ask:
PC: F0.3C
Analyser: F0.3A15-06-2004 15:24:38
Set:
PC: F0.3C15-06-2004 14:24:38
Analyser: F0.3A

F0.4.1.1 - Display Line-1
The upper line of the Analyser display (40 characters).

Example:
The upper line of an ADI 2003 Analyser display is asked:
PC: F0.4.1.1C
Analyszer: F0.4.1.1A ADI2003 - MAIN-MENU - ALERT ION-ANALYZER

F0.4.1.2 - Display Line-2
The lower line of the Analyser display (40 characters).

Example:
PC: F0.4.1.2C
Analyser: F0.4.1.2A RUN MANUAL PROGRAM UTILITY LOGIN

F0.4.2 - Keyboard Emulation
Format: String (1 character)
This function emulates the keyboard of the Analyser. All keys (function-keys and numeric-keys) are represented by a character. By sending a character, a key command is send to the User-Interface of the Analyser. When the character for the key-command does not exist, Error 37 is send back.

F0.4.3 - Backlight

The characters and the accompanying key-command for Keyboard Emulation					
Char-acter	Key	Char-acter	Key-	Char-acter	Key
A	F1 (Function-Key)	0	Numeric-Key 0	5	Numeric-Key 5
B	F2 (Function-Key)	1	Numeric-Key 1	6	Numeric-Key 6
C	F3 (Function-Key)	2	Numeric-Key 2	7	Numeric-Key 7
D	F4 (Function-Key)	3	Numeric-Key 3	8	Numeric-Key 8
E	F5 (Function-Key)	4	Numeric-Key 4	9	Numeric-Key 9
M	Main	>	ENTER	.	. (Decimal Point)
U	Up	#	CLEAR	-	- (Numeric Minus)
@	Emergency Stop				

Fig. 105 Key-command for Keyboard Emulation

Direction: Read/Write
Coding: 1 = Backlight ON; 0 = Backlight OFF
The text-character Åe1' means an activated backlight.

Example:
The state of the Backlight is asked with ASCII-coding:
PC: F0.4.3C
Analyser: F0.4.3A1
The Backlight is controlled (set off) with ASCII-coding:
PC: F0.4.3C0
Analyser: F0.4.3A

F0.5.1 - Analyser State Flags
The Analyser State Flags give information about the state of the Analyser.

bit-7	bit-6	bit-5	bit-4	bit-3	bit-2	bit-1	bit-0
Stopping	Frozen	Running	PAL	Keyboard Blocked	Logged-IN	Run-Menu active	Main-Menu active

Fig. 106 Bitvalues

Bit-0: This bit is ’1' when the Main-menu is active.
Bit-1: This bit is ’1' when the Run-menu is active.
Bit-2: This bit is 1' when the user is logged-in.
Bit-3: This bit is ’1' when the key-board is blocked by hardware.

Bit-4: This bit is ’1' when the PAL-relay is (seen from the software point of view) active.
Bit-5: This bit is ’1' when the analyzer is executing one program or more programs (ratio).
Bit-6: This bit is ’1' when the analyzer is in the so-called Frozen state. This state happens when, while running, the timers are halted (press the Main and Up key at the same time).
Bit-7: This bit is ’1' when the analyzer will stop (with running) at the end of the present Run Cycle.

Example:
ASCII-coding:
PC: F0.5.1C
Analyzer: F0.5.1A36
Fast-Float:
PC: F0.5.1c
Analyzer: F0.5.1a4B

F0.5.2 - Analyzer Menu Level (the active menu)
To ask which menu is active.

bit-7	bit-6	bit-5	bit-4	bit-3	bit-2	bit-1	bit-0
Menu Selection 0 - Main Menu 1 - Run Menu 2 - Manual Menu 3 - Program Menu 4 - Utility Menu 5 - Login/Logout Dialogue			Sub-Menu Selection. This value shows which sub-menu of: - the Manual or - the Utility Menu is selected.				

Fig. 107 Construction of the Analyzer Menu Level

value	Sub-Menu	Value	Sub-Menu
1	Manual.Rinse	9	Manual.Print
2	Manual.Drain	10	Manual.Extern1
3	Manual.Stirrer	11	Manual.Extern2
4	Manual.Sample1	12	Manual.Extern3
5	Manual.Sample2	13	Manual.Buret
6	Manual.Pipet	14	Manual.Input
7	Manual.Blank	15	Manual.Output
8	Manual.Buffer		

Fig. 108 Manual Menu Sub-Menu Level Coding

value	Sub-Menu	Value	Sub-Menu
1	Utility.Const	9	Utility.Anal.No
2	Utility.Results	10	Utility.Serial
3	Utility.History	11	Utility.B.Light
4	Utility.Map	12	Utility.Clock
5	Utility.P.Code	13	Utility.Uref/bat
6	Utility.Adjust	14	Utility.Version
7	Utility.Init	15	Utility.RamTest
8		16	Utility.Checksum

Fig. 109 Utility Menu Sub-Menu Level Coding

Example: the analyzer is in the Manual.Input menu:
ASCII-coding:
PC: F0.5.2C
Analyzer: F0.5.2A65
Fast-Float:
PC: F0.5.2c
Analyzer: F0.5.2a1D

F0.5.3 - Last PAL Code
To ask the last occurred PAL

PAL-Code (Hex)	PAL Message	Remarks
01	EMERGENCY STOP OCCURRED	A manual, serial or remote EMERGENCY STOP command is given.

Fig. 110 PAL-codes for the Analyzer, part 1

PAL-Code (Hex)	PAL Message	Remarks
11	BURETTE VALVE FAILURE	The burette valve is not in the correct position within 5 sec. after the burette valve was activated.
20	BURETTE END LIMIT REACHED	The piston of the burette is in highest position while a DOSE was executed. Program might be incorrect.
21	BURETTE TIME-OUT	The burette action could not be completed within the allowed time interval. The burette drive might have failed.
30	LEAK DETECTED	The Leak Detection input is active during more then 1 second.
40	ANALYSIS TIME-OUT	The MEASR macro could not be completed within the programmed time interval.
41	MEASURE INPUT NOT AVAILABLE	No mV/pH sensor card found.
42	CALIBRATION TIME-OUT	The CALIB macro could not be completed within the programmed time interval.
43	SAMPLE OUT-OF-RANGE	The MEASR-macro detects that the concentration of the sample is higher than the concentration of the standard and the programmed action for this is PAL. Is the slope factor is properly set ?
80	ARITHMETIC FATAL ERROR: X YY	An internal arithmetic error has occurred. Carry out an EPROM (checksum) and RAM test (see Utility menu). Verify the constant settings in the Utility menu. Any division by zero?
90	REFERENCE RESULT ERROR	The reference run has found a result outside the specified alarm limits (OUTPUT macro).
A0	PRINTER TIME-OUT	The analyzer can not sent its information to the printer; verify if the printer is on-line.
C0	POWER FAILURE OCCURRED	The power supply has been interrupted while the analyzer was running.
F0	ALL RUN-SELECT RATIOS ZERO	All run select ratios are zero while the RUN-START command is entered. Program the run ratios.
F1	NO ANALYSIS-PROGRAM	The analysis run is started while it does not exist.
F2	NO REFERENCE-PROGRAM	The reference run is started while it does not exist.
F3	NO CLEANING-PROGRAM	The cleaning run is started while it does not exist.
F4	ALL SAMPLE-SELECTS ZERO	At the start of the ANALYSIS program are the Selection Ratio's for both Sample-Streams zero.
F5	ILLEGAL CONSTANT VALUES	At least one of the constants has an illegal value (like 0).
FF	INTERNAL ERROR	

Fig. 111 PAL-codes for the Analyzer, part 2

Example: the PAL ILLEGAL CONSTANT VALUES has occurred:
ASCII-coding:
PC: F0.5.3C
Analyzer: F0.5.3A245
Fast-Float:
PC: F0.5.3c
Analyzer: F0.5.3a5O

F0.5.4 - Arithmetic Fatal-Error Info (information about the last Arithmetic Fatal-Error)

The information of the Arithmetic Fatal-Error consists of two parts.
- The Function-Code (bits 15 - 8) shows where it went wrong, and
- The Error-Code (bits 7- 0) shows what went wrong.

Fig. 112 contains the coding of these codes:

Arithmetic Fatal-Error: **Error** Coding		
Code	Error	Description
1	Attempted Division by Zero	It is attempted to divide by Zero
2	Domain Error	The value of the (or an) operand is not in the domain of the operation; Example square root of -1.
3	Overflow	The result of the operation is too large (outside the range of a 4-byte ANSI Floating-Point value).
4	Underflow	The result of the operation is too small (outside the range of a 4-byte ANSI Floating-Point value).
5	Invalid Number in FAC	An invalid 4-byte ANSI Floating-Point value is in the FAC (Floating-Point Accumulator). This is probably caused by a previous calculation or by the unintentionally overwriting of a buffer.
6	Invalid Number in Memory	An invalid 4-byte ANSI Floating-Point value is in a memoryplace (parameter). This is probably caused by a previous calculation or by the unintentionally overwriting of a buffer.

Arithmetic Fatal-Error: **Function** Coding		
Code	Function	Description
1	FADD	An error occurred during an addition, e.g. *x + y*
2	FSUB	An error occurred during a substraction, e.g. *x - y*
3	FMUL	An error occurred during a multiplication, e.g. *x * y*
4	FDIV	An error occurred during a division, e.g. *x / y*
5	FIXSD	
6	FCMPR	An error occurred during a function, e.g. *x is not the same as y*
7	FZTST	An error occurred during a function with 0, e.g. *x is not the same as 0*
8	FNEG	An error occurred during making negative of an argument, e.g. *x = -y*
9	FABS	An error occurred making the absolute value of an argument, e.g. *x = | y |*
10	FQSRT	An error occurred during a root calculation, e.g. *x = square root of y*

Fig. 112 Coding of these codes

Example:

ASCII-coding:
PC: F0.5.4C
Analyzer: F0.5.4A1025
Fast-Float:
PC: F0.5.4c
Analyzer: F0.5.4a0@0@

F0.6.1.1 - Analog-Output 1 Present
To ask if the Analog-Output Card 1 is present.
Coding: 1 = Output Present; 0 = Output Not Present

Example:
ASCII-coding:

PC: F0.6.1.1C
Analyzer: F0.6.1.1A1

F0.6.1.2 - Analog-Output 2 Present
To ask if the Analog-Output Card 2 is present.

Example: see F0.6.1.1

8.3.2 Function group 1: Inputs (Analog and Digital)

F1.1.2 - Sensor-value mV input (in mV)
To ask the last executed mV-input measurement.
This functioncode does not start a measurement.
Note:
- A mV-measurement is started in the Manual.Input menu and during a measurement/calibration macro.

F1.1.3 - Sensor-value Temperature input (in degree Centigrade)
To ask the last executed temperature-input measurement.
This function code does not start a measurement.
Note:
- A temperature measurement is started in the Manual.Input menu and during a measurement/calibration macro.

F1.2.0 - Digital Input State Flags
The state of all digital inputs can be asked.

Digital Input State Flags (the function of the bits in the State Byte)							
bit-7	bit-6	bit-5	bit-4	bit-3	bit-2	bit-1	bit-0
Leak Detector	Ctl.Power / Heater	GPI	Remote Start/Continue	Remote Stop state	Remote Emergency Stop state		SPI SamplePump Inhibit

Fig. 113 Digital Input

SPI - Sample-Pump Inhibit input signal
This flag shows the state of the Sample-Pump Inhibit input signal. This (hardware) signal can be used by the analyzer-software IF the Sample-Pump Inhibit option is set in the Software System Options (See F0.2.5 - Software System Options Flags).
Coding: 0 = terminal strip X11(on the central computer board), terminal 22 connected to GND
1 = terminal strip X11, terminal 22 connected to 24 Volt

Remote Emergency Stop state (E-Stop)
This state can be asked to know if there was stopped by Remote Emergency-Stop.
The Remote Emergency-Stop state is a software interpretation and can be triggered by applying a logical-low signal to the Remote Emergency-Stop input (terminal strip X11, terminal 17) on the central computer board.
Coding: 0 = no Remote E-Stop triggered
1 = Remote E-Stop triggered

Remote Stop state.
This state can be asked to know if there will be / is stopped because of Remote Stop (if hardware switch block S2 is set correctly).
The Remote Stop state is a software interpretation and can be triggered by applying a logical-high signal to the Remote Stop input (terminal strip X11, terminal 19) on the central computer board
Coding: 0 = no Remote Stop triggered
1 = Remote Stop triggered

Remote Start/Continue
This state can be asked to know if there was started by Remote Start/Continue (if hardware switch-block S2 is set correctly).

The Remote Start/Continue state is a software interpretation and can be triggered by applying a logical high signal to the Remote Start/Continue input (terminal strip X11, terminal 18) on the central computer board.
Coding: 0 = no Remote Start triggered
1 = Remote Start triggered

GPI - General Input
This bit contains the state the GPI (General Purpose Input) signal on the Controller-board.
The analyzer-software does nothing with the GPI.
Coding: 0 = terminal strip X17 terminal 17 low (connected to GND)
1 = terminal strip X17 terminal 17 high (connected to 24 Volt)

Heater - Heater Feedback / Ctl. Power
This bit contains the input signal state of terminal strip X3 (on the central computer board), terminal 1 (the H_TEMP signal) on the Controller-board.
The Heater Feedback input is used only for heater-feedback in the 2019 Colorimeter, and then only if the hardware is configured that way.
For the ADI2016, 2018, 2003, 2004 analyzers it is a Control Power detection if the hardware is configured that way; The input is connected with the 24 Volt Control Power.
Coding: 0 = terminal strip X3 (on the central computer board), terminal 1 low (connected to GND)
1 = terminal strip X3, terminal 1 high (connected to 24 Volt)

Leak Detector
This bit contains the state the Leak signal input signal (hardware) on the Controller-board.
This (hardware) signal can be used by the analyzer-software IF the Leak option is set in the Software System Options (See F0.2.5 - Software System Options Flags).
Coding: 0 = terminal strip X17 (on the central computer board), terminal 22 connected to GND
1 = terminal strip X17, terminal 22 connected to 24 Volt

Example: the SPI and LEAK signals are high:
ASCII-coding:
PC: F1.2.0C
Analyzer: F1.2.0A129
Fast-Float:
PC: F1.2.0c
Analyzer: F1.2.0A1H

F1.2.1 - Sample-Pump Inhibit State

The *Sample-Pump Inhibit State* depends on

- the *SPI* bit in the state-flags of F1.2.0, and
- the *Sample-Pump Inhibit option* (in the *System Options*)

When the *Sample-Pump Inhibit option* (in the *System Options*) is not set active, the *Sample-Pump Inhibit State* can also not become active. See also F0.2.5 - Software System Options Flags.
Coding: 1 = Sample-Pump Inhibited

Example:
ASCII-coding:
PC: F1.2.1C
Analyzer: F1.2.1A1

F1.2.2 - Leak Detector State
The *Leak Detector State* depends on

- the *Leak* bit in the state-flags of F1.2.0, and
- the *Leak option* (in the *System Options*)

When the *Leak option* (in the *System Options*) is not set active, the *Leak Detector State* can also not
become active. See also F0.2.5 - Software System Options Flags.
Coding: 1 = Leak Detected

Example:
ASCII-coding:
PC: F1.2.2C
Analyzer: F1.2.2A1

F1.2.3 - Control-Power State
This is a software interpretation. It can be used for troubleshooting
Coding: 1 = Control Power ON
0 = Control Power OFF

F1.2.4 - General Input State
This state is the same as the state of the *GPI* bit in the state-flags of F1.2.0.
Coding: 1 = GPI input connected to logical high (24 Volt)
0 = GPI input connected to logical low (GND)

Example:
ASCII-coding:
PC: F1.2.4C
Analyzer: F1.2.4A1

F1.2.5 - Remote Start/Continue function State
This state is the state of the *Remote Start/Continue* bit in the state-flags of F1.2.0.

F1.2.6 - Remote Stop function State
This state is the state of the *Remote Stop* bit in the state-flags of F1.2.0.

F1.2.7 - Remote E-Stop function State
This state is the state of the *Remote Emergency Stop* bit in the state-flags of F1.2.0.

F1.2.8 - Heater Failure detection State (only functional in ADI 2019-HD and ADI 2019-S)
This is a software interpretation.
Coding: 0 = Heater OK
1 = Heater Failure

Example:
ASCII-coding:
PC: F1.2.8R
Analyzer: F1.2.8A1

8.3.3 Function Group 2: Input settings

F2.1.2.x - mV-input, Calibration Setttings
Unit: mV and mV/mV
To ask the Calibration Settings of the mV-Sensor:
F2.1.2.1 Slope of the mV-sensor
F2.1.2.2 Offset of the mV-sensor

Example: the value of the Offset is 0.0:
ASCII-coding:
PC: F2.1.2.2C
Analyzer: F2.1.2.2A0.0
Fast-Float:
PC: F2.1.2.2c
Analyzer: F2.1.2.2a0@0@0@0@

F2.1.3.x - Temperature-input, Calibration Setttings
Unit: °C and °C /°C
To ask the Calibration Settings of the Temperature-Sensor:
F2.1.3.1 Slope of the Temperature-Sensor
F2.1.3.2 Offset of the Temperature-Sensor

Example: see F2.1.2.x

8.3.4 Function group 3: Programs

F3.1 - Upload/Download Program-Array

This function can be used to Up- and Download the program-array. The program-array contains the
macro-programs and most of the utilities (see list below).

- macro-programs (Analysis, Reference and Cleaning)
- run-ratios & cycle-time
- constants
- analog output mapping and scaling (range limits)
- analog output adjust-pace
- analog input mapping
- burette size / burette refill-speed
- stirrer-speed (manual)

Downloading of the program-array (i.e. sending it to the analyzer) is only allowed when the user-interface is in the MAIN-menu. In all other menus error-53 (download error) or error-56 (command data only allowed in main/run-menu) will be returned.

Since the size of the program-array is too big to fit in a single data-section, the ADI-protocol must use the UNIT-mode to exchange the complete program-array.

*Exampl*e of a request of the program-array (upload):

command: F3.1C
reply: F3.1U1A0@0@0@0@0@ ... 0@

The strange characters in the data-section are the program-bytes in the ADI-coded format. A
program-byte can not be transmitted immediately (un-translated) since 8-bits will not fit in a 7-bit
data-format (when 7 data-bits are selected) and when 8-bits are selected it will conflict with the
ADI-protocol (e.g. 0Dhex can both be <CR> and a program-byte). Therefore the program-byte is coded into ASCII-characters; two ASCII-characters are used to represent one program-byte.

The program-byte is first split into a low-nibble (4 lowest bits) and a high-nibble (4 highest bits); the value of the low-nibble is added to the ASCII-character '0', this creates a character in the range 30hex .. 3Fhex (0..?), this character is transmitted first. The value of the high-nibble is added to the ASCII-character '@', this creates a character in the range 40hex..4Fhex (@ .. O), this character is transmitted as second.

This coding serves two purposes, the program-byte is transmitted in ASCII-format, the order of the
nibbles can be guarded by checking the range of the received characters (high-nibble follows low-nibble).

When the HOST acknowledges the first unit, the second one is returned automatically by the analyzer:
command: F3.1U1C
reply: F3.1U2C0@0@0@0@0@ ... 0@
This handshake continues until the last unit is send by the analyzer:
command: F3.1U11C
reply: F3.1U0C0@0@0@0@0@ ... 0@
Unit-number 0 marks the last unit. The host should not acknowledge the last unit.

The REPEAT-command can be used to request the last unit (i.e previous unit) one more time, in case an error has occurred in the reception of the reply:
command: F3.1U0CR
reply: F3.1U0C0@0@0@0@0@ ... 0@
The REPEAT-command can be repeated indefinitely.

When the program-array is downloaded, the host must send the program-array in units to the analyzer, starting with unit-1. This differs from the upload-process where the host first requested the program-array without an unit-number.
command: F3.1U1C0@0@0@0@0@ ... 0@
reply: F3.1U1A

Now it is the analyzer which acknowledges the unit and requests for the next one. In theory it is possible for the analyzer to request the unit one more time (repeat), however the analyzer firmware will not do so. The download process continues until the last unit is send by the host; the analyzer replies in the usual way:
command: F3.1U0C0@0@0@0@0@ ... 0@
reply: F3.1U0A

The unit-mode is strictly guarded by the firmware. The host should always acknowledge with the same unit-number; if the unit-number is different, error-39 will be returned.

If the host does not acknowledge the unit but requests something else (another function-code), error-39 will be returned.
If the host starts sending a unit other than the first unit, error-39 will be returned.
If the next unit send by the host is not the successor of the previous unit, error-39 will be returned.
Whenever error-39 is returned, the Unit-mode is reset; the host must start the up-/ download-process from the very beginning again.

Also the download-process itself is guarded by the firmware.
When the first unit is attempted to be downloaded, the firmware checks to see that:

- the analyzer is not running
- the user is logged-on

–the user is in the main-menu
–If one of these situations is not true, the download-process is aborted and error-53 is returned.
The format of the downloaded-data is checked to see that the proper coding is used (low-nibble 30..3F, high-nibble 40..4F); if an illegal character is received, or if the order of the characters is wrong, the download-process is aborted and error-53 is returned.

When the last unit is received, the firmware checks to see if exactly enough (all) program-bytes are
received, if more or less program-bytes are received the download-process is aborted and error-53 is
returned.
The downloaded program-array also contains a checksum in the last program-byte; this checksum
should be equal to the summed value of all program-bytes, if not the download-process is aborted and error-53 is returned.
If everything is OK, the buffered program-array is copied into the real program-memory; this sets the new program and utilities.

F3.3.X - Constant-X
To ask or change the value of a Constant.

The function codes and constants are:

F3.3.1 - Constant-1, Sample Volume (in ml)
F3.3.2 - Constant-2, Buffer Volume (in ml)
F3.3.3 - Constant-3, Standard Concentration
F3.3.4 - Constant-4, Slope Factor
F3.3.5 - Constant-5, Engineering Factor
F3.3.6 - Constant-6, Engineering Unit

Changing a constant is only possible when the analyzer is in the Main-menu, Run-menu or if the analyzer is running; if not, then Error 57 is send back.
Asking a constant is always possible.

The value of the Sample-Volume must be more then 0 ; if not, then Error 37 is send back.

The value of the Buffer-Volume must be more then or equal to 0 ; if not, then Error 37 is send back.

The value of the Concentration of Standard must be more then 0 ; if not, then Error 37 is send back.

The value of the Slope Factor must NOT be equal to 0 ; if not, then Error 37 is send back.

The value of the Engineering Factor must NOT be equal to 0 ; if not, then Error 37 is send back.

The value of the Engineering Unit is an index in the table with the possible units. The table below shows the relation between the value of the constant and the chosen unit

Engineering Unit Coding	
Value	Unit
1	*empty*
2	mol/l
3	mmol/l
4	g/l
5	mg/l
6	micro g/l
7	ppm
8	ppb
9	%

Fig. 114 Engineering Unit Coding

If the value of the Engineering Unit is not in the table above; then Error 37 is send back.

Example: the value of Sample Volume is 20.2 ml:
Asked with ASCII-coding:
PC: F3.1.1C
Analyzer: F3.1.1A20.2
Fast-Float:
PC: F3.1.1c
Analyzer: F3.1.1a:I9I1J1D

Example: the value of Sample Volume is changed into 20.8 ml:
Control (change) with ASCII-coding:
PC: F3.1.1C20.8
Analyzer: F3.1.1A
Fast-Float:
PC: F3.1.1c6F6F6J1D

8.3.5 Function group 4: Output control

4.1.3.X - Sample-X Result State (with: X= 1 or 2)
F4.1.3.1 - Sample-1 Result State.
F4.1.3.2 - Sample-2 Result State.
To ask the state of the Analysis result of Sample-1 (or Sample-2).
The state of the Analysis result consists of a byte-value (State Word) with State Flags.

Analysis Result State Word coding: construction of the State Word							
bit-7	bit-6	bit-5	bit-4	bit-3	bit-2	bit-1	bit-0
Action			Diagnostics	Out-of-Range	Too High	Too Low	Available

Fig. 115 Analysis result

The bits have the following meaning:

- Available

This bit is '1' when the analysis result is available. This bit is set to '0' at the start of the analysis-program and is set to '1' as soon as the MEASR macro has calculated the result.

- Too Low

This bit is '1' when in the OUTPUT macro is concluded that the value of the result is belowthe programmed Low Limit.

- Too High

This bit is '1' when in the OUTPUT macro is concluded that the value of the result is abovethe programmed High Limit.

- Out-of-Range

This bit is '1' when during the analysis the measured mV (sensor value) goes the wrong way (up instead of down, or down instead of up). (This can happen when the concentration of the sample is higher then the standard.)

- Diagnostics

This bit is set to '1' when the MEASR or the OUTPUT macro starts a Diagnostic cycle. In the first case because the result is Out-of-Range, in the second case because an alarm-limit is exeeded.

- Action

These bits contain the action that is taken as a consequence of the analysis result. The bits get a value in the MEASR macro or the OUTPUT-macro.The table below shows the coding of the Action bits:

State Word bits	Action
0 0 0	No Action
0 0 1	RAL-1 activated
0 1 0	RAL-2 activated
0 1 1	Both RAL relays activated
1 0 0	PAL initiated

Fig. 116 State word bits

Example:

ASCII-coding:
PC: F4.1.3.1C
Analyzer: F4.1.3.2A35

Fast-Float:
PC: F4.1.3.1c
Analyzer: F4.1.3.1a3B

F4.1.4.X - Sample-X Result Value (with: X= 1 or 2)
F4.1.4.1 - Sample-1 Result Value.
F4.1.4.2 - Sample-2 Result Value.

To ask the value of the Analysis result of Sample-1 (or Sample-2).
For the validity of this value see the Sample-X Result State Word (see F4.1.3.X). Only when bit-0 in the State-Word is '1' , a result is available (from the MEASR macro). Only when also bit-3 is '0' - so no Out-of-Range - there is a valid value.

Example: the value of Sample-1 is 20.2:
ASCII-coding:
PC: F4.1.4.1C
Analyzer: F4.1.4.1A20.2
Fast-Float:
PC: F4.1.4.1c
Analyzer: F4.1.4.1a:I9I1J1D

F4.1.5.1/4 - Calibration Result State, Slope-X (with: X= 1, 2, 3 or 4)
To ask the state of the value of Slope-1 ... Slope-4 (Calibration result) in the last Reference-Run. The state is send back as a byte-value which is a State Word.
The construction of the State Word is described at F4.1.3.X (Sample-X Result State). In the case of the Calibration Result (the Slope) are only the bits Available (0), Too Low (1) and Too High (2) of importance.
When the result is outside the alarm-limits then is the Action always PAL (100)

F4.1.5.5/8 - Mean Calibration Result State, Slope-X (with: X= 5, 6, 7 or 8)
To ask the state of the average value of Slope-1 ... Slope-4 of the Calibration result.
Because no alarm limits are used on this result, only 1 state-bit is used; the Available bit. Like all other booleans the state is a string, so a '0' or a '1'.

F4.1.6.1/4 - Calibration Result Value (in mV/dec)
To ask the value of Slope-1 ... Slope-4 in the Calibration result in the last Reference-Run.
For the validity of this value see the Calibration Result State Word (F4.1.5.1).
Only when bit-0 in the State-Word is '1' , a result is available (from the CALIB macro). This bit is set to '0' at the beginning of every Reference run.

F4.1.6.5/8 - Mean Calibration Result Value (in mV/dec)
To ask the value of Slope-1 ... Slope-4 in the average Calibration result.
For the validity of this value see the Mean Calibration Result State Flag (F4.1.5.5/8). Only when this is '1' , an average result is calculated by the CALIB macro. This bit is set to '0' at the beginning of the first Reference run in the sequence according to the run-ratio's.

8.3.6 Function group 5: Outputs

F5.1.1 - Analog-Output 1, Output-Value
This value has the range 0 to 100 % (percent of full-scale).
Control is only possible when the analyzer is in the Main menu or Run menu, if not; Error 57 is send back.
When the hardware is not installed and Analog-Output 1 is accessed, then Error 31 is send back. (Use F0.6.1.1 to determine if the hardware for Analog-Output 1 is present.)

Example:
Ask with ASCII-coding:
PC: F5.1.1C (request value Output-1)
Analyzer: F5.1.1A50.2 (value = 50.2 %)
Fast-Float:

PC: F5.1.1c
Analyzer: F5.1.1a=L<L8D2D (value = 50.2 %)
Control (change) with ASCII-coding:
PC: F5.1.1C34.8 (set Output-1 to 34.8%)
Analyzer: F5.1.1A
Fast-Float:
PC: F5.1.1c3C3C;@2D (value = 34.8 %)
Analyzer: F5.1.1a

F5.1.2 - Analog Out 2 Value
See F5.1.1 (Use F0.6.1.2 to determine if the hardware for Analog-Output 2 is present)

F5.2.x - Digital-Output x, Status
Coding: Åe1' = Active (seen from the software point of view)
These digital outputs / software function-codes are:

F5.2.1 - PAL-relay state
F5.2.2 - RAL-1 relay state
F5.2.3 - RAL-2 relay state
F5.2.4 - Extern-1 relay state
F5.2.5 - Running relay state

Example:
ASCII-coding:
PC: F5.2.1C
Analyzer: F5.2.1A1

F5.2.6 - Measurement Busy State
To ask the Measurement Busy State of the analyzer. The Measurement Busy State indicates that the
analyzer is busy with a measurement (analysis or calibration).

Example:
ASCII-coding:
PC: F5.2.6C
Analyzer: F5.2.6A1

F5.3.x - Relay state
Coding: Åe1' = Active (seen from the software point of view)
These relays are:

F5.3.1 - Extern-1 relay state
F5.3.2 - Extern-2 relay state
F5.3.3 - Extern-3 relay state
F5.3.4 - GPO-1 relay state
F5.3.5 - GPO-2 state

Note:
- Any Extern-output can only be controlled when the analyzer is:
  - in the Main- or Run-menu, or
  - running.

If the Extern-output can not be controlled; Error 57 is send back.
- The GPO-2 output can be controlled in the analyzer. This function is not to be used as control in the analyzer.

Example:
Ask with ASCII-coding:
PC: F5.3.1C
Analyzer: F5.3.1A1

Control (activate) with ASCII-coding:
PC: F5.3.1C1
Analyzer: F5.3.1A

F5.5 - Digital Output State Flags
To ask the state of several digital inputs (all at once).

Digital Output State Flags: function of the bits in the State Word							
bit-7	bit-6	bit-5	bit-4	bit-3	bit-2	bit-1	bit-0
GPO-2	Extern-2	Extern-3	Backlight	Running	RAL-1	RAL-2	PAL
bit-15	bit-14	bit-13	bit-12	bit-11	bit-10	bit-9	bit-8
Extern-1	n/a	n/a	n/a	n/a	n/a	GPO-1	n/a

Fig. 117 Digital Outputs

PAL:
The state of the PAL (Processing ALarm) output. (from the perspective of the software)
RAL-2:
The state of the RAL-2 (Result ALarm-2) output. (from the perspective of the software)
RAL-1:
The state of the RAL-1 (Result ALarm-1) output. (from the perspective of the software) Running This bit contains the state of the Running output. (from the perspective of the software)
Back light:
This bit contains the state of the Back light control of the analyzer-display .
Extern-3:
This bit contains the state of the Extern-3 output.
Extern-2:
This bit contains the state of the Extern-2 output.
GPO-2:
This bit contains the state of the Heater output. Because the Heater output is only used in the analyzer, it is available as GPO-2 (General Purpose Output) in the analyzer.
GPO-1:
This bit contains the state of the GPO-1 output.
Extern-1:
This bit contains the state of the Extern-1 output.

Example: Extern-1 and the Backlight are activated:
ASCII-coding:
PC: F5.5C
Analyzer: F5.5A-32752
Fast-Float:
PC: F5.5c
Analyzer: F5.5a0A0H

F5.6 - Device State Flags
To ask the state of all internal digital outputs (Valve/Pumps and Stirrer) all at once.

Device State Flags: The function of the bits in the State Word							
bit-7	bit-6	bit-5	bit-4	bit-3	bit-2	bit-1	bit-0
Stirrer	Pipette	Sample-2	Sample-1	Rinse	Drain	Buffer	Blank
bit-15	bit-14	bit-13	bit-12	bit-11	bit-10	bit-9	bit-8
n/a	n/a	BV-2	n/a	BV-1	n/a	Bur.Dir	Bur.Active

Fig. 118 Device State Flags

Bur.Act:
This bit contains the state of the *ENA* signal that is being used in the control of the Burette step-motor.
Bur.Dir:
This bit contains the state of the *DIR* signal that is being used in the control of the Burette step-motor.
BV-1:
This bit contains the state of the *IN1* signal that is being used in the (direction)control of the Burette Valve.
BV-2:
This bit contains the state of the *IN2* signal that is being used in (direction)the control of the Burette Valve.

8.3.7 Function group 6: Run control

F6.1.1.x - Start the Analyzer with Start Command X
These function-codes start the run-process by initiating a Start-Command. These Start-Commands are:

F6.1.1.1 - START command (use Run-Rato- Selection)
F6.1.1.2 - start execution of the ANALYSIS run
F6.1.1.3 - start execution of the REFERENCE (=calibration) run
F6.1.1.4 - start execution of the CLEANING run

These commands function only when the analyzer is in the Main-menu or Run-menu, if not Error 57 is send back.

Example:
PC: F6. 1.1.1C
Analyzer: F6.1.1.1A

F6.1.2 - Emergency Stop
To generate an Emergency Stop.
This command functions only when the analyzer is in the Main-menu, Run-menu or if the analyzer is running, if not Error 57 is send back.

Example:
PC: F6.1.2C
Analyzer: F6.1.2A

F6.1.3.1 - Stop Running
To stop the running of the analyzer (execution of the Macro program(s)) at the end of the cycle.

This command functions the same as the Stop key (F5) on the key board.
This command functions only when the analyzer is running, if not Error 52 is send back.

Example:
PC: F6.1.3.1C
Analyzer: F6.1.3.1A

F6.1.3.2 - Continue Running
To continu the execution of the program(s) that was running when the analyzer was ordered to Stop. This command functions the same as the Continue key (F5) on the key board.
This command functions only when the analyzer is in the Main-menu or Run-menu, if not Error 57 is send back.

Note:
- When no programma was executed and stopped, then the Start Run-Ratio function will be executed.
- When the Cycle-Limit is reached, this function can not be performed. In this case the RUN-menu is shown in the display of the analyzer. No Error is given.

Example:
PC: F6.1.3.2C
Analyzer: F6.1.3.2A

F6.1.4 - Last Run Command
To ask the command that started the execution of the program.

Code	Run Command
0	No Run Command
1	Start Run-Ratio
2	Start Analysis
3	Start Reference
4	Start Cleaning

Fig. 119 Run Command

The 'Last Run-Command' is reset (to '0') by an Emergency-Stop.

Example: the Last Run-Command is Start Run-Ratio:
ASCII-coding:
PC: F6.1.4C
Analyzer: F6.1.4A1
Fast-Float:
PC: F6.1.4c
Analyzer: F6.1.4a1@

F6.2.1.x - Run Ratio

These function-codes can be used to ask or change the Run-Select-Ratio of the several runs.
These Run-Ratios are:
F6.2.1.1 - Analysis-Run ratio

F6.2.1.2 - Reference-Run ratio
F6.2.1.3 - Cleaning-Run ratio

The Ratio can only be changed when the analyzer is in the Main-menu or Run-menu or when the analyzer is running. If not; Error 57 is send back.
When (writing) the value is outside the range 0 ... 9999 then Error 37 is send back.

Example:
Ask with ASCII-coding (Value = 1):
PC: F6.2.1.1C
Analyzer: F6.2.1.1A1
Fast-Float:
PC: F6.2.1.1c
Analyzer: F6.2.1.1a1@0@

Control (change value into 1) with ASCII-coding:
PC: F6.2.1.1C1
Analyzer: F6.2.1.1A
Fast-Float:
PC: F6.2.1.1c1@0@
Analyzer: F6.2.1.1a

F6.2.2 - Cycle Time
To ask or change the Cycle-Time of the Macro programs (Ref, Ana and Clean).
The range of the Cycle-Time is from 0 up to1440 minutes. The value 0 is interpreted as ’no Cycle-Time’.
The Ratio can only be changed when the analyzer is in the Main-menu or Run-menu or when the analyzer is running. If not Error 57 is send back.
When, writing, the value is outside the range 0..1440 then Error 37 is send back.

Examples:
Ask the Cycle-Time with ASCII-coding:
PC: F6.2.2C
Analyzer: F6.2.2A15
Fast-Float:
PC: F6.2.2c
Analyzer: F6.2.2a?@0@
Control (change) with ASCII-coding:
PC: F6.2.2C15
Analyzer: F6.2.2a
Fast-Float:
PC: F6.2.2c?@0@
Analyzer: F6.2.2a

F6.2.3.x - Cycle-Limit
These function-codes can be used to ask or change the Cycle-Limit for a specific run.
F6.2.3.1 - Run-Ratio Cycle Limit
F6.2.3.2 - Cycle Limit Analysis Program
F6.2.3.3 - Cycle Limit Reference Program
F6.2.3.4 - Cycle Limit Cleaning Program
The Cycle-Limit (and the Cycle-Counter) has a range from 1 up to 99999. The value 0 is interpreted as no limit.
The Cycle-Limit only can be changed when the analyzer is in the Main-menu or Run-menu, or when the analyzer is running. If not; Error 57 is send back
When the value is outside the range 0..99999 ; Error 37 is send back.

Example: Ask the Cycle-Limit:
ASCII-coding:
PC: F6.2.3.1C
Analyzer: F6.2.3.1A10000
Fast-Float:
PC: F6.2.3.1c
Analyzer: F6.2.3.1a0@0D<A6D

Change the Cycle-Limit in 10000:
Control (change) with ASCII-coding:
PC: F6.2.3.1C10000
Analyzer: F6.2.3.1A
Fast-Float:
PC: F6.2.3.1c0@0D<A6D
Analyzer: F6.2.3.1a

F6.2.4.X - Sample-X Selection-Ratio (With: X = 1 or 2)
F6.2.4.1 - Sample-1 Selection-Ratio
F6.2.4.2 - Sample-2 Selection-Ratio
To ask or change the Sample-Selection Ratio of Sample-1 or Sample-2.
Operation: Main or Run menu: The Ratio can only be changed when the analyzer is in the Main-menu or Run-menu; if not, then Error 57 is send back.

Note:
- When both Sample Selection Ratio's have the value 0 then; at the beginning of the Analysis run the PAL ALL SAMPLE-SELECTS ZERO is generated.

Examples:
Ask with ASCII-coding:
PC: F6.2.4.1C
Analyzer: F6.2.4.1A1
Fast-Float:
PC: F6.2.4.1c
Analyzer: F6.2.4.1a1@0@
Control (change) with ASCII-coding:
PC: F6.2.4.1C1
Analyzer: F6.2.4.1A
Fast-Float:
PC: F6.2.4.1c1@0@
Analyzer: F6.2.4.1a

F6.3.1.x - last PAL information
To ask information about the last PAL.
When a PAL terminates a run, the information about the current status of the run is saved (as the last PAL information). This information can be requested later.
These function-codes can only be used when the analyzer has stopped. When the analyzer is running; Error 51 is send back.

The following information is available:

F6.3.1.1	- last PAL, macro-number	1-byte signed integer [1..32]
F6.3.1.2	- last PAL, macro-action	1-byte integer (analyzer-model specific signed 8 bit). The macro that was active at the moment that a PAL stopped the execution of the program. The coding of the Macro-Actions is described at F6.3.3.2 RUN Macro-Action.
F6.3.1.3	- last PAL, macro-time	2-byte integer (signed 16-bits) (in seconds) The Macro-Time can be up- or down-counting, this depends on the Macro-Action.
F6.3.1.4	- last PAL, run-type	1-byte integer (signed 8 bit) The three possibilities are: 1 - Analysis Program 2 - Reference Program 3 - Cleaning Program
F6.3.1.5	- last PAL, cycle-counter	floating-point [0..99999]
F6.3.1.6	- last PAL, Sample-Selection	To ask the selected sample stream at the moment that a PAL stopped the execution of the program. The value 1 indicates Sample-1 was selected, the value 2 indicates Sample-2 was selected.
F6.3.1.7	- last PAL, PAL-code	1-byte unsigned 8 bit. The PAL Code is analyzer-model specific and is described per analyzer at F0.5.3.
F6.3.1.8	- PAL Display	String, 40 characters. Contains the upper display-line at the moment that a PAL terminated the execution of a programma.
F6.3.1.9	- PAL Arithmetic Error Info	Word, 2-byte integer (unsigned 16-bits). Contains information about the Arithmetic Error that caused the PAL. See F0.5.4 for more information.

Fig. 120 Function-codes of PAL, macro-number

Example:
ASCII-coding:
PC: F6.3.1.2C
Analyzer: F6.3.1.2A3
Fast-Float:
PC: F6.3.1.2c
Analyzer: F6.3.1.2a3@

F6.3.2.1 - RAL-1 Limit Exceeding
F6.3.2.2 - RAL-2 Limit Exceeding
To ask the amount of limit-exeeding of the alarm-limit that resulted in the activation of RAL-1 (RAL-2.).
When a RAL-relay is active, the value this function returns does not have to be the value that caused the RAL-relay to be activated; new causes could have arisen without the RAL-relay being de-activated.

Example:
ASCII-coding:
PC: F6.3.2.1C
Analyzer: F6.3.2.1A1.234
Fast-Float:
PC: F6.3.2.1c
Analyzer: F6.3.2.1a1@0@0@0@

F6.3.3.0 - RUN State
To ask the present Run-State.

This function-code can only be used when the analyzer is running. If not, Error 52 is send back.

F6.3.3.0 - Run State Flags: the function of the bits in the State Word							
bit-7	bit-6	bit-5	bit-4	bit-3	bit-2	bit-1	bit-0
Stopping	Frozen	Running	Single Cycle	Diagnostics		Run-Type	

Bit 0/1: Run-Type	These 2 bits together contain the active run-type. 0 - No Run Selection 1 - Analysis Run 2 - Reference Run / Diagnostics Run 3 - Cleaning Run
Bit 2/3: Diagnostics	These 2 bits together contain the Diagnostics action (selcted by the Analyze run). 0 - No Diagnostics 1 - Diagnostics 1 (Diagnostics Run only) 2 - Diagnostics 2 (Cleaning + Diagnostics)
Bit-4: Single Cycle	This bit contains the Single-Run state. This bit has the value '1' when by Remote (hardware) control only one Analyse cycle is executed.
Bit-5: Running	This bit contains the Running state. This bit is '1' when the analyzer is executing one or more programs (per ratio).
Bit-6: Frozen	This bit is '1' when the analyzer is in the so-called Frozen state. This happens when during running the timers are halted with the Main + Up keys on the analyzer key board
Bit-7: Stopping	This bit contains the Stopping state. When this bit is '1' the analyzer will stop running at the end of the present Run Cycle.

Fig. 121 Function-code of Run State

Example:

ASCII-coding:
PC: F6.3.3.0R
Analyzer: F6.3.3.0A0
Fast-Float:
PC: F6.3.3.0r
Analyzer: F6.3.3.0a0@

F6.3.3.1 - RUN Macro-Number

To ask the Macro-Number of the macro that is at the moment active.
The range of the Macro-Number is 1 to 32.
This function-code can only be used when the analyzer is running. If not, Error 52 is send back.

Example:

ASCII-coding:
PC: F6.3.3.1C
Analyzer: F6.3.3.1A5
Fast-Float:
PC: F6.3.3.1c

Analyzer: F6.3.3.1a1@

F6.3.3.2 - RUN Macro-Action
To ask which Macro-Action of the macro is now active.
The Macro-Action is analyzer-model specific.
This function-code can only be used when the analyzer is running. If not, Error 52 is send back.
The Macro-Action is specified by a 1-byte integer value and is analyzer specific.
The table below gives an overview of the Macro-Actions:

Value	Macro-Action	Macro-Time
1	DRAIN	Down
2	RINSE	Down
3	SAMPLE	Down
4	BLANK	Down
5	BUFFER	Down
6	WAIT	Down
7	FLUSH	Down
8	MEASURe	Up

Value	Macro-Action	Macro-Time
9	CALIBrate	Up
10	OUTPUT	Down
11	EXTeRN-1	Parallel
12	BURET	Up
13	EXTeRN-2	Parallel
14	EXTeRN-3	Parallel
15	IDLE	???

Fig. 122 Overview of the Macro-Actions

Example:
ASCII-coding:
PC: F6.3.3.2C
Analyzer: F6.3.3.2A3
Fast-Float:
PC: F6.3.3.2c
Analyzer: F6.3.3.2a3@

F6.3.3.3 - RUN Macro-Time
To ask the Macro-Time (in seconds) of the active macro.
The Macro-Time can be up- or down-counting, this depends of the Macro-Action.
This function-code can only be used when the analyzer is running. If not, Error 52 is send back.

Example:
ASCII-coding:
PC: F6.3.3.3C
Analyzer: F6.3.3.3A25
Fast-Float:
PC: F6.3.3.3c
Analyzer: F6.3.3.3a9A0@

F6.3.3.4 - RUN Run-Type
To ask the active program.
The three possible answers are:
1 - Analysis Program
2 - Reference Program
3 - Cleaning Program
This function-code can only be used when the analyzer is running. If not, Error 52 is send back.

Example:

The selected program is asked with ASCII-coding:

PC: F6.3.3.4C

Analyzer: F6.3.3.4A1

Fast-Float:

PC: F6.3.3.4c

Analyzer: F6.3.3.4a1@

F6.3.3.5 - RUN Cycle-Counter

To ask the value of the actual Cycle-Counter.

The Cycle-Counter can be 0 up to maximal 99999.

This function-code can only be used when the analyzer is running. If not, Error 52 is send back.

Example:

ASCII-coding:

PC: F6.3.3.5C

Analyzer: F6.3.3.5A125

Fast-Float:

PC: F6.3.3.5c

Analyzer: F6.3.3.5a1@0@0@0@

F6.3.3.6 - RUN Sample-Selection

To ask which samplestream is now selected.

The value 1 indicates Sample-1 is selected, the value 2 indicates Sample-2 is selected.

F6.3.3.8 - RUN Macro-Number & Action

To ask the active Macro-Number and the active Macro-Action.

This function-code can only be used when the analyzer is running. If not, Error 52 is send back.

The format: The value is a 2-byte integer (signed 16-bits). BUT should be interpreted as a 16-bits UNsigned integer. From these 16 bits two separate 8-bits bytes must be made. The Macro-Number is contained in the most significant byte, the Macro-Action in the least significant byte. Use of the Fast-Float notation is recommended.

The meaning of the send values are identical to the values from F6.3.3.1 and F6.3.3.2.

The coding of the Macro-Action is analyzer-model specific.

Example:

ASCII-coding:

PC: F6.3.3.8C

Analyzer: F6.3.3.8A261

Fast-Float:

PC: F6.3.3.8c

Analyzer: F6.3.3.8a5@1@

8.4 Code tables

ADI 2018-HD V2 Overview of all supported function-codes			
F-Code	**Action**	**Direction**	**Format**
F0	Cancel All	Command	implicit (no data)
F0.0.0.0	Silent Ping	Read/Write	string
F0.0.0.1	Noisy Ping	Read/Write	string
F0.1.1	Uref	Read	floating point value (32-bits)
F0.1.2	Ubat	Read	floating point value (32-bits)
F0.2.1	Device-Code	Read	string
F0.2.2	Version	Read	string
F0.2.3	Analyzer-Nbr	Read	byte (unsigned 8-bits)
F0.2.4	Checksum Tested OK	Read	string (boolean, '0' or '1')
F0.2.5	System Options	Read	byte (unsigned 8-bits)
F0.3	Date & Time	Read/Write	string
F0.4.1.1	Display Line-1	Read	string (40 characters)
F0.4.1.2	Display Line-2	Read	string (40 characters)
F0.4.2	Keyboard Emulation	Write	string (1 character)
F0.4.3	Backlight	Read/Write	string (boolean, '0' or '1')
F0.5.1	Analyzer State Flags	Read	byte (unsigned 8-bits)
F0.5.2	Analyzer Menu Flags	Read	byte (unsigned 8-bits)
F0.5.3	Last PAL Code	Read	byte (unsigned 8-bits)
F0.5.4	Artihmetic Fatal Error Info	Read	word (unsigned 16-bits)
F0.6.1.1	Analog-Output 1 Present	Read	string (boolean, '0' or '1')
F0.6.1.2	Analog-Output 2 Present	Read	string (boolean, '0' or '1')
F1.1.2	Sensor-value mV input	Read	floating point value (32-bits)
F1.1.3	Sensor-value Temperature input	Read	floating point value (32-bits)
F1.2.0	Digital Input State Flags	Read	byte (unsigned 8-bits)
F1.2.1	Sample-Pump Inhibit State	Read	string (boolean, '0' or '1')
F1.2.2	Leak Detector State	Read	string (boolean, '0' or '1')
F1.2.3	Control Power State	Read	string (boolean, '0' or '1')
F1.2.4	General Input State	Read	string (boolean, '0' or '1')
F1.2.5	Remote Start/Continue State	Read	string (boolean, '0' or '1')
F1.2.6	Remote Stop State	Read	string (boolean, '0' or '1')
F1.2.7	Remote E-Stop State	Read	string (boolean, '0' or '1')
F2.1.2.1	mV-Sensor calibration, Slope	Read	floating point value (32-bits)
F2.1.2.2	mV-Sensor calibration, Offset	Read	floating point value (32-bits)
F2.1.3.1	Temp. Sensor calibration, Slope	Read	floating point value (32-bits)
F2.1.3.2	Temp. Sensor calibration, Offset	Read	floating point value (32-bits)
F3.1	Upload / Download	Read/Write	fast-float coded byte-array
F3.3.1	Constant-1, Sample Volume	Read/Write	floating point value (32-bits)
F3.3.2	Constant-2, Buffer Volume	Read/Write	floating point value (32-bits)
F3.3.3	Constant-3, Standard Concentration	Read/Write	floating point value (32-bits)
F3.3.4	Constant-4, Engineering Factor	Read/Write	floating point value (32-bits)

Fig. 123 Code tables, part 1

ADI 2018-HD V2 Overview of all supported function-codes			
F-Code	**Action**	**Direction**	**Format**
F3.3.5	Constant-5, Slope Factor	Read/Write	floating point value (32-bits)
F3.3.6	Constant-6, Engineering Unit	Read/Write	floating point value (32-bits)
F4.1.3.1	Sample-1 Result State	Read	byte (unsigned 8-bits)
F4.1.3.2	Sample-2 Result State	Read	byte (unsigned 8-bits)
F4.1.4.1	Sample-1 Result Value	Read	floating point value (32-bits)
F4.1.4.2	Sample-2 Result Value	Read	floating point value (32-bits)
F4.1.5.1	Calibration State, Slope-1	Read	byte (unsigned 8-bits)
F4.1.5.2	Calibration State, Slope-2	Read	byte (unsigned 8-bits)
F4.1.5.3	Calibration State, Slope-3	Read	byte (unsigned 8-bits)
F4.1.5.4	Calibration State, Slope-4	Read	byte (unsigned 8-bits)
F4.1.5.5	State Mean Calibration, Slope-1	Read	string (boolean, '0' or '1')
F4.1.5.6	State Mean Calibration, Slope-2	Read	string (boolean, '0' or '1')
F4.1.5.7	State Mean Calibration, Slope-3	Read	string (boolean, '0' or '1')
F4.1.5.8	State Mean Calibration, Slope-4	Read	string (boolean, '0' or '1')
F4.1.6.1	Calibration-Result, Slope-1,Value	Read	floating point value (32-bits)
F4.1.6.2	Calibration-Result, Slope-2, Value	Read	floating point value (32-bits)
F4.1.6.3	Calibration-Result, Slope-3,Value	Read	floating point value (32-bits)
F4.1.6.4	Calibration-Result, Slope-4, Value	Read	floating point value (32-bits)
F4.1.6.5	Mean Value, Slope-1 Value	Read	floating point value (32-bits)
F4.1.6.6	Mean Value, Slope-2 Value	Read	floating point value (32-bits)
F4.1.6.7	Mean Value, Slope-3 Value	Read	floating point value (32-bits)
F4.1.6.8	Mean Value, Slope-4 Value	Read	floating point value (32-bits)
F5.1.1	Analog Out 1 Value	Read/Write	floating point value (32-bits)
F5.1.2	Analog Out 2 Value	Read/Write	floating point value (32-bits)
F5.2.1	PAL-relay state	Read	string (boolean, '0' or '1')
F5.2.2	RAL-1 relay state	Read	string (boolean, '0' or '1')
F5.2.3	RAL-2 relay state	Read	string (boolean, '0' or '1')
F5.2.4	Extern-1 relay state	Read	string (boolean, '0' or '1')
F5.2.5	Running state	Read	string (boolean, '0' or '1')
F5.2.6	Measurement Busy	Read	string (boolean, '0' or '1')
F5.3.1	Extern-1 relay state	Read/Write	string (boolean, '0' or '1')
F5.3.2	Extern-2 relay state	Read/Write	string (boolean, '0' or '1')
F5.3.3	Extern-3 relay state	Read/Write	string (boolean, '0' or '1')
F5.3.4	GPO-1 relay state	Read/Write	string (boolean, '0' or '1')
F5.3.5	GPO-2 relay state	Read/Write	string (boolean, '0' or '1')
F5.5	Digital Output State Flags	Read	word (unsigned 16-bits)
F5.6	Device State Flags	Read	word (unsigned 16-bits)
F6.1.1.1	Start Run-Ratio	Command	implicit (no data)
F6.1.1.2	Start Analysis Program	Command	implicit (no data)
F6.1.1.3	Start Reference Program	Command	implicit (no data)
F6.1.1.4	Start Cleaning Program	Command	implicit (no data)
F6.1.2	Emergency Stop	Command	implicit (no data)
F6.1.3.1	Stop Runnning	Command	implicit (no data)
F6.1.3.2	Continue Running	Command	implicit (no data)
F6.1.4	Last Run Command	Read	byte (unsigned 8-bits)
F6.2.1.X	Run-Ratio Program-X	Read/Write	integer (signed 16-bits)
F6.2.2	Cycle Time	Read/Write	integer (signed 16-bits)

Fig. 124 Code tables, part 2

ADI 2018-HD V2 Overview of all supported function-codes

F-Code	Action	Direction	Format
F6.2.3.1	Run-Ratio Cycle Limit	Read/Write	floating point value (32-bits)
F6.2.3.2	Cycle-Limit Analysis Program	Read/Write	floating point value (32-bits)
F6.2.3.3	Cycle-Limit Reference Program	Read/Write	floating point value (32-bits)
F6.2.3.4	Cycle Limit Cleaning Program	Read/Write	floating point value (32-bits)
F6.2.4.1	Sample-1 Selection Ratio	Read/Write	integer (signed 16-bits)
F6.2.4.2	Sample-2 Selection Ratio	Read/Write	integer (signed 16-bits)
F6.3.1.1	PAL macro-number	Read	integer (signed 8-bits)
F6.3.1.2	PAL macro-action	Read	integer (signed 8-bits)
F6.3.1.3	PAL macro-time	Read	integer (signed 16-bits)
F6.3.1.4	PAL run-type	Read	integer (signed 8-bits)
F6.3.1.5	PAL cycle-counter	Read	floating point value (32-bits)
F6.3.1.6	PAL sample-selection	Read	integer (signed 8-bits)
F6.3.1.7	PAL code	Read	byte (unsigned 8-bits)
F6.3.1.8	PAL display	Read	string
F6.3.1.9	PAL Arithmetic Error Code	Read	word (unsigned 16-bits)
F6.3.2.1	RAL-1 Limit Exceeding	Read	floating point value (32-bits)
F6.3.2.2	RAL-2 Limit Exceeding	Read	floating point value (32-bits)
F6.3.3.1	RUN macro-number	Read	integer (signed 8-bits)
F6.3.3.2	RUN macro-action	Read	integer (signed 8-bits)
F6.3.3.3	RUN macro-time	Read	integer (signed 16-bits)
F6.3.3.4	RUN run-type	Read	integer (signed 8-bits)
F6.3.3.5	RUN cycle-counter	Read	floating point value (32-bits)
F6.3.3.6	RUN sample-selection	Read	integer (signed 8-bits)
F6.3.3.8	Run, Macro Number & Action	Read	See text

Fig. 125 Code Tables, part 3

Note:

- It is recommended to use FAST-FLOAT MODE (if possible) to transfer data. The Fast-Float mode is NOT possible for TEXT.If the Fast-Float protocol is used then there is no probleem with signed/unsigned as long as the data-bytes are placed directly in the memory-area of the concerning variable. The type of this variable must match the type according to the table above.
- An integer is always converted signed to ASCII. So, when a byte-value is larger then 127, it is shown as a negative number between -1 and -128. When a word-value is larger then 32767 it is shown as a negative number between -1 and -32768.
- If the format of a functioncode is described as unsigned the table above, then should it (after reception of the ASCII-data) first be converted.
- If a functioncode has Direction: Read/Write then the action can be asked or changed. If a functioncode has Direction: Read then the action can only be asked.
- Format: An Integer is ALWAYS signed.
- Whenever a number is returned (float or integer) the leading spaces in the number are removed, the formats listed above are therefore the maximum lengths (the real length may be shorter).
- A float can be commanded or requested using the ADI-coded format. Then a 8-character string will be send/returned which represents the 4-byte IEEE floating-point number. This will save time since the ADI-format <-> IEEE conversion will take less time than the ASCII <-> IEEE conversion.
- It is also possible to command or request an integer in this format, this is not recommended since the conversion float -> integer will take more time than the ascii -> integer conversion so no time improvement will be made.
- The Up- & Downloading of the Program-Array (F3.1) uses a special type of ADI-coding; just like the floating-point numbers each byte is represented by 2 characters. In this case not only 4, but the complete program-array is con-

verted into one big string. This strings has, for example, the length of 1348 characters. This exceeds the maximum of 128 characters per message, so the actual data-size will be reduced to 110 characters. Up- & Downloading will therefore be done in (at least) 13 UNITS.

8.5 Error codes

Whenever an error occurs in receiving or interpreting the command-string, the analyzer responds with an error-message. An error-message is coded by using an 'E' character at the position of the command separator:

<stx>[N*to*,*from*][M*module*][F*code*|B*code*|L*code*][U*unit*]E*code*<cr>[<lf>]

All sections, except the command-separator and the data-section (the error-code) are optional, even the function-code (e.g. Busy Error).

The data-section contains a number that represents an error-code. Each error (error-source) has its own error-code. These errors are:

8.5.1 Communication-line errors

- starting with 1

11 - parity error:
parity fault during the reception of the command-string; check for correct setting of the parity
(none, even, odd) on both devices (analyzer and host).

12 - framing error:
no stop-bit is, or not enough stopbits are, detected at the end of the character. Check the number of stop-bits (1 or 2) and data-bits (7 or 8) on both devices.

13 - USART overrun error:
a character of the command-string is not read in time (by the analyzer), the next character has overrun its predecessor; set the correct baud-rate (i.e. use a lower baudrate) or use handshake (Xon / X-off)

14 - receive buffer overrun:
the internal receive-buffer of the analyzer has been overrun; set the correct baud-rate (i.e. use a lower baudrate) or use handshake (X-on / X-off).

8.5.2 Data errors

- starting with 2

21 - syntax error:
the received command-string can not be interpreted by the analyzer.

22 - numerical error:
the numerical data in a section is not correct, the numeric-field (i.e the section where the number is expected) contains no numerical characters, contains a non-numerical character, or contains too much numerical-characters.

23 - internal buffer overflow:
too many data is send to the analyzer is one command-string. The maximum length of the command-string is 128 characters including the <stx> and <cr>. This is not the serial-input queue (described at error-14). At this stage each section uses its own buffer (the command- string is split into sections); if one section is too big for it's buffer, error-23 is generated.

24 - checksum error:
the received checksum is not correct.

25 - checksum expected / checksum not expected:
no checksum is received while expected or a checksum is received while not expected.

26 - fast-float error:
the data-section contains a character that is illegal for the fast-float notation, or the order of the characters of the fast-float notation is illegal. The fast-float notation uses characters in the range [30..4Fhex]; first [30..3Fhex] followed by [40..4Fhex].

8.5.3 Device errors

starting with 3

32 - parameter error:
the requested function-code (or block-code) does not exist in this instrument.

34 - busy error:
the analyzer is already (or still) busy with a command/request. This error is replied without the function-code since the analyzer has no time to decode the function-code; only the node-section will be decoded to see if the command-string was addressed to the analyzer.

35 - time-out error:
the analyzer has generated a time-out for the communication-task. It took too long to interpret a command and send the reply. When this error occurs, contact your nearest service office.

36 - incorrect command data setting:
tried to set a function that can not be set (e.g. setting an input), tried to read a parameter that can not be read (e.g. read the keyboard-emulation) or tried to set an implicit-command (e.g. set the Run-Start function)

37 - parameter data error:
illegal parameter data; not a correct number for the function (e.g. map analog-output to a non defined source or setting a Run-Ratio to -1).

39 - unit-mode error:
error in the Unit-mode handshaking. Not acknowledging a previous send unit, acknowledging with the wrong unit-number or function-code, starting with an unit other than unit-1. When this error occurs, the unit-mode is reset automatically.

8.5.4 Device specific errors

- starting with **5**

51 - analyzer running:
requesting or commanding a function that is not available when the analyzer is running (e.g. the continue-run command).

52 - analyzer not running:
requesting or commanding a function that is only available when the analyzer is running (e.g. the run-status).

53 - upload/download aborted
the upload/download process is aborted.

54 - arithmetic fatal error in communication task
an arithmetic fatal error has occurred in the communication task, so no valid data can be returned or no function can be set with valid data.

57 - command only allowed in Main/Run-menu
the functions in the analyzer can only be commanded (i.e data send to it) when the analyzer is in an idle-state, this is when the analyzer is in the MAIN-menu or in the RUN-menu.

Implicit commands (commands with no data) are also only allowed in the MAIN or RUN-menu.

The only exceptions are:

F0.4.2 - keyboard emulation:
allowed everwhere in order to create a remote humaninterface in conjunction with the display-request functions (F4.1.1.x).

F6.1.2 - Emergency Stop:
also allowed when the analyzer is running.

F6.3.1.2 - STOP Running: also allowed when the analyzer is running.

8.6 Examples

8.6.1 Examples of error messages

- **21: Syntax Error**

command: 3.1**H** (sending a H instead of C)
reply: 3.1HE21 (syntax error: Illegal Character in Command-String)

command: **b**3.1C
reply: 3.1E21 (syntax error: period (.) missing in instruction-item)

command: 3.1.1**.1**
reply: 3.1.1.1E21 (syntax error: more than 4 instruction-items)

command: 3.1U1**b**

reply: 3.1U1**b** (syntax error: illegal character in terminating Unit-Section)

command: 3.1
reply: 3.1E21 (syntax error: command separator missing)

- **22:Numeric Error**

command: **b**,2F3.3.1C
reply: 3.1E22 (numeric error: numeric data expected)

command: **b**2F3.3.1C
reply: 3.1E22 (numeric error: illegal character separating Node-Numbers)

command: 2**b**3.1C (send with analyzer-nbr set to 1)
reply: 3.1E22 (numeric error: illegal character terminating Node-Section)

command: **0000**1.1C
reply: 00001.1E22 (numeric error: too many digits in numerical data)

command: 3.1U**b**
reply: 3.1UbE22 (numeric error: numeric data expected)

command: 3.1C**lklk**
reply: 3.1E22 (numeric error: illegal characters in data-section)

command: 3.1C**--**10.000
reply: 3.1E22 (numeric error: more than 1 minus-sign in numeric data)

command: 3.1C10**..**000
reply: 3.1E22 (numeric error: more than 1 decimal-point in numeric data)

- **23: Internal Buffer Overflow**

command: **1,000002**3.1C
reply: 3.1E23 (buffer overflow: Node Buffer Overflow)

command: **3.3.2.3.4.5.6.7**
reply: 3.2.3.4.5.6.7E23 (buffer overflow: Instruction Buffer Overflow)

command: 3.1U**000**
reply: 3.1U000E23 (buffer overflow: Unit Buffer Overflow)

command: 3.1C/**0**@**0**@
reply: 3.1E23 (buffer overflow: Checksum Buffer Overflow)

- **24: CheckSum Error**

command: 3.1C/**0** (send while checksum is enabled on analyzer)
reply: 3.1E24 (checksum error: too few checksum characters)

command: 3.1C/0**Q** (send while checksum is enabled on analyzer)
reply: 3.1E24 (checksum error: illegal checksum character)

command: 3.1C/@**0** (send while checksum is enabled on analyzer) reply: 3.1E24 (checksum error: illegal checksum)

- **25: CheckSum (Not) Expected**

command: 3.1C (send while checksum is enabled on analyzer)
reply: 3.1E25 (checksum expected)

command: 3.1C**/8J** (send while checksum is disabled on analyzer)
reply: 3.1E25 (checksum NOT expected)

- **26: Fast Float Error**

command: 3.1c**0**@**0**@
reply: 3.1E26 (fast-float error: too few characters in fast-float)

command: 3.1c**0**@**0**@**0**@**0**@**0**@
reply: 3.1E26 (fast-float error: too many characters is fast-float)

command: 3.1c0@0@0**Q**0@
reply: 3.1E26 (fast-float error: illegal character in fast-float)

command: 3.1c@0@0@0@0
reply: 3.1E26 (fast-float error: characters in wrong order)

- **32: Function-Code does not exist**

command: **F0.1.3**C
reply: F0.1.3E32 (function-code does not exist on this device)

- **34: Busy Error**

command: F3.3.1C
command: **F3.3.2C** (send without waiting for reply on first command)

reply: E34 (busy error)
reply: F3.3.1C5000.0 (reply on first command)

- **36: Incorrect Command Data Setting**

command: F6.3.1.1C**5000**
reply: F6.3.1.1E36 (error: this parameter is read-only)

command: F0.4.2C
reply: F0.4.2E36 (error: this parameter is write-only)

command: F6.1.1.1C**1**
reply: F6.1.1.1E36 (error: this parameter is implicit)

- **37: Parameter Error**

command: F0.4.2C**K**
reply: F0.4.2E37 (parameter error: illegal keyboard-character)

command: F6.2.1.1C**12345**
reply: F6.2.1.1E37 (parameter error: should be in range [0..9999])

- **39: Unit-Mode Error**

command: F3.1**U2**0@0@ .. 0@
reply: F3.1U2E39 (unit-mode error: 1st unit should be Unit-1)

command: F3.1U1C0@0@0@0@0@0@0@0@0@0@
reply: F3.1U1A

command: F3.1**U1**C0@0@0@0@0@0@0@0@0@0@
reply: F3.1U1E39 (unit-error: should be unit-2)

command: F3.1U1C0@0@0@0@0@0@0@0@0@0@
reply: F3.1U1A

command: F3.1**U3**C0@0@0@0@0@0@0@0@0@0@
reply: F3.1U3E39 (unit-error: should be unit-2)

command: F3.1C
reply: F3.1U1A0@0@0@0@0@0@0@0@0@0@

command: F3.1U**2**C
reply: F3.1U2E39 (unit-error: acknowledge with wrong Unit-Number)

command: 1C
reply: 1U1A0@0@0@0@0@0@0@0@0@0@

command: **3.3.1**
reply: 3.1U1E39 (unit-error: acknowledge with wrong Instruction)

command: 1C
reply: 1U1A0@0@0@0@0@0@0@0@0@0@

command: **F3.3.1C**
reply: 3.1E39 (unit-error: no acknowledge on previous unit)

command: 1C
reply: 1U1A0@0@0@0@0@0@0@0@0@0@

command: 1U1C**0**@**0**@**0**@**0**@**0**@**0**@**0**@**0**@**0**@**0**@
reply: 1U1E39 (unit-error: data-section filled)

- **51: Analyzer Running**

command: 3.1.1C (request last PAL macro-number)
reply: 3.1.1E51 (error: analyzer should not be running)

- **52: Analyzer NOT Running**

command: 1.3.1 (stop running)
reply: 1.3.1E52 (error: analyzer not running)

- **53: Upload/Download Error**

command: 1U1C0@0@..0@ (start download while user is in run-menu)
reply: F3.1U1E53 (download error: analyzer not in main-menu)

command: 1U1C0@0@..0@ (start download while user is logged-out)
reply: 1U1E53 (download error: user logged-out)

command: 1U1C0**Z**0@0@0@
reply: 1U1E53 (download error: illegal character)

command: 1U1C0**0**0@0@0@

reply: 1U1E53 (download error: high-nibble should follow low-nibble)

command: 1U1C0@@@0@0@
reply: 1U1E53 (download error: low-nibble should follow high-nibble)

command: 1U1C0@0@0@0@
reply: 1U1A (ok, next unit please)

command: 1U0C0@0@ (send last unit with download-characters)
reply: 1U0E53 (download error: too few/too many download characters)

command: 1C0@0@0@0@0@0@0@0@0@0@
reply: 1E53 (download error: this function expects unit-mode when writing)

- **57: Command only allowed in main/run-menu**

command: F3.3.1C10 (set constant-1 to 10 while in Manual-Menu)
reply: F3.3.1E57 (command only allowed in main/run menu)

command: F6.2.2C60 (set cycle-time to 60 min. while running)
reply: F6.2.2E57 (command only allowed in main/run menu)

command: 1U1C0@0@..0@0@ (start download while not in main- or run-menu)
reply: 1U1E57 (command only allowed in main/run menu)
command: 1.1.1C (start running)
reply: 1.1.1E57 (command only allowed in main/run menu)

8.6.2 Practical Examples

1) A p.c. asks for the status of analysis result:
   question: <stx> F4.1.4.1C <cr>
   reply (o.k.) <stx> F4.1.4.1A 52.6 <cr> (means 52.6)
   reply (error) <stx> F4.1.4.1E xx <cr> (several error codes are possible)

2) In a network system, a p.c. (device 1) requires from device 13 the first Constant value:
   question: <stx> N13,1 F3.3.1 C <cr>
   reply: <stx> N1,13 F3.3.1 A 9.8 <cr>

3) Example of saving the user program of the Analyzer in the memory of the p.c.:
   question: <stx> F3.1 C <cr>
   reply: <stx> F3.1 U1 Axxxxxxx..xx <cr> (first 110 reply bytes)
   next request: <stx> F3.1 U1 C <cr> (acknowledgement of first package)
   next reply: <stx> F3.1 U2 Axxxxxxx..xx <cr> (second 110 reply bytes)
   next request: <stx> F3.1 U2 C <cr> (acknowledgement of second package)
   ......
   ......
   final reply: <stx> F3.1 U0 Axxxxxxx..xx <cr> (final reply bytes)

Note:
- The user program can be downloaded to the Analyzer again by sending the following command lines:
command: <stx> F3.1 U1 Cxxxxxxx..xx <cr> (first 110 command bytes)
reply: <stx> F3.1 U1 A <cr> etc.

4) Example program in BASIC to show the use of the ADI-protocol: First a communication-channel must be opened on the p.c.; in BASIC this can be achieved by programming a OPEN "COM:... statement, see below:

```
OPEN "COM1:4800,E,7,1,CS,DS,PE" AS#1
```

the creation of the COM1 port as channel #1, combined with following parameters:
4800 = baud rate,
E = even parity,
7 = 7 data bits,
1 = 1 stop bit,
CS = CTS line is ignored,
DS = DSR line is ignored,
PE = parity checking is enabled.
Now a simple command can be send to the analyzer:

```
PRINT #1,CHR$(2);"F3.3.1C"
```

CHR$(2) means "start of text" or <stx>, F3.3.1 asks for the value of the first constant.
Next the reply string of the analyzer must be read:

```
LINE INPUT #1, reply$
```

The variable contains the reply of the analyzer, being: <stx>F3.3.1A5.000.
A few BASIC statements should now be used to identify the data field in the string:

```
apos = INSTR(reply$,"A")
answer$ = RIGHT$(reply$,LEN(reply$)-apos)
```

The BASIC variable now holds the reply: " 5.000".

The following command is used to update the setting of constant C3:

```
PRINT #1, CHR$(2);"F3.3.3C100"
```

The value of C3 is now set to 100 and the reply line will be: <stx>F3.3.3A<cr>.

5. Example concerning the "node-information": The NODE-parameter should be used, when more than one analyzer communicates with one host, using a network (RS 422 or RS 485 option is required). In this example is demonstrated how the NODE-parameter can be localized.

```
10 PRINT #1,CHR$(2);"N2,1F4.1.4.1C"
20 LINE INPUT #1, reply$ (results in the reply:<stx>N1,2F4.1.4.1Axxx<cr>
30 npos = INSTR(reply$,"N")
40 fpos = INSTR(reply$,"F")
50 node$ = MID$(reply$,npos+1,fpos-npos-1)
```

In line 10, device number 1 (host) requests the value of the first analysis result.
Using the same technique as in previous examples, line 50 identifies that the holds the text: "1,2".

9 Basic Maintenance Part

Effective maintenance on an instrument, like the process analyzer, means that both the technical and economical lifetime of the instrument are extended considerably.
Too much preventive maintenance results in unnecessary high maintenance costs. Too little maintenance however may result in frequent, but avoidable failures.
Based on our customers and our own experiences over the years, we have combined these experiences in a comprehensive maintenance program, providing an optimum balance between preventive and corrective maintenance aspects.

Performance of this basic maintenance does not require any additional skills, and in most cases, does not involve opening of the wet part door. In some cases however the inside of the analyzer has to be accessed by opening the door to the electronic part of the analyzer.

Beware of electrical hazard of internal parts of the analyzer.
SWITCH OFF POWER BEFORE OPENING THE WET PART DOOR.

- **Realization of electrical connections and service work may only be carried out by qualified personnel.**
- **Beware that devices may be damaged when touched when powered on.**
- **Do not connect or disconnect devices with I/O power On.**
- **Make sure that proper precautions against Electro Static Discharge are taken.**

When the wetpart door of the analyzer is opened by means of the special key provided with the analyzer, the 24 Volt I/O power is switch off automatically. This power is feeding all devices connected to the I/O box and the burettes. The power can be powered on while the door is opened by pulling the service switch. See also Hardware & Installation Part of the manual.

- **Beware that devices may be damaged when touched when powered on.**
- **Do not connect or disconnect devices with I/O power On.**
- **Make sure that proper precautions against Electro Static Discharge are taken.**

When electronic parts are handled or connected, this should be done by qualified personnel, LAR service engineers or your local dealer. LAR will not accept any liability for damage, injury or loss, directly or indirectly caused by incompetent handling of any part or module of the analyzer.

The more detailed *preventive maintenance* aspects of the ADI 2016 / 2018 / 2019 series Process analyzer and the respective modules are described in the 'ADI Maintenance Program', which is available on request.

9.1 General

Basic maintenance on the ADI 2016 / 2018 / 2019 series Process analyzer involves in any case that the reagent containers are refilled or replaced and that the electrode system is cleaned and/ or conditioned, the tubing in the pumps are replaced and the cuvette in the colorimeter is cleaned, all on a regular base. In addition we advise you to perform a regular 'visual overall-check' of the wet part for immediate corrective measures, e.g. in case of leakages etc. Cleaning of the analyzer cabinet is best performed using a soft, non-aggressive cleaner. The use of a logbook for registrations and scheduled maintenance is strongly advised, i.e. of reagent replenishment, tubing replacements, cuvette cleaning, electrode cleaning and other corrective measures.

During the performance of the basic maintenance work, as described in this chapter, the analyzer can not be operational. Prior to the maintenance work, all necessary precautions regarding personal safety (protective clothing, safety glasses etc.) are to be taken into consideration.

The Analyzer is based on chemical analysis methods, using chemical solutions. Take necessary safety precautions , e.g. using safety gloves and glasses, when connecting and disconnecting tubes to reagent containers and sample and drain point, and replacing tubing, with regards to hazardousness of chemical substances.

Consult appropriate safety data sheets before reagent and samples are handled and make sure that appropriate measures are taken. Always be sure to label and rinse all connected tubing with water prior to removal.

All wet part modules may simply be removed after opening the big door of the electric part and unscrewing the module from the rear side of the door. Each module is fixed with 4 screws.
If a module must be removed or replaced, the electric cable should be decoupled. This can be done at the module itself. Only the Vessel/Stirrer module is provided with a fixed cable. In the occasion that this module must be removed first unplug the electric cable at the Central Computer Board.

Fig. 126 Unplugging of the electric cable at the Central Computer Board

Note:
- The Vessel/Stirrer assembly is mounted with six screws, and takes 2 wet part positions, unlike all other wet part modules.
- If wet part modules are removed permanently they should be replaced by blind plates (see Hardware and Installation part of the manual), in order to maintain a necessary protection of the electric part of the analyzer.

9.2 Electrodes and sensors

The best way of keeping electrodes in good shape is to use two identical sets of electrodes and to swap them on a regular base (e.g. every week). One set can be cleaned and reconditioned, while the other set is installed in the Ion - analyzer. Cleaning and reconditioning of the electrodes is to be performed as described in the instructions supplied with the electrodes.

The electrodes can easily be calibrated when they are installed in the Process analyzer (see Operation Part, Manual menu). In case a pH electrodes is installed, it is also advisable to have pH buffer solutions available in the vicinity of the Process analyzer for calibration purposes. Both reference and buffer solutions have a limited shelf life and must be replaced or refreshed in time.

Other sensors like Temperature sensor, LED Dipping Probe (LDP) and Heater probe do not need any special maintenance apart from cleaning with an appropriate cleaner and tissue. The cleaning of the LDP should be done carefully concerning the windows in the light path. Scratching of the windows should be avoided.

ISE:
Cleaning and reconditioning of the ISE is to be performed as described in the instructions supplied with the electrodes. The ISE has to be replaced when the obtained slope values in the calibration run of the analyzer are not within spec. The analyzer will trigger an alarm message in that case. Slopes values can also be inspected in the analyzer or be printed, see Operation Reference manual.

Note:
- Erroneous slope values may also be caused by a malfunctioning reference electrode.
In case of an AMMONIA ISE, no reference electrode is present, this is already included in the ISE itself, see manual AMMONIA ISE.
Some electrodes can be regenerated by polishing the electrode sensing surface. A polishing set is available for this purpose.
The AMMONIA ISE can be provided with a new membrane and electrolyte, see manual ISE.

9.3 Stirrer/ vessel holder module

The reaction vessel can be removed from the stirrer/vessel holder module after rinsing with water, disconnecting the drain tube, loosening (not remove!) the two knurled bolts and gently moving the reaction vessel together with the top plate forward (place the top plate back in the vessel holder after removal of the reaction vessel):

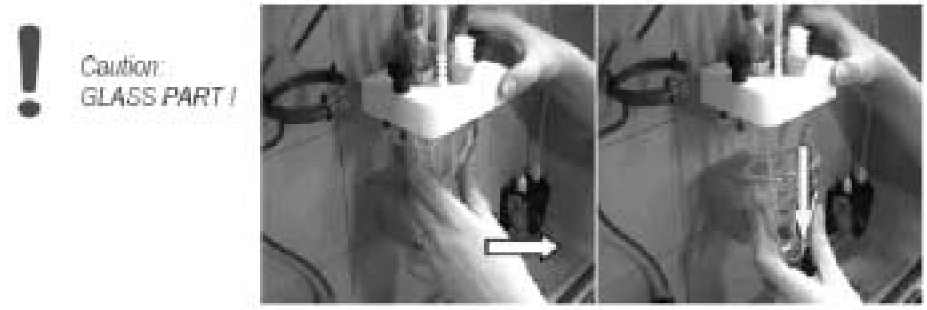


Fig. 127 Cleaning of the vessel

Use tissue paper and an appropriate cleaner for cleaning the vessel. When reinstalling the reaction vessel make sure the teflex(R) O-ring in the top plate is in place.
For service purposes a spare O-ring set (see spare parts) for the top plate is available. It is advisable to replace the top plate O-rings once every year.

9.4 Burette module

The burette module mainly consist of a drive assembly, mounting plate and a cylinder head with a glass cylinder and a piston. The burette drive assembly is the same for all burette volumes.
The recommended basic maintenance of the burette module mainly concerns cleaning and inspection on mechanical damage on a regular basis (depending on reagent and usage) and replacement of the glass cylinder and piston (recommended once every year).
The more extensive preventive maintenance of the burette module is described in the ADI Maintenance Program, which is available on request.

Replacement procedure for the glass cylinder and piston:

- disconnect the M6 flared reagent inlet tube (not the reagent outlet tube!) on the reagent container with the special wrench delivered with the analyzer.
- perform the burette RECYCLE function about five times or enough times in order to empty the burette and the M6 inlet and outlet tubes completely in the reagent container. (See Operation Part for Manual commands).

Note:
- In case of a 2 ml burette or if longer M6 flared inlet and outlet tubes are installed, it might be necessary to extend the number of recycle cycles in order to empty the burette and the connected tubes completely.

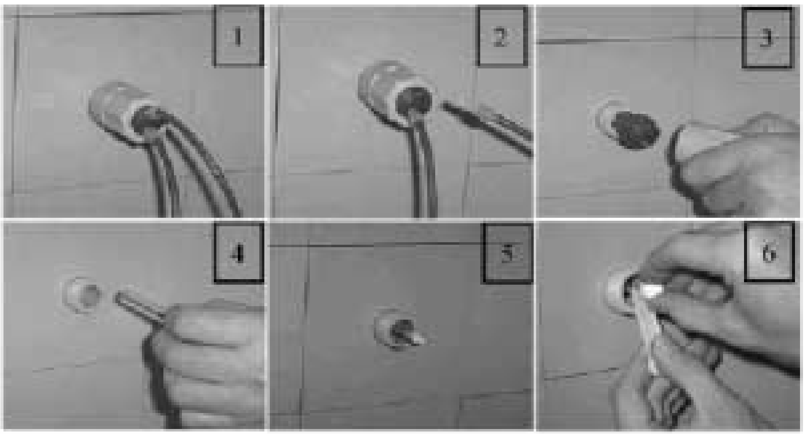


Fig. 128 Changing of the burette

- disconnect the M6 flared inlet and outlet tubes from the burette module
- fill the burette to zero (piston moves back to its lowest position), (see Operation Part, for Manual commands).
- unscrew the cylinder head nut and verify if the glass cylinder is empty.
- carefully pull the glass cylinder together with the black cylinder head from the piston.
- dose the burette to maximum volume (piston moves forward until its highest position (see Operation Part, for Manual commands).
- carefully remove the piston from the spindle moving part, while holding the spindle in place with e. g. the M6 wrench, delivered with the analyzer.
- lubricate the piston slightly with special grease (delivered with the analyzer) and replace the piston and glass cylinder in reversed order.
- reassemble the burette module and reconnect the M6 flared tubes with the M6 wrench.
- verify the function of the burette module function using manual keyboard commands (see Operation Part, Manual menu)

9.5 Multi way valves, Burette valve module

The different valves are all very similar, they have different inner sliders and head connectors. They mainly consists of a motor unit and a valve unit (slider valve) with connections for M6 flared tubes.
Both the motor unit and slider valve do not require any basic maintenance, other than the regular 'visual overall check', especially on possible leakage's of the slider valve. Any liquid or crystal appearance (due to crystallization of liquids) on the small front hole of the valve unit indicates a leakage of the valve unit, in which case it needs to be replaced:

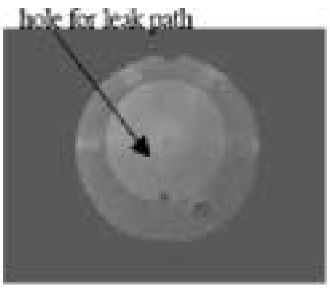


Fig. 129 Burette valve

Before dismounting the valve unit make sure that all tubes are empty or are flushed with e. g. water. Use the MANUAL keyboard commands as described in the Operation part of the manual.

Make sure that none of the connected tubes is pressured with any liquid.

Disconnect the M6 flared tubes connector (from reagent container etc) on the valve unit. Then pull the burette valve unit out of the mounting plate.
Replace the burette valve unit (lubricate the EPDM o-ring slightly with special grease (delivered with the analyzer). Also just the O-ring can be replaced if necessary.

Fig. 130 Replacement of the burette valve

When replacing a valve unit, always make sure that the valve unit fits correctly in the motor unit valve module. The valve module therefore has to be set to a proper position (see Operation Part, for Manual commands) :

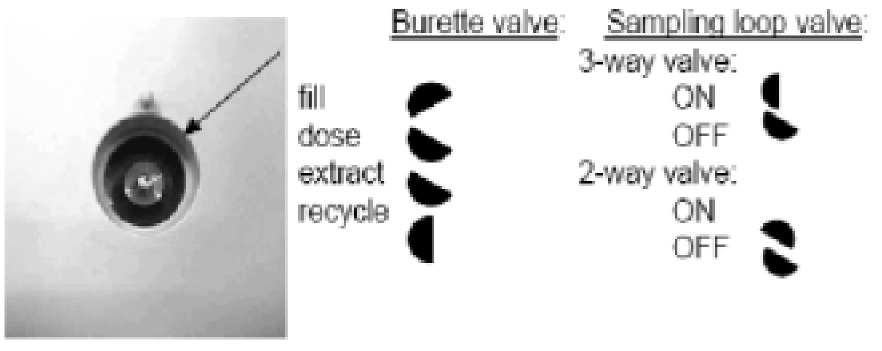


Fig. 131 Position of a burette valve

Keep in mind that if the valve unit and motor unit are not aligned properly prior to installation of the valve unit, this may lead to malfunction or damage of the valve unit.

For adjustment of the valve unit position a special tool is available:

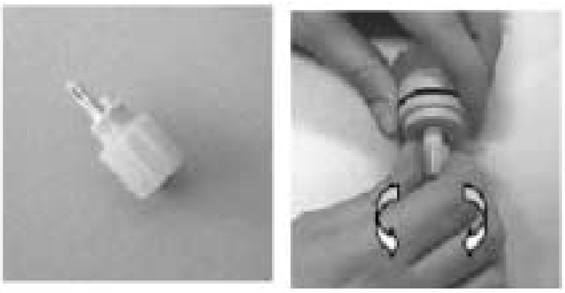


Fig. 132 Tool for the adjustment of the valve

When connecting the M6 flared tubes make sure they are on the correct ports again (see Hardware & Installation Part). Verify the function of the valve module using manual keyboard commands (see Operation Part).

10 Technical Data

Table 14 Technical data

Parameter	Data
Matrix	Drinking water, Industrial waste water, Municipal waste water and Surface .
Principle	After sampling a T(otal) I(onic) S(trength) B(uffer) solution is added to obtain a constant total ionic strength of the sample during analysis. The Ammonia concentration in thesample is determined using the dynamic standard addition method.
Detection method NH3	*Method* *Detector* *Ion* Standard addition ISE IS NH3
Specification NH3	
Range	0-100 mg/l
Repeatability	1.5 %
Inaccuracy	2 %
Analysis time	10 minutes
Interferences	Volatile Amines, Fats. Oil, Proteins, Surfactants and Tar
Measurement and Sample preparation	
Type of measurement	NH4 detection by ion selective electrode
Methods of measurement	Standard addition method
Measurement range	0-100 mg/l
Response time	30 seconds
Sample preparation	particle-free sample required
Sample temperature	max. 40 °C
Sample streams	2
Pressure	0-0.5 bar
Dimensions	660x440x300 (HxWxD)
Weight	20 kg
Cabinet	IP 54
Connections	
Electrical power	150-240 V/ 50-60 Hz
Signal output	2 analogue outputs, 0/4-20 mA
Interfaces	RS 232, RS 422
Potential-free contacts	3 programmable relays, Connection for Printer, PC
Operation and Data Output	
LCD-screen Industry-standard data interface	

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