EnviroTech Instruments LLC
1517 Technology Drive, Suite 101
Chesapeake, VA 23320
T. 757 549 8474
F. 757 410 2382
mail@envirotechinstruments.com

1.0 Terms of Use

1.1 Limited Liability

EnviroTech Instruments LLC disclaims all product liability risks arising from the use or servicing of this equipment. EnviroTech Instruments LLC cannot take steps to comply with laws pertaining to product liability, including laws which impose a duty to warn the user of any dangers as it has no way of controlling the use of this equipment or selecting the personnel to operate it. Acceptance of this system by the customer shall be deemed to include a covenant by the customer to defend, indemnify, and hold EnviroTech Instruments LLC harmless from all product liability claims arising from the use or servicing of this system.

1.2 Disclaimers

All information in this manual is believed to be accurate and reliable. However, no responsibility is assumed by EnviroTech Instruments LLC for inaccuracies. While every effort has been made to ensure that this document is correct, errors can occur. If you find any errors or omissions please let us know. EnviroTech Instruments LLC reserves the right to change product design, operation, specifications and documentation without notice.

1.3 Warranty

EnviroTech Instruments LLC warrants the product against faulty materials and workmanship for a period of one year from dispatch.

Faulty units will be repaired or replaced at the Company's option free of charge provided they are delivered to EnviroTech Instruments LLC's premises at the owners/users expense and providing all manufacturers recommendations with regard to operation, servicing and storage have been adhered to. In particular the warranty will not apply if the fault has been caused by misuse, attempted repair or modifications in a manner unauthorized by EnviroTech Instruments LLC.

2.0 Introduction

The AutoLAB 4 Analyzer System is a discrete chemical analyzer for remote/unattended long-term monitoring of dissolved chemicals in surface and saline waters. Analyte include nitrate, orthophosphate, ammonium, iron, chloride and others. Many other standard colorimetric methods may also be adapted.

The system comprises of a main controller and 1 to 6 “slave” analysis units, reagent storage racks, protective frame and external flow-through sampling cell. Pump control and telemetry modem features are incorporated to provide a complete stand-alone system.

Each “slave” analysis module includes a fluid handling unit, detector, electronics and environmental housing.

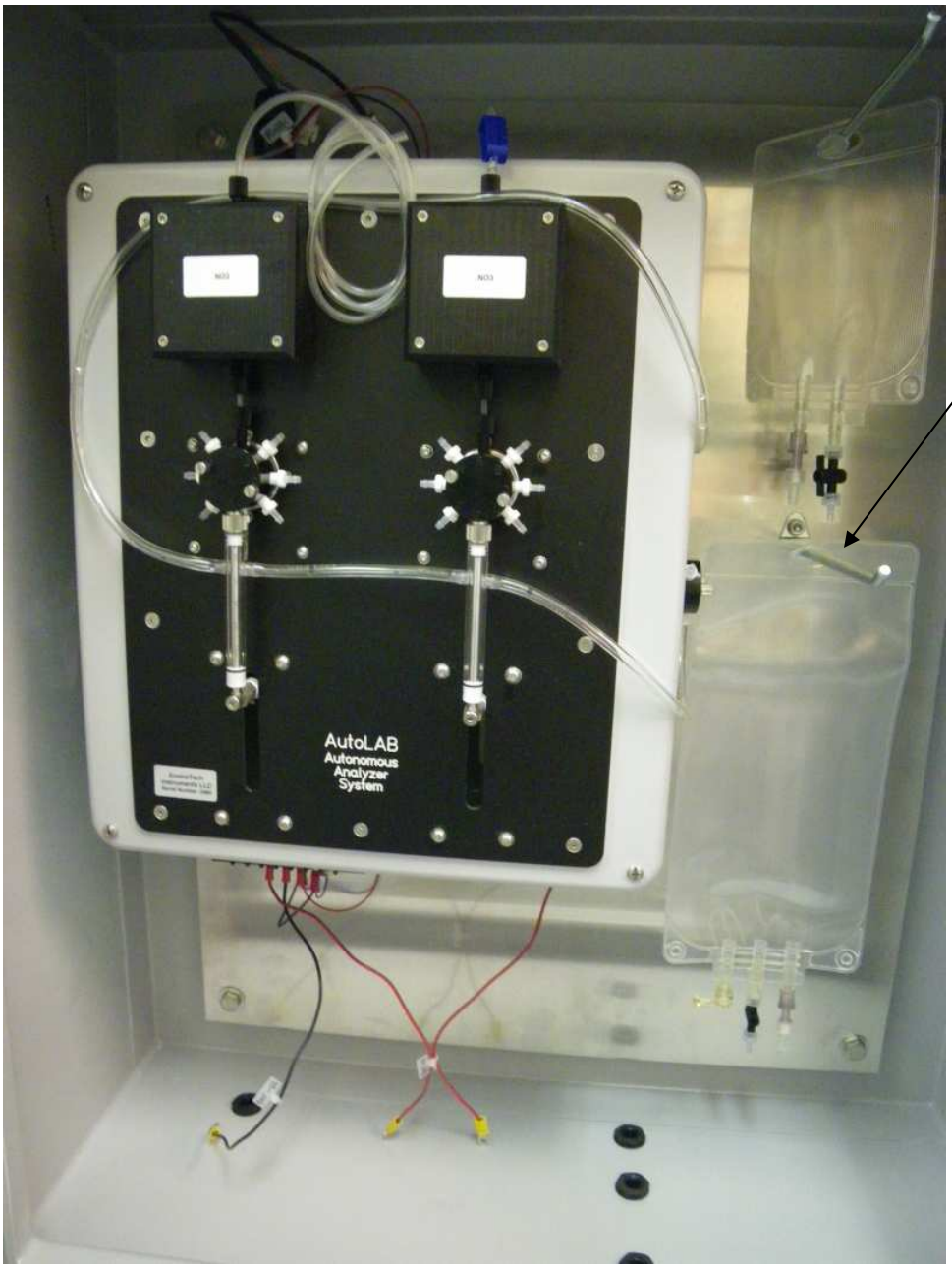
The fluid handling units incorporates a precision 2.5 ml syringe-pump and 8-port rotary valve. The syringe is used for sampling, reagent dosing, mixing, dilution and flushing. The 8-port valve can select one reagent, standard, inlet, detector or outlet allowing sample and reagents to be mixed and then delivered to the detector.

The detectors incorporate a fixed wavelength narrow-band colorimeter optimized for the peak response of the selected analyte. Miniature high-efficiency heaters are integrated into the detector block.

The analytical modules are in the front section of the instrument and reagents, standards, etc. are stored in the back in gas-impermeable reagent bags. Reagents and standards are delivered to the valve via gas-impermeable tubing. Waste may be stored in the rear section or exhausted out of the front or back panel of the system for collection in a waste container.

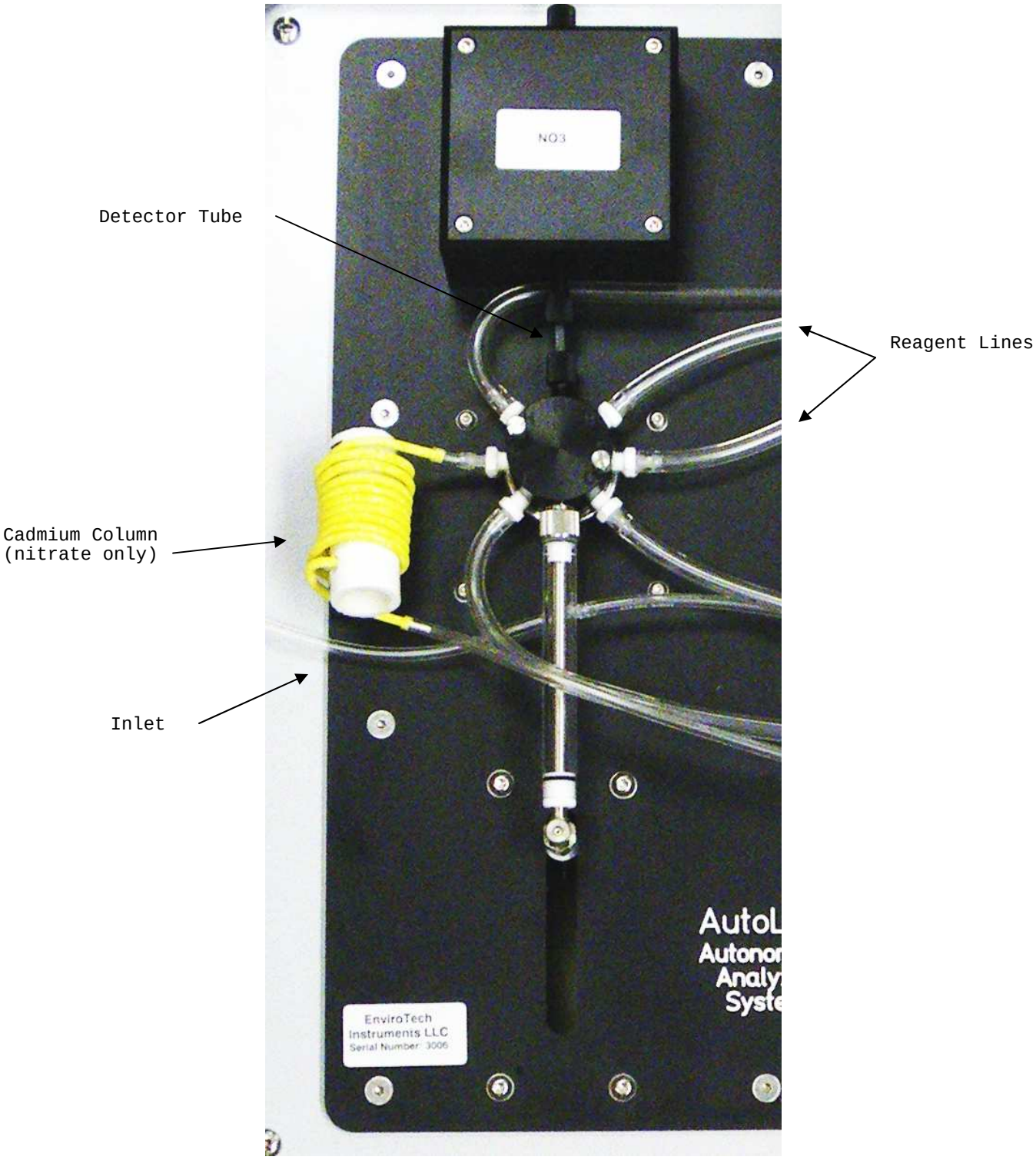
The AutoLAB 4 system has been designed to be easy to use. However, it is strongly recommended that this manual and the analytical method sheets are read in full before trying to operate the system. The most common cause of “new user” problems and frustration is incomplete familiarization and short testing time.

Dual Analyzer Module



Main Enclosure Door Open

Flow-Through Cell / Inlet
(External Pump)



Plumbing – Analyzer Unit 1

Detector Connection

Multiple Intake System
(with peristaltic pump)

AutoLAB may be fitted with a multiple intake valve. This is used to sample from more than one source.

3.0 Methods

Analytical routines are based on well established methods using non-proprietary reagent formulations. Many methods are based directly on approved US EPA methods, or where not available the industry standard method. A list of available analyte methods is given below.

3.1 Analyte List

0 – Nitrate
1 – Phosphate
2 – Ammonium
3 – Silicate
4 – Urea
5 – Nitrite
6 – Iron
7 – Chloride

A full description of the method associated with your equipment configuration is given in another section of the manual.

3.2 Analysis Macros

AutoLAB 4 utilizes a set of macros routines to perform each analysis. Analyses types include sample, standard, reagent blank and calibrations. Each macro has a number given in the table below. This is the default list and may change depending on the method. Please read the method documentation carefully.

Default Macro List

M1 - Sample
M2 - Standard
M3 – Sample + Standard
M4 - Prime
M5 – Blank
M6 – Calibration
M7 – Flush
M8 – Utility

4.0 Operation

The AutoLAB 4 system is designed to be easy to use. With an adequate power supply, a clear understanding of the system commands and carefully prepared reagents/standards the user will obtain excellent data returns. Short-cuts and false economies are invariably fatal to the operation of the instrument.

4.1 Power

Power supply: 12 vDC / 4 Amps peak

The AutoLAB 4 system operates at a nominal 12 volts DC.

The recommended range is 10 – 14 volts DC. Reverse polarity and voltages outside the recommended range may cause the unit to malfunction or damaged it.

The power supply must be capable of providing at least 3 Amps for short peaks. The most common cause of “new user” problems is an inadequate power supply. Please consult the factor for advice if unsure.

4.2 Communication

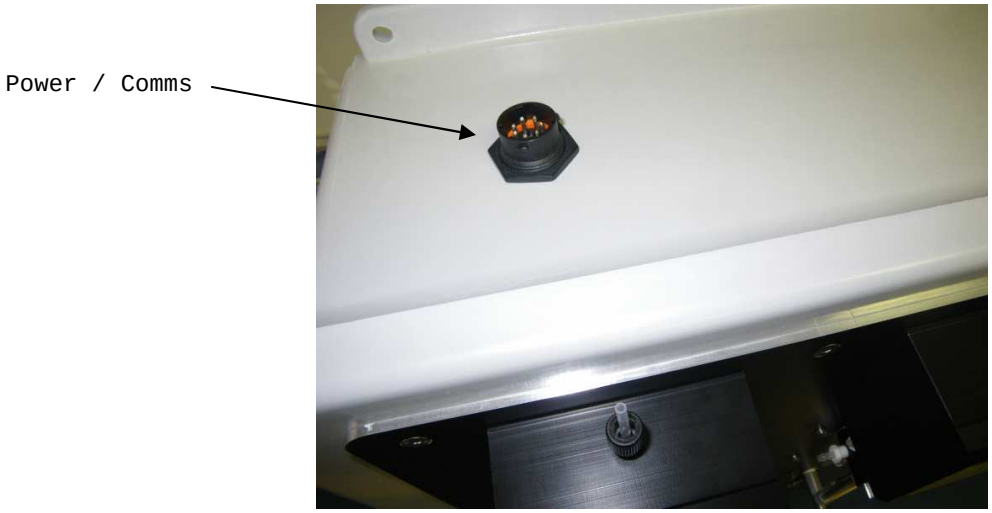
The user or master system can communicate with the AutoLAB 4 using the following configuration.

Communication format: RS232, ASCII
Baud, Protocol: 19200, N81

A terminal emulator (e.g. HyperTerminal) may be used to control the system on the bench.

4.3 Connecting up

Each unit has a connector on the top as shown below.



Electrical Connectors

Remove the sealing cap from the left hand connector (from the front). It also has a red ID ring. Connect and secure the bench lead.

Connect the red and black jack plugs on the bench lead to a suitable 12 VDC power supply. DO NOT POWER UP.

Attach the **FEMALE** DB9 connector on the bench lead to a suitable RS232 port on any PC.

Start a terminal emulator program (e.g. HyperTerminal) and configure it for the correct communications protocol (above).

Turn on the power supply and check that the following sign-on message is displayed on the screen.

ASLM V1.015
@OK!
@CMD
>

Commands are entered after the '>' Prompt. The prompt indicates "ready for next command". Commands can only be entered when the prompt is shown.

Please read the rest of this manual before continuing to operate the system.

5.0 Commands

All commands are in the following format:

<Cmd><Arg><CR>

Where: Cmd = Command (letter – case sensitive)
Arg = Argument (number)
CR = Carriage return [ENTER]

5.1 Slaves / Analytical Modules

Each unit may have one or two slave analytical modules and further units may be “daisy-chained” for form a three to six channel system. The first/left-hand analytical module in the first unit is “Slave 1” and the second “Salve 2”. The first/left-hand module in the next unit is “Slave 3” and so on.

5.2 Commands

Cmd	Arg	Description	Notes
&	<password>	Upload firmware	Uploads new .hex image
/	<slave><cmd><arg>	Directs following command to “slave” unit	Must be valid slave unit command (see table below)
?	none	Query if slave is active	Ready (@RDY) OR Busy (@BSY)
$$	none	Wake from sleep	If in auto-sampling mode ESC required after wake for command mode
@	9600, 19200 38400, 57600	Set baud rate	
A	0 1 - 8	List calibrations Enter calibration	See description in the “Data” section
B	0 - 2	Broadcast mode 0 = disables 1 = COM1 2 = COM1 + SMS	Enabled for data broadcast at the end of each macro
D	<various>	Data command	See description below
E	<slave><switch>	Enable /disable slave	e.g. enable slave 2 = 21, disable = 20
F	<password>	Reset default variables & reset CPU	
G	<slave>	Get new data from slave	Slave must be enabled
H	none	Header information	
I	5 – 65535	Sampling interval	
i	1 - 6	Sample intakes	
J	0 - 65535	Set serial number	
K	<password>	Set future start time	MMDDYYhhmmss
L	<slave><channel>	Set active light measurement channel	e.g. slave 1, channel 2 = 12
M	0 1 - 8	Start auto-sampling Run macro	For each enabled slave
N	1 – 1000	Number of samples	

O	0 or 1	Disable/enable ping characters from slaves	Ping response = '*' when slave macro running
P	<slave>	Open serial connection	P1<CR> = connect to slave 1 [CTRL]-D to close P0<CR> = modem
Q	<slave><switch>	Power off/on slave	Q11 = slave 1 on Q20 = slave 2 off
R	1 - 1000	Run analyses for all enabled slaves per the slave cycle macros	Analyses are back-to-back
r	1	Run pump	For test. Uses T setting.
S	<slave><macro>	Send analysis macro to slave	e.g. M1 to slave 1 = S11
T	seconds	Pump sampling time	
t	seconds	Start macro delay from pump switch on	
U	<slave>	Upload cycle macro	Note U0 clears all macros
V	<slave>	View cycle macro	
W	<password>	Set RTC	MMDDYYhhmmss
X	<password>	Send test SMS	
Y	<password><enter> phone number	SMS destination phone number	Max 24 numbers (only)
Z	<password>	Shutdown	

<slave> = 1 to 6, <password> = 5525, <switch> = 0(off)/1(on)

5.3 Header Format

The "header" is used to view the configuration of the system. When the "H" command is entered the header will be shown in the following format.

```
@S/N1234 B1 I60 i2 N840 n0 T10 t4 12.1V
@EN! 1:1 2:1 3:0 4:0
@CH! 1:1 2:1 3:1 4:1
@PHN:0
@RTC:07/17/09 14:08:39
@PWR:07/17/09 14:08:31
@ALM:07/17/09 13:00:00
```

Line 1: @S/N1234 B1 I60 i2 N840 n0 T10 t4 12.1V

In general each setting in the first line corresponds to a command. For example, "B" is the broadcast mode, "I" is the sample interval, "N" is the number of samples and "T" is the pump time.

The unit serial number (S/N) is displayed, the "n" setting shows the current sample number and the reading before "V" is the supply voltage.

Line 2: @EN! 1:1 2:1 3:0 4:0

The enabled status of the slaves is shown. In the example above slaves 1 & 2 are enabled and 3 & 4 are disabled.

Line 3: @CH1 1:1 2:1 3:1 4:1

Each detector has two channels 1 & 2 (if fitted). The active channel is show. In each case above the active channel is 1 (the default)

The enabled status of the slaves is shown. In the example above slaves 1 & 2 are enabled and 3 to 6 are disabled.

Line 4: @PHN:7574128107

The destination phone number is shown. This is normally the system base station running DataLINK software, but can be any device capable of receiving an SMS message.

Line 5: @RTC:07/17/09 12:35:52

The current real-time clock setting.

Line 6: @PWR:07/17/09 12:19:24

The last time the system was powered-down (i.e. power completely removed, not entry to sleep mode).

Line 7: @ALM:07/17/09 13:00:00

The wake-up time to start auto-mode.

5.4 Slave ‘/’ Commands

The utility commands below are addressed to each “slave” or module.

Slave commands are in the following format:

/<Addr><Cmd><Arg><CR>

Where: / = start command
Addr = Unit address (1 – 6)
Cmd = Command (capital letter)
Arg = Argument (number)
CR = Carriage return [ENTER]

Cmd	Arg	Description	
+	Steps	Insert steps	
-	Steps	Retract steps	
G	1	Align valve	
p	Port	Move to port	Note: lower case ‘p’
X	5525	Clear memory	

5.5 Command examples

The command to start auto-sampling is:

M0[ENTER]

The command to start macro 4 on each enabled slave is:

M4[ENTER]

The command to enable slave/module 2 is:

E21[ENTER]

The command to run 6 analyses in the main cycle (back-to-back) is:

R6[ENTER]

5.6 Analysis Macros

Each slave unit is pre-loaded with macros that perform the various analyses (sample, standard, etc.). The system controller runs the main cycle for the analysis macros. This is dependent on which units are enabled.

Each slave unit has an individual cycle that can be up to 1024 analyses in length. For example the typical cycle is:

M3 M1 M1 M1 M1 M1

Which is equivalent to:

<sample>+<standard> <sample> <sample> <sample> <sample> <sample>

At the end of the sequence the cycle loops back to the first analysis, which is M3 in this case (and the default).

The cycle for each slave/module is viewed using the “V” (view) command. To view the cycle for slave 1 type V1[ENTER].

View cycle	>V1[ENTER]
Sample + standard	M3
Sample	M1
Sample	M1
Sample	M1
Sample	M1
Sample	M1
End of cycle	;0
Prompt	>

To change the cycle for slave 2 use the “U” (upload) command. After typing U2[ENTER] the “:” prompt will be shown to indicate macro upload mode.

```
Upload cycle            >U2[ENTER]
Sample + standard       :M3[ENTER]
Sample                  :M1[ENTER]
Sample                  :M1[ENTER]
Sample                  :M1[ENTER]
Sample                  :M1[ENTER]
Sample                  :M1[ENTER]
End of cycle            :;0[ENTER]
Prompt                  >
```

Multiple Intake Systems

AutoLAB may be fitted with a multiple intake valve. This is used to sample from more than one source.

The “i” command determines the number of intakes that are active. If i=2 the system will run two steps in the main cycle, switching the intake valve and running the pump before each step.

In this case a typical main cycle would be:

```
Macro:      M3 M3 M1 M1 M1 M1 M1 M1 M1 M1 M1 M1
Intake:      1  2  1  2  1  2  1  2  1  2  1  2
```

5.7 Auto-sampling Mode

AutoLAB 4 is designed to run in a stand-alone mode, unattended for extended periods.

Configuring auto-sampling

Auto-sampling mode is configured with the following steps.

1. Check the RTC is correct (command H) and reset if required (command W)
2. Enter the future start time for the deployment (command K)
3. Check the required slaves are enabled (command H) and enable as needed (command E)
4. Set the analysis interval (command I)
5. Set the number of analyses required (command N)
6. Set the data broadcast mode (command B) as required
7. Set the pump on-time (command T) as required
8. Set auto-sampling mode (command M) – M1[ENTER]

Auto-sampling sequence

The system will compare the RTC time and the start time. If the alarm is in the future the system will enter a low power sleep mode until the start time. If the alarm is in the past the cycle will start immediately.

When the system wakes-up at the start time it will run the pump and initiate the first analysis macro in the cycle for each enabled slave.

After all slave analysis macros are complete the system will broadcast data as programmed and then return to sleep mode until the next sample analysis time.

Analysis interval “I”

The analysis interval is between the start of each analysis, so if the first sample was at 13:00 and the interval (I) is 60 minutes, the next analysis will start at 14:00.

Waking the system from sleep

When the system is “asleep” it may be woken with the “$$” command.

Exiting from auto-sampling mode

If the system is “woken” with the “$$” command or it is power cycled while in auto-sampling mode it will remain in auto-sampling mode. To exit auto-sampling mode the ESC key (ASCII 27) must be pressed. If the ESC key is not pressed within ~20 seconds the system will go to “sleep” again and continue auto-sampling.

6.0 Data & Calibration

AutoLAB provides two types of data called raw and real (calibrated) data. The raw data signal is transmission and is represented as a 16-bit count (0-65535). Real data are given as absorbance and concentration, where concentrations are derived using the currently stored (non-volatile) calibration coefficients.

Absorbance = LOG10[blank/reaction]

Where: blank & reaction are the transmission signals

Concentration = m x absorbance + c

Where: m = calibration slope
c = calibration intercept

6.1 Raw Data Line Format

The data line contains any time stamp information, the current flag, a series of data points and the status of the detector heaters.

The signal ADS0 is the signal from the first channel of the colorimeter. If fitted the second channel signal is ADS2. All other data are for housekeeping and error checking. The data format is shown below.

A line or a block of raw data is always preceded by @DAT and followed by @END.

<MM/DD/YY hh:mm:ss>,<flag>,<ADS0>,<ADS1>,<ADS2>,...
<ADS3>,<ADS4>,<ADS5>,<ADS6>,<ADS7>,<heaters><CR/LF>

MM/DD/YY hh:mm:ss,031,12345,12345,12345,...
12345,12345,12345,12345,12345,03<CR/LF>

6.2 Flags

Data flags are attached to each detector reading. The flags indicate the method, the analysis macro and the type of reading.

<flag> = XYZ (e.g. 031)

Where: X = Analyte
Y = Macro
Z = Reading Type

The key to each flag section are given in the tables below:

Analyte	X
0	Nitrate
1	Phosphate
2	Ammonium
3	Silicate
4	Urea
5	Nitrite
6	Iron
7	Chloride

Macro	Y
1	Sample
2	Standard
3	1+2
4	Prime
5	Blanks
6	Cal
7	Flush
8	Utility

Reading	Z
1	Sample Blank (Bs)
2	Sample Reaction (Rs)
3	Std. Blank (Bt)
4	Std. Reaction (Rt)
5	Reagent Blank (Br)
6	Reagent Reaction (Rr)
7	Utility Blank (Bu)
8	Utility Reaction (Ru)

Example

031 = Nitrate, Sample+Standard, Sample Blank (Bs)
112 = Phosphate, Sample, Sample Reaction (Rs)
221 = Ammonium, Standard, Sample Blank (Bs) = INVALID FLAG

6.3 ADS channels

Ch	Signal	Data range / resolution
0	Channel 1 Signal	0 – 65535 / 16-bit
1	Channel 1 Ground	0 – 65535 / 16-bit
2	Channel 2 Signal	0 – 65535 / 16-bit
3	Channel 2 Ground	0 – 65535 / 16-bit
4	Channel 1 LED current	0 – 32768 / 16-bit L4095 = 25 mA = ILEDK = ~32,768
5	Channel 2 LED current	0 – 32768 / 16-bit L4095 = 25 mA = ILEDK = ~32,768
6	Detector internal temp	0 – 65535 / 16-bit
7	Voltage reference	0 – 65535 / 16-bit

6.4 Real/calibrated data format

Each line of real/calibrated data comprises time-stamp, flag, blank, reaction, absorbance, cal m, cal c, conc.

<time-stamp>,<flag>,<blank>,<reaction>,<abs>,<cal m>,<cal c>,<conc><CR/LF>

MM/DD/YY hh:mm:ss,031,36142,11960,0.4803,8.01180,-0.02090,3.827

A line or a block of raw data is always preceded by @CAL and followed by @END.

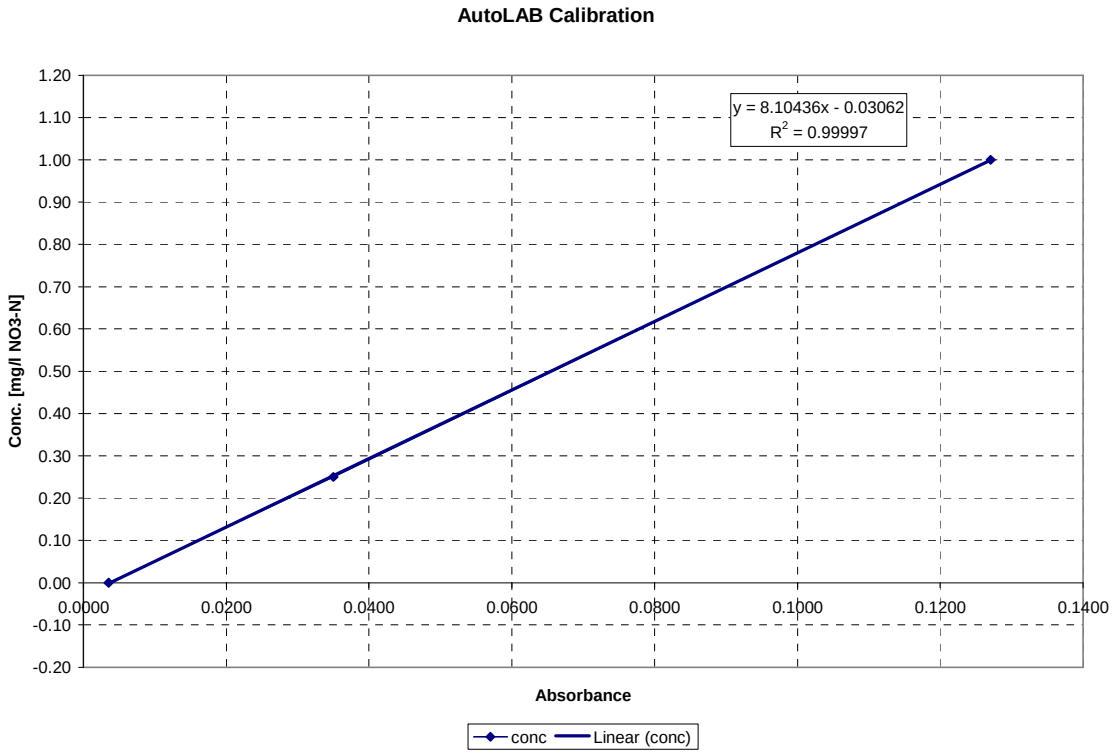
6.5 Calibration

A 3-point calibration curve is obtained by running macro M6 for each analytical channel. The calibration includes a reagent blank, sample and standard. The sample should be between 25% and 75% of the standard concentration.

Using the results construct a linear regression and determine the coefficients for slope (m) and intercept (c) in the form:

Concentration = m x absorbance + c

This can be done easily in Microsoft Excel and other data plotting packages. An example is give below.



Note that concentration is plotted on the Y-axis and absorbance on the X-axis.

Ensure that the R-squared valve is greater than 0.9995 and if not re-run the calibration.

Enter the calibration coefficients using the “A” command and the allocations below.

A0 – Show all calibration coefficients
A1 – Unit 1 “m” (slope)
A2 – Unit 1 “c” (intercept)
A3 – Unit 2 “m” (slope)
A4 – Unit 2 “c” (intercept)
A5 – Unit 3 “m” (slope)
A6 – Unit 3 “c” (intercept)
A7 – Unit 4 “m” (slope)
A8 – Unit 4 “c” (intercept)

Example

A3[ENTER]
C2m:8.10436[ENTER] C2m: is displayed as a prompt
A4[ENTER]
C2c:-0.03062[ENTER] C2c: is displayed as a prompt

6.6 Downloading Data

All data are stored in files located on the systems SD memory card.

Raw data – Stored in one file per unit
Real data - Two files for all real data

All data required as stored in the real data files. The raw data files are intended to be used as back-up and contain some housekeeping/trouble shooting information.

Real data are stored in two identical files. The purpose of two files is to allow one to be deleted after download so that the data downloaded is always new. The second file is a back-up of all data real data in case of mishap.

Data are downloaded and deleted using the “D” command as shown below.

Cmd	Arg	Description	Notes
D	1	Download unit 1 raw data	
	2	Download unit 2 raw data	
	3	Download unit 3 raw data	
	4	Download unit 4 raw data	
	11	Get data buffer line 1	1st line latest data
	12	Get data buffer line 2	2nd line latest data
	13	Get data buffer line 3	3rd line latest data
	21	Download real data file 1	Used for all data
	22	Download real data file 2	Used for new data
	50	Delete all raw data	
	51	Delete real data file 1	
	52	Delete real data file 2	

7.0 Deployment

7.1 Preparing for Deployment

The following procedure to prepare for deployment is recommended:

1. Prepare all reagents and standards as detailed in the analytical method
2. Set aside 50-100 ml of the standard for separate laboratory analysis
3. Install the bags in the AutoLAB 4 reagent area & connect the plumbing
4. Prime the system using the prime macro
5. Run several standards to ensure repeatability in the blank and reaction
6. Compare the standard results with previous results as a calibration check OR make several standards across the range of measurement and run a few replicates of each one. Create a new calibration curve.
7. Download & clear the memory
8. Check the plumbing and connect the inlet to the flow-through cell
9. Secure all the covers
10. Install the AutoLAB 4 in the deployment shelter
11. Connect flow-through cell / inlet, waste and drain lines
12. Connect the analyzer to the master system and run

7.2 Simple Service / Deployment Procedure

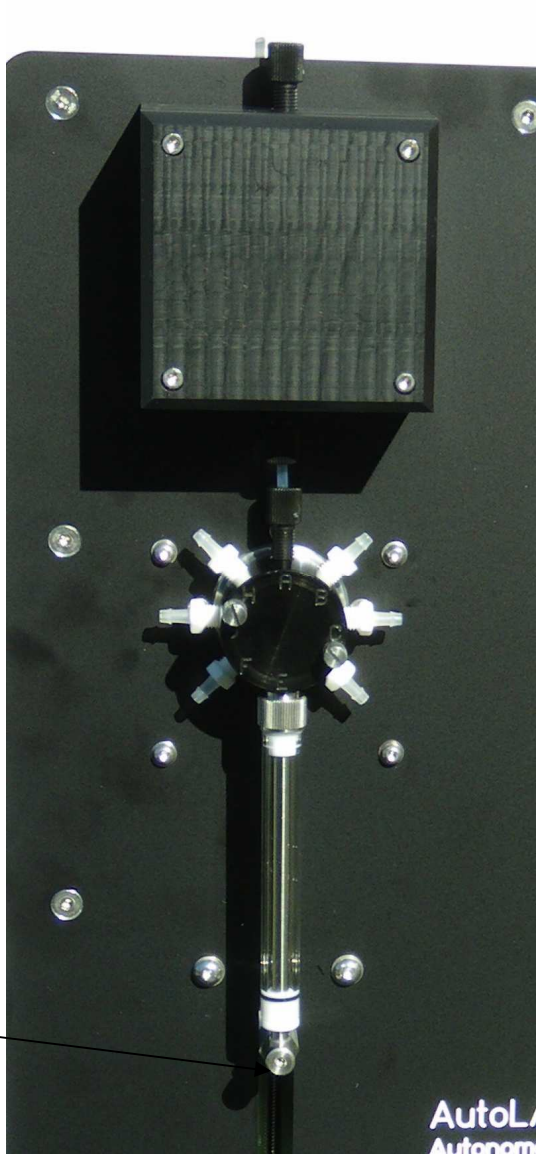
1. Remove the front, the back and one side cover.
2. If removing bags first close all stop-cocks and disconnect each bag. Remove each bag-to-bulkhead tube with bag end draining into a waste container. Reconnect the lines at the bulkhead end.
3. Hang the wash, standard & reagent bags on the hanger. Connect an empty waste bag.
4. Connect power & RS232
5. Type “H” to check comms. The header will be displayed
6. If required change the syringe (see manual)
7. One by one open the bag stop-cock and allow fluid to flow to the connector. Do not allow excess flow out of the bag. Collect all waste
8. Connect & double-check that the tubing is per the method details
9. Open a connection (command P) to the first slave and initiate the prime macro (M4) to pull-through all the fluid in the bulkhead to valve tubing and any remaining air in the bag tubing.
10. Repeat the command as necessary for slave 1 (e.g. /1M4[ENTER]) and then repeat for each slave.
11. Run the standard macro M2 for the first slave Watch the analyzer operate and check for good flow and no air leaks/bubbles. Repeat two or more times until blank & reaction data are consistent. Then repeat for each slave.
12. Run the calibration macro M6 for each slave.
13. Close the slave connection CTRL-D and configure auto-sampling mode.

8.0 Servicing

The AutoLAB 4 system has been designed to require minimal servicing and maintenance. The service routines are limited to cleaning and simple part exchange.

Other than tubing, all user serviceable parts are on the front of the analyzer module. There are no user serviceable parts inside the environmental or detector housings.

The syringe may be removed for cleaning or exchange/replacement. The 8-port valve may be exchanged or replaced.



Syringe Drive

8.1 Syringe Replacement

1. Withdraw the syringe
2. Remove the shoulder screw
3. Carefully unscrew the syringe from the valve by turning on the knurled metal fitting at the top of the syringe
4. Reverse the procedure to reinstall a syringe
5. Do not operate the system while the syringe is removed
6. Home the syringe

8.2 Valve Replacement

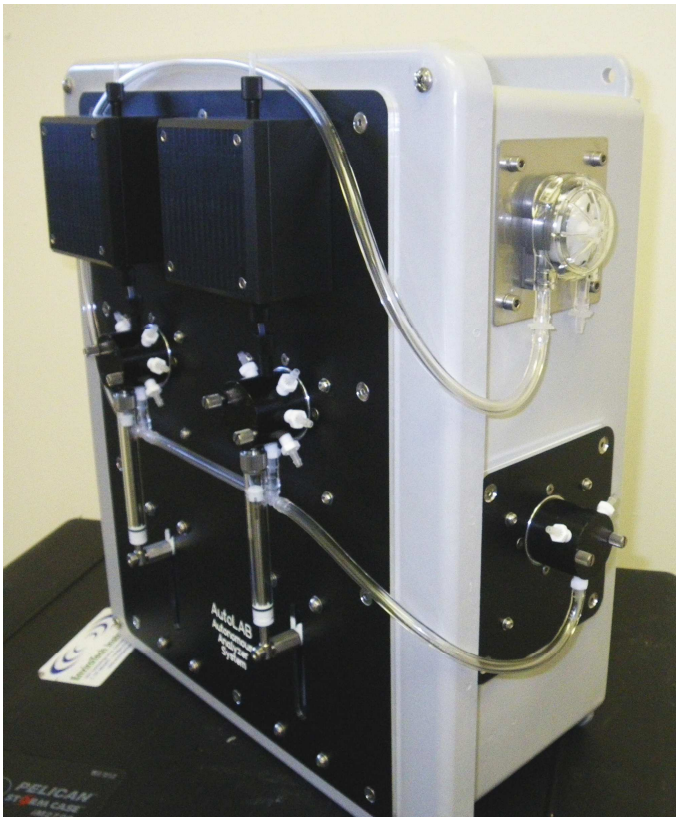
1. Home the valve at Port A and withdraw the syringe
2. Disconnect tubing, columns or mixing coils from all valve port nozzles
3. Carefully unscrew the knurled detector tube nut
4. Carefully unscrew the syringe from the valve by turning on the knurled metal fitting at the top of the syringe
5. Using a suitable flat bladed screw-driver remove the two valve fixing screws.
6. Pull the valve off its mount perpendicularly to the main plate
7. Do not operate the system while the valve is removed
8. Reinstall by reversing the procedure
9. When fitted home the syringe

8.3 Detector cleaning

1. Cleaned by flushing a solution of 5% CONTRAD in deionized water solution through the detector using macro M7.
2. After cleaning flush at least 10 times with deionized water only.

8.4 Multiple Intake System

1. The peristaltic pump tubing will wear and must be changed periodically. Open the face of the pump and slide out the tubing. Replace the tubing and close the face.
2. The flow-line tubing should be replaced when fouled.



Plumbing for a Dual-Intake System

9.0 Repair

If diagnostic or repair services are required please consult the factory for advice.

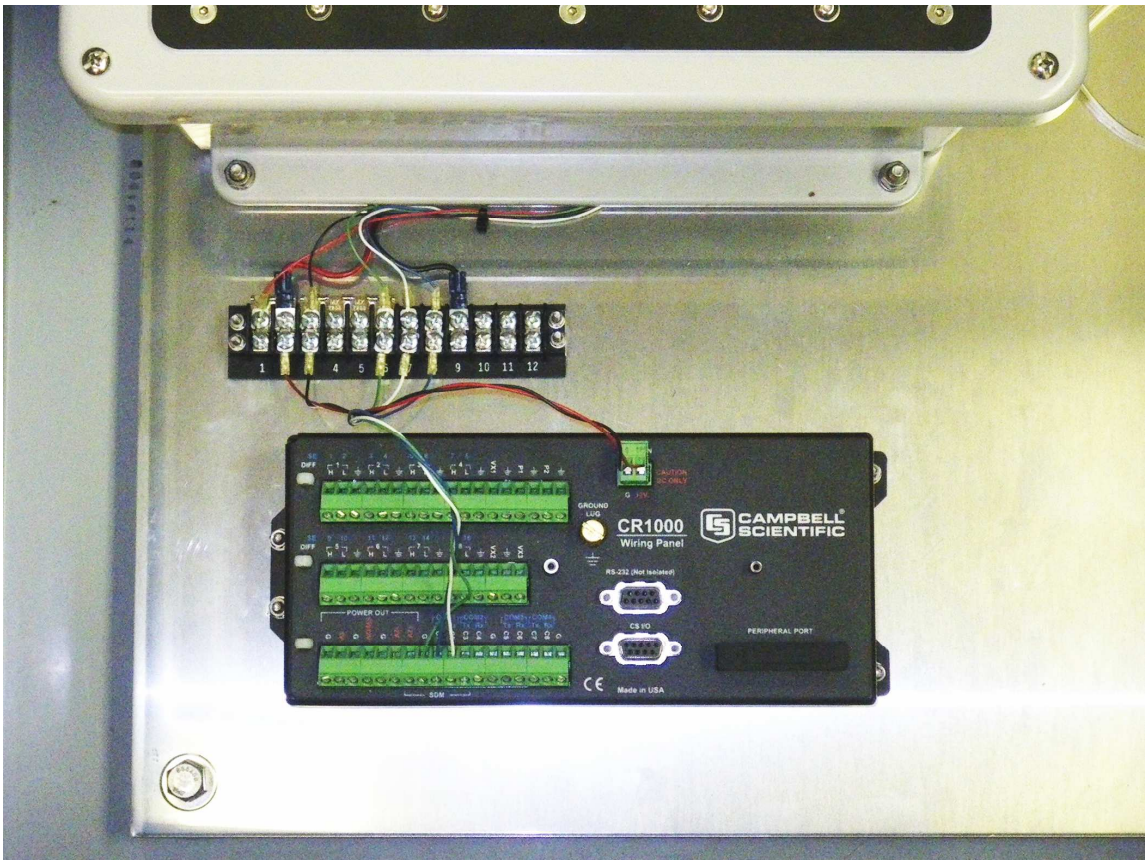
Opening the environmental or detector housings without prior authorization will void the product warranty.

9.1 Return Material Authorization

A Return Material Authorization (RMA) number must be obtained prior to returning and equipment to the factory. Equipment received without an RMA number may be refused. All return shipments must pre-paid unless otherwise agreed in writing.

Appendix A – Campbell Dataloggers

AutoLAB systems may be fitted with Campbell Scientific CR800, CR1000 and higher model dataloggers to provide additional control, data acquisition and telemetry/communication capability. Water quality sondes, weather stations and other sensors can be integrated as part of a system. User editable control programs, written in CR BASIC, are provided.



Intergrated Campbell CR1000 Datalogger