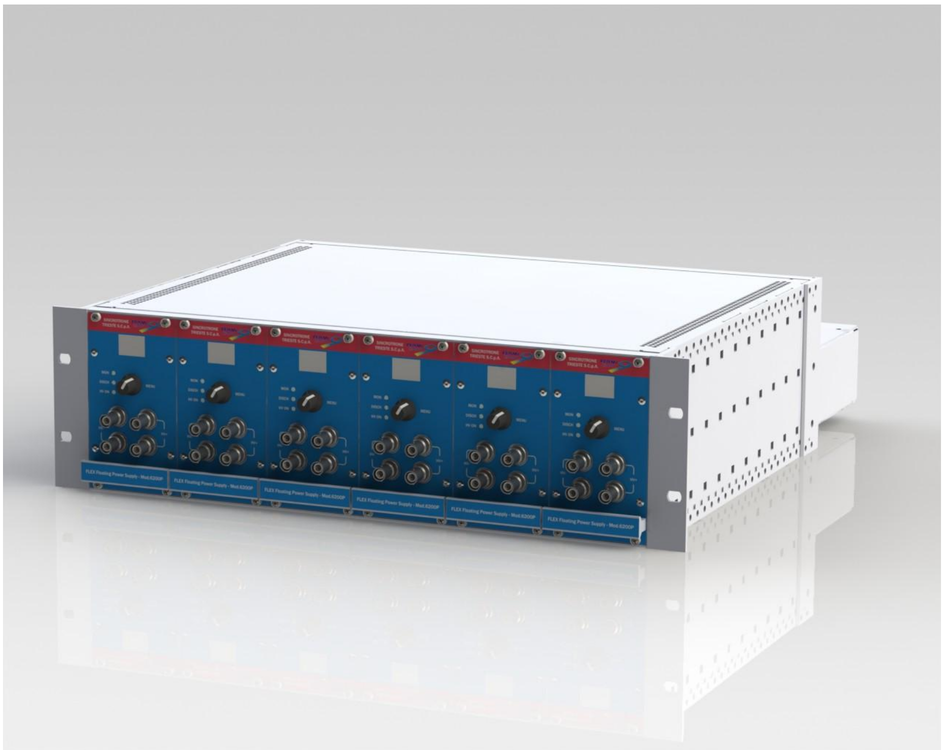
FLEX SYSTEM
Floating High Voltage Power Supply

Elettra Sincrotrone Trieste

User's Manual



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Elettra - Sincrotrone Trieste S.C.p.A
Strada Statale 14 - km 163,5 in AREA Science Park
34149 Basovizza, Trieste ITALY
Tel. +39 040 3758303
Fax. +39 040 9380902
www.elettra.eu

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Document Revision	Date	Comment
0.1	February 4th 2015	First Release

Safety information - Warnings

Read over the instruction manual carefully before using the instrument.
The following precautions should be strictly observed before using the FLEX System:

WARNING

- Do not use this product in any manner not specified by the manufacturer. The protective features of this product may be impaired if it is used in a manner not specified in this manual.
- Do not use the device if it is damaged. Before you use the device, inspect the instrument for possible cracks or breaks before each use.
- Do not operate the device around explosives gas, vapor or dust.
- Always use the device with the cables provided.
- Turn off the device before establishing any connection.
- Do not operate the device with the cover removed or loosened.
- Do not install substitute parts or perform any unauthorized modification to the product.
- Return the product to the manufacturer for service and repair to ensure that safety features are maintained

CAUTION

- This instrument is designed for indoor use and in area with low condensation.

The following table shows the general environmental requirements for correct operation of the instrument:

Environmental Conditions	Requirements
Operating Temperature	5°C to 45°C
Operating Humidity	20% to 85% RH (non-condensing)
Storage Temperature	-20°C to 70°C
Storage Humidity	5% to 90% RH (non-condensing)

1. Introduction

This chapter describes the general characteristics and main features of the FLEX System.

1.1 The FLEX system

The FLEX System is a xxxxxx 4-channel, 20-bit resolution, low noise, high performance picoammeter. It is composed of a particular charge-integration input stage for low current sensing, coupled with a 20-bit sigma-delta ADC converter including a noise reduction digital filter.

The AH401B performs current measurements from 50pA (with a resolution of 50 aA) up to 1.8µA (with a resolution of 1.8 pA), with integration times ranging from 1ms up to 1s. Moreover, each input channel has two parallel integrator stages, so that the current-to-voltage conversion can be performed continuously also during the ADC conversion, avoiding any dead time in the data throughput.

It also performs digitization of the acquired current data, thus strongly minimizing the transmission length of analog current signals from the detector and providing directly digital data output, which is easy to transmit over long distances without any noise pick-up.

The AH401B is housed in a light, practical and extremely compact metallic box that can be placed as close as possible to the current source (detector) in order to reduce cable lengths and minimize possible noise pick-up during the propagation of very low intensity analog signals. It is specially suited for applications where multi-channel simultaneous acquisitions are required, a typical application being the currents readout from 4-quadrant photodiodes used to monitor X-ray beam displacements. Low temperature drifts, good linearity and the very low intrinsic noise of the AH401B allow obtaining very high precision current measurements.

The AH401B with its modular communication capability allows the user to freely select the type of communication interface, allowing control of the instrument with different types of programming languages and/or operating systems. Currently available communication modules are: RS232, RS422/485, USB and Ethernet (TCP/IP and UDP).

The efficient integration realized in the AH410B of the whole acquisition, counting and digitization chain in a single compact element allows simplifying and streamlining to a great extent the task to read out at high speed and with extremely low noise X-ray detectors, while also greatly enhancing the price/performance ratio and its user-friendliness.

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1.2 The FLEX system at a glance

In Fig. 1 the FLEX System and its I/O connections can be easily seen:

Fig. 1 - The FLEX HV Power Supply Module

1.3 Features

The FLEX HV Module input stage is based on a typical charge integrator topology, thus the instrument really measures the charge integrated during the selected integration time. Eight full scale capacitor ranges are available as reported in the following table:

	Full Scale
RNG 0	1.8nC
RNG 1	50pC
RNG 2	100pC
RNG 3	150pC
RNG 4	200pC
RNG 5	250pC
RNG 6	300pC
RNG 7	350pC

Whereas the integration time can be varied between 1ms and 1s in incremental steps of 100µs.

In order to convert the input data from "integrated charge" to current the following formula must be applied:

$$I_{IN} = Q_{IN}/t_{INT}$$

In the following table the maximum and minimum currents that can be measured with the AH401B are reported, along with the LSB resolution, for each capacitor range:

	Full Scale	Equivalent Current FS @1ms t_{INT}	LSB Resolution @1ms t_{INT}	Equivalent Current FS @1s t_{INT}	LSB Resolution @1s t_{INT}
RNG 0	1.8nC	1.8µA	1.8pA	1.8nA	1.8fA
RNG 1	50pC	50nA	50fA	50pA	50aA
RNG 2	100pC	100nA	100fA	100pA	100aA
RNG 3	150pC	150nA	150fA	150pA	150aA
RNG 4	200pC	200nA	200fA	200pA	200aA
RNG 5	250pC	250nA	250fA	250pA	250aA
RNG 6	300pC	300nA	300fA	300pA	300aA
RNG 7	350pC	350nA	350fA	350pA	350aA

A host PC is necessary in order to operate the AH401B and properly set the desired parameters (i.e. range and integration time) and to acquire the converted data. Please refer to the "Software Commands" chapter for a complete description of available commands, their purposes and syntax.

A fully developed LabView™ GUI is available, allowing to plot the AH401B outputs up to 500 Hz and performing all necessary operations to convert the current data into positional information for all most commonly used Beam Position Monitors geometry. It also performs calculation of statistical data on the sampled buffers of data (average and rms) and, most importantly, provides the user with a FFT function that is of uttermost importance when using the AH401B as a spectrum analyzer to characterize the vibrational properties of the X-ray beam. The FFT can extend up to 250 Hz, fully covering the critical 0-100 Hz range where most of the beamlines require extreme stability in order not to spoil the science data acquisition.

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1.4 Data Format

Since the AH401B works in "charge integrator mode" the data output values depend on the range and integration time selected. For this reason it is important to properly set these parameters in order to avoid input stage saturation and the corresponding data clipping (to 0 or to 1048575, the latter being the upper limit before saturation for the AH401B in raw digital data) in the output values.

Moreover, as an output offset has been built into the instrument to allow for the measurements of input signals near and below zero, this data offset must be taken into account for proper data conversion. For this reason an offset calibration procedure must be performed before using the AH401B. In the following table the correspondence between the read value and the full scale range is reported:

Data Value	Input Signal
1048575	Full Scale
4096	0
0	-0.4% Full Scale

The data read from the AH401B are the raw values of the 20-bit ADC converter, thus the data conversion from the read values to the corresponding current values must be performed by the user applying the following formula:

$$I_{IN} = \frac{\frac{FSR}{2^{20}-1} * (Value - Offset)}{t_{INT}}$$

with:

- I_{IN}: the calculated input current;
- FSR: the selected Full Scale Range;
- Value: the raw data value from the AH401B;
- Offset: the data offset (~4096). For a proper estimation of this offset a calibration procedure must be performed (see "AH401B Offset Calibration" paragraph);
- t_{INT}: the selected Integration Time.

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1.5 Offset Calibration

As explained in the previous paragraph, an output offset is built into the instrument to allow for the measurements of input signals near and below zero. For this reason with an input signal of 0 the read value from the AH401B is equal to ~4096. If a precise estimation of this offset is necessary, the following procedure must be followed:

- Place on each input connector a shielding cap in order to avoid noise pick-up (be aware that the central input pin must be left open and shielded but not grounded otherwise the read values are meaningless);
- Switch on the AH401B;
- Let it warm-up for about half an hour;
- Acquire a set of data (for example 100pts.) from each input channel and calculate the mean value;

The calculated mean values are the new Data Offset that must be taken into account in the current evaluation formula (see 1.4) that has to be applied to each channel.

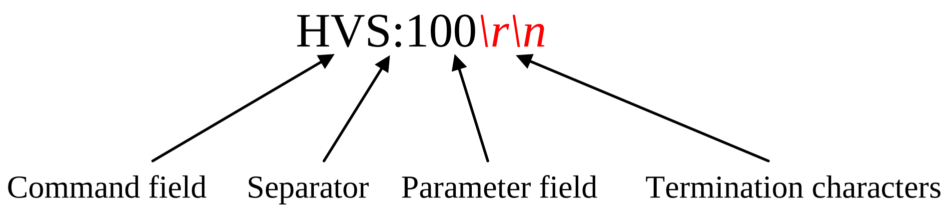
2. Software Commands

This chapter describes the software commands used to tune and read the FLEX system.

2.1 Command Syntax

The command syntax used by the FLEX system protocol is described in the following paragraphs.

The commands are sent in ASCII format and are composed by two fields, the “command field” and the “parameter field”, separated by a space. Instructions are not case sensitive and therefore the command string can freely use either uppercase or lowercase. Each instruction is terminated with the “carriage return/line-feed” characters (*‘\r\n’* or 0x0D 0x0A in hexadecimal notation), e.g.:



There are two types of software commands: “configuration commands” and “query commands”. The “query commands” usually have the same “command field” as the “configuration commands” with a “?” in the “parameter field”.

After each received command the FLEX system replies with a string whose content depends on the type of command sent and its correctness.

There are three possible scenarios (with some exceptions, as described in the corresponding command paragraph):

1) *the command syntax is incorrect:* the FLEX system will always answer with the string "NAK" terminated with a "carriage return/line feed" characters (*'\r\n'* or 0x0D0x0A in hexadecimal notation), e.g.:

HWS:100\r\n →

← NAK\r\n

example 2:

HVS:100000\r\n →

← NAK\r\n

2) *the command syntax is correct and it is a "configuration command":* the FLEX system will answer with the string "ACK" terminated with a "carriage return/line feed" (*'\r\n'*) characters, e.g.:

HVS:100\r\n →

← ACK\r\n

example 2:

HVSB:65535\r\n →

← ACK\r\n

3) *the command syntax is correct and it is a "query command":* the FLEX system will answer with the echo of the "command field" and the value of the requested parameter, separated with a ":" and terminated with the "carriage return/line feed" (*'\r\n'*) characters, e.g.:

HVS:?\r\n →

← HVS:100\r\n

example 2:

HVR:?\r\n →

← HVR:100.25\r\n

2.2 Command List

Please find hereafter the command list used by the FLEX system with their syntax, the description of their purpose and the description of any special requirements.

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2.2.1 "HVS" Command

The purpose of the HVS command is to set/read the HV voltage output with calibrated voltage value.

Since the HV Module can be of different type with various output voltages the value can range from 0 to the *Module Type max voltage*. This parameter can be read using the PARAM command (refer to the corresponding paragraph for details).

With the HVS:? command the returned value corresponds to the voltage set-point not the actual output value. If you want the real output voltage use the HVR command that use the 16-bit ADC to sample the HV output.

The returned value is in floating point notation with 3 digits of precision.

Examples:

HVS examples:

HVS:100.25\r\n →

← ACK\r\n

HVS:-1200.5\r\n →

← ACK\r\n

HVS:?\r\n →

← HVS:1250.650\r\n

HVS:?\r\n →

← HVS:-280.790\r\n

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2.2.2 "HVSB" Command

The purpose of the HVSB command is to set the HV voltage output with uncalibrated DAC binary raw value.

Since the output voltage is based on a 16-bit DAC the values can range from 0 to 65535.

Examples:

HVSB example:

HVSB:10250\r\n →

← ACK\r\n

2.2.3 "HVR" Command

The purpose of the HVR command is to read-back the voltage supplied by the HV Module with calibrated V value.

Since the HV Module can be of different type with various output voltages the returned value can range from 0 to the *Module Type max voltage*. This parameter can be read using the PARAM command (refer to the corresponding paragraph for details)

The value is returned in floating point notation with 3 digits of precision.

Examples:

HVR example:

HVR:?\r\n →

← HVR:1120.560\r\n

HVR:?\r\n →

← HVR:-250.680\r\n

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2.2.4 "HVRB" Command

The purpose of the HVRB command is to read the output voltage supplied by the HV Module with uncalibrated ADC binary raw value.

Since the reading is based on a 16-bit ADC the values can range from 0 to 65535.

Examples:

HVRB example:

HVRB:?\r\n →

← HVRB:25320\r\n

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2.2.5 "HVI" Command

The purpose of the HVI command is to read the current supplied by the HV Module with calibrated uA value.

The value is returned in floating point notation with 3 digits of precision.

Examples:

HVI example:

HVI:?\r\n →

← HVI:4.123\r\n

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2.2.6 "HVIB" Command

The purpose of the HVIB command is to read the current supplied by the HV Module with uncalibrated ADC binary raw value.

Since the reading is based on a 12-bit ADC the value can range from 0 to 4095.

Examples:

HVIB example:

HVIB:?\r\n →

← HVIB:1058\r\n

2.2.7 "PARAM" Command

The purpose of the PARAM command is to read the FLEX System parameters.

Since the FLEX System is made of a Main Board and a HV Module, it is possible to query the corresponding parameters with the following commands:

for the Main Board parameters: PARAM:?\r\n
for the HV Module parameters: PARAM:A:?\r\n

Here are the returned, comma separated, parameters:

Calibration Date, Production Date, Serial Number

For the Main Board: 00/00/0000,30/01/2014,000002

Calibration Date, Production Date, Serial Number, HV Module Type

For the HV Module: 01/02/2014,30/01/2014,000002,+2000

Examples:

Main Board PARAM examples:

PARAM:?\r\n →

← PARAM:00/00/0000,30/01/2014,000002\r\n

HV Module PARAM examples:

PARAM:A:?\r\n →

← PARAM:A:00/00/0000,30/01/2014,000002,+2000\r\n

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2.2.8 "DISP" Command

The purpose of the DISP command is to write a string on the Module OLED Display.

The string can have a maximum of 12 characters and cannot have any blank space or special character inside it. The string will be printed right aligned on the last line of the display.

In order to remove the string from the display the special parameter string CLR must be used.

Examples:

DISP examples:

DISP:____MOD1____\r\n →

← ACK\r\n

DISP:FOCUS\r\n →

← ACK\r\n

DISP clear example:

DISP:CLR\r\n →

← ACK\r\n

2.2.9 "VER" Command

The purpose of the VER command is to report the firmware version currently installed in the FLEX System on-board processors.

Since the FLEX System is made of a Main Board and a HV Module each with its own processor, it is possible to query the firmware version installed on each microcontroller with the following commands:

for the Main Board on-board processor: VER:?\r\n
for the HV Module on-board processor: VER:A:?\r\n

Examples:

Main Board VER example:

VER:?\r\n →

← VER:0.4.9\r\n

HV Module VER example:

VER:A:?\r\n →

← VER:A:0.2.4\r\n

2.2.10 "*IDN?" Command

The purpose of the *IDN? command is to query the FLEX system for the Main Board and the installed HV Module information.

Here are the returned information:

Main Board firmware version HVModule firmware version

Flex Main v1.2 - v0.4.9 # Flex HVModule v2.0 - v0.2.4 # +2000V

Main Board HW version HV Module HW version HV Module max voltage

Examples:

**IDN? example:*

IDN?\r\n*

Flex Main v1.2 - v0.4.9 # Flex HVModule v2.0 - v0.2.4 # +2000V*\r\n*

2.2.11 "*RST" Command

The purpose of the *RST command is to perform a software reset on the FLEX system, putting the module back to the Power-on state.

Examples:

**RST example:*

*RST\r\n →

← ACK\r\n

…the FLEX system reboot

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2.3 Command Table Summary

Command	Purposes	Parameters	Power-up default value
HVS:	Set HV module output voltage (calibrated V Value)	0.00 to "*HV Module max voltage*"	*0.00*
	Query HV module set point (V Value)	?	
HVSB:	Set HV module output voltage (uncalibrated raw binary DAC Value)	0 to 65535	*0*
HVR:	Query HV module output voltage (calibrated V value)	?	
HVRB:	Query HV module output voltage (uncalibrated raw binary ADC value)	?	
HVI:	Query HV module output current (calibrated uA value)	?	
HVIB:	Query HV module output current (uncalibrated raw binary ADC value)	?	
PARAM:	Query Controller parameters	?	
PARAM:A:	Query HV Module parameters	?	
DISP:	Write <*string*> on the display (max 12 characters)	*string*	
	Clear display	CLR	
VER:	Query Controller firmware version	?	
VER:A:	Query HV Module firmware version	?	
*IDN?	Query System identification data		
*RST	System software reset		

3. Communication Modules

This chapter describes the currently available communication modules (RS232Piggy, RS422/485Piggy, USBPiggy and ETHERPiggy) and how to install and configure them.

3.1 Module Hardware Installation

The AH401B is shipped with a communication module already installed as shown in Fig. 2.

Fig. 2 - The AH401B with an Ethernet communication module

In order to change the communication module type follow these steps:

- Switch off the instrument;
- Unscrew the module retaining screw;

- Gently pull out the communication module using the retaining screw;

- Insert the new module. Be careful to verify that the module connector and the AH401B receptacle connector are properly aligned;

- Fix the retaining screw;
- Switch on the instrument.

Now the new communication module should be installed and running. To properly set-up each module, please follow the software configuration instructions in the corresponding paragraph.

3.2 "ETHERPiggy" Module

The "ETHERPiggy" module is based on the Lantronix Xport® embedded Ethernet device server. To properly configure the Xport® device the user must configure the IP address, the communication protocol and all other network parameters needed by the AH401B. Please, refer to the Xport® documentation and configuration software available at the Lantronix site www.lantronix.com for a complete description.

3.2.1 "ETHERPiggy" IP Address Assign

Every "ETHERPiggy" module is shipped with a default IP address as indicated on a label on the module itself (see Fig. 3).

Fig. 3 - "ETHERPiggy" Module with label

Before assigning a new IP address it is required to install, on the host PC, the "DeviceInstaller" software that can be downloaded from the Lantronix website www.lantronix.com.

Even if the AH401B can be connected on the global LAN, a point-to-point Ethernet connection is strongly recommended in order to insure maximum speed performance and to avoid possible communication problems. This implies that the host PC and the "ETHERPiggy Module" should reside on the same ethernet subnet, i.e.:

Host PC address: 192.168.10.100 → ETHERPiggy address: 192.168.10.200

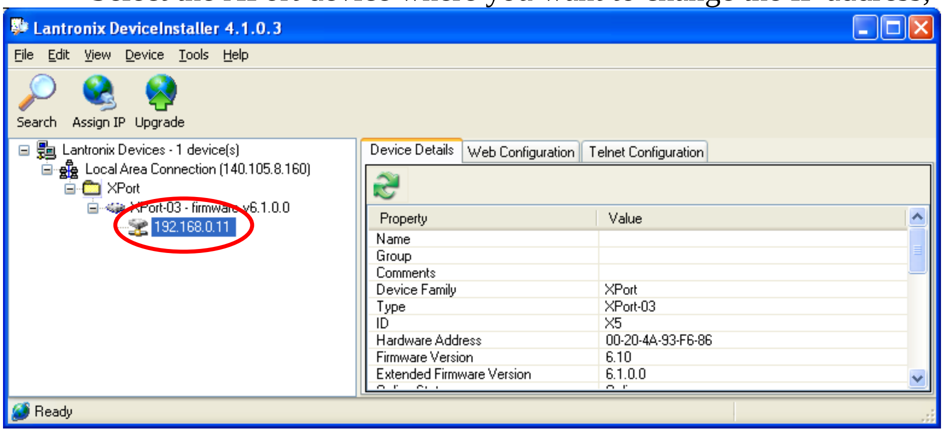
Please note that in a point-to-point direct connection a twisted Ethernet cable must be used.

In order to assign the IP address to the "ETHERPiggy" module the next steps must be followed:

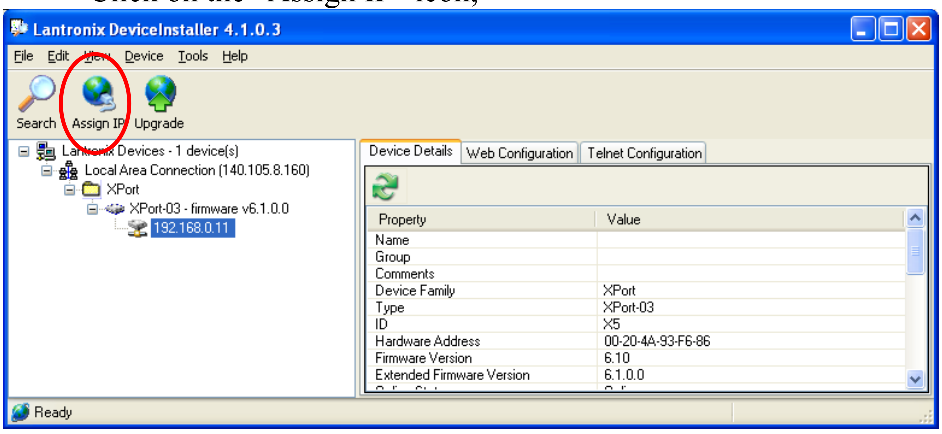
- Connect the host PC and the AH401B with a twisted Ethernet cable;
- Switch on the AH401B;
- Verify that the "Link LED" on the RJ45 connector is on (amber for a 10Mbps connection, or green for a 100Mbps connection) and the corresponding "Network Connection" is active on the host PC;

The "Link LED"

- Launch the "DeviceInstaller" program;
- Select the XPort device where you want to change the IP address;



- Click on the "Assign IP" icon;



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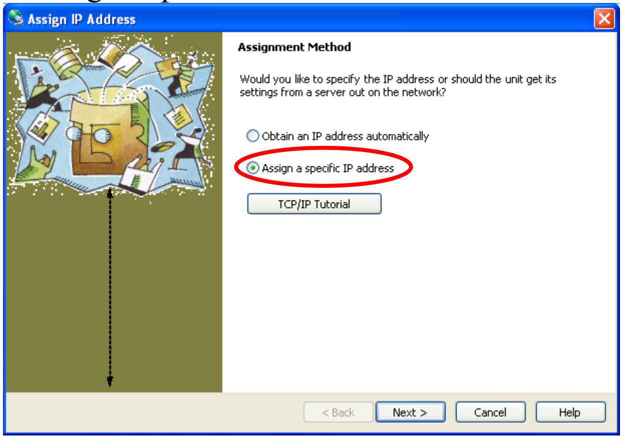
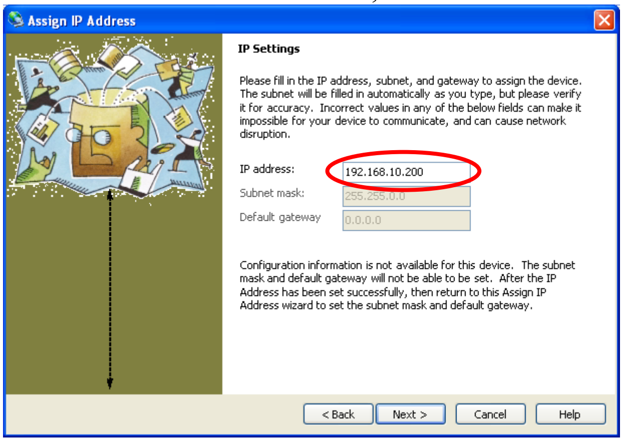
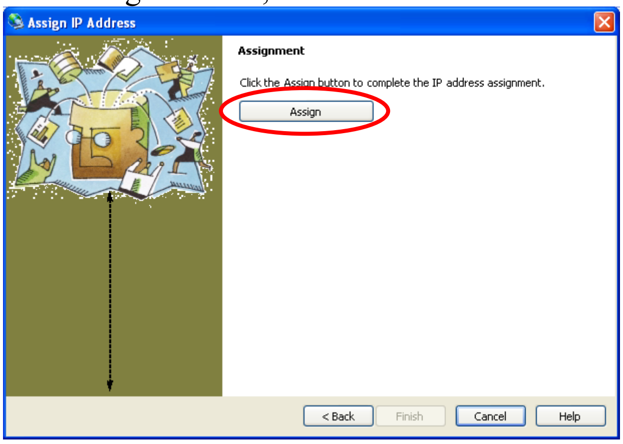
- Select "Assign a specific IP address" and then click "Next";



- Set the "IP address". Click "Next";



- Click the "Assign" button;



- Wait the "Assignment" then click "Finish".

Now the new module IP address should be assigned and the success of the operation can be verified on the "DeviceInstaller" window.

3.2.2 "ETHERPiggy" Software Configuration

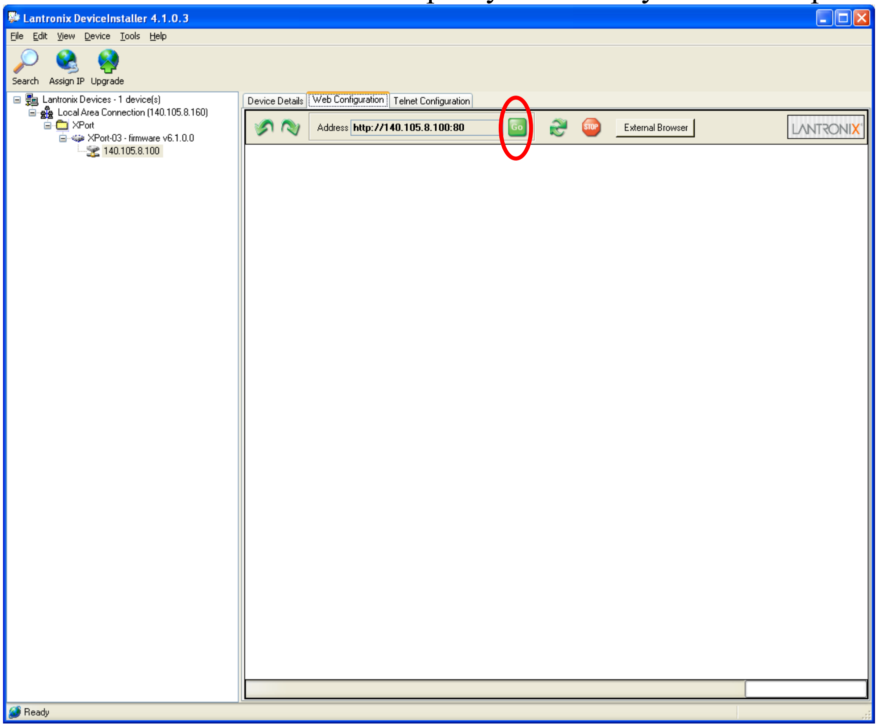
After assigning the IP address, the user must configure some other parameters on the Xport® device. There are two possibilities to configure such parameters:

- using the web server interface;
- using a telnet connection.

In this manual we describe only the web interface procedure, if you need to configure via the telnet connection please refer to the Xport® user guide.

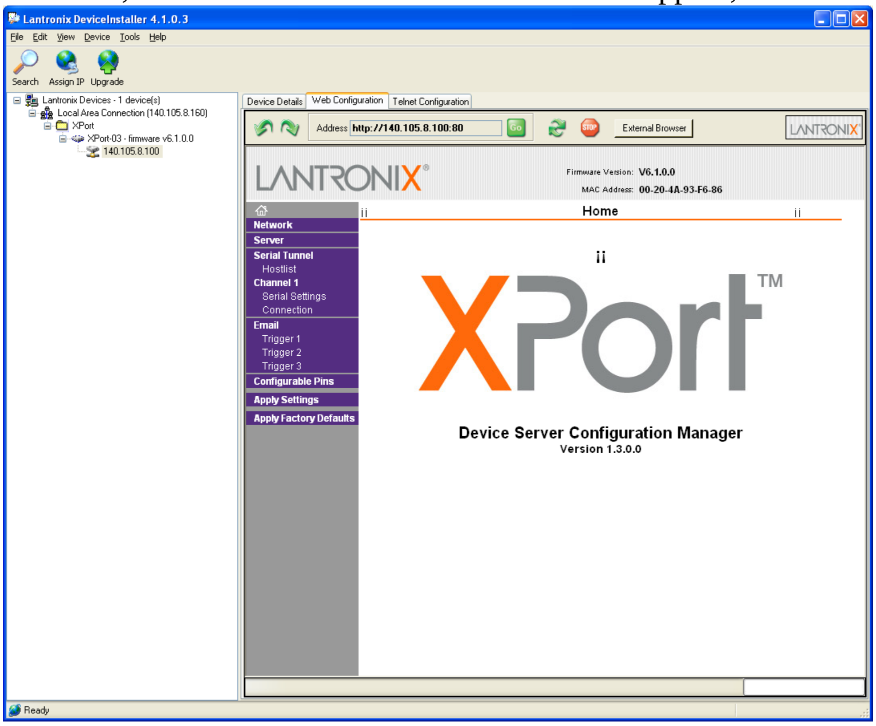
Follow the next steps to properly setup the ETHERPiggy communication module:

- Select the "Web Configuration" tab, then click the "Go" button. Be sure to disable the "proxy server" option in your "Internet Options" application: go to the "Control Panel" folder, open the "Internet Options", then click on the "Connections" tab, go to the "LAN settings" and then deselect the "Use a proxy server for your LAN" option;

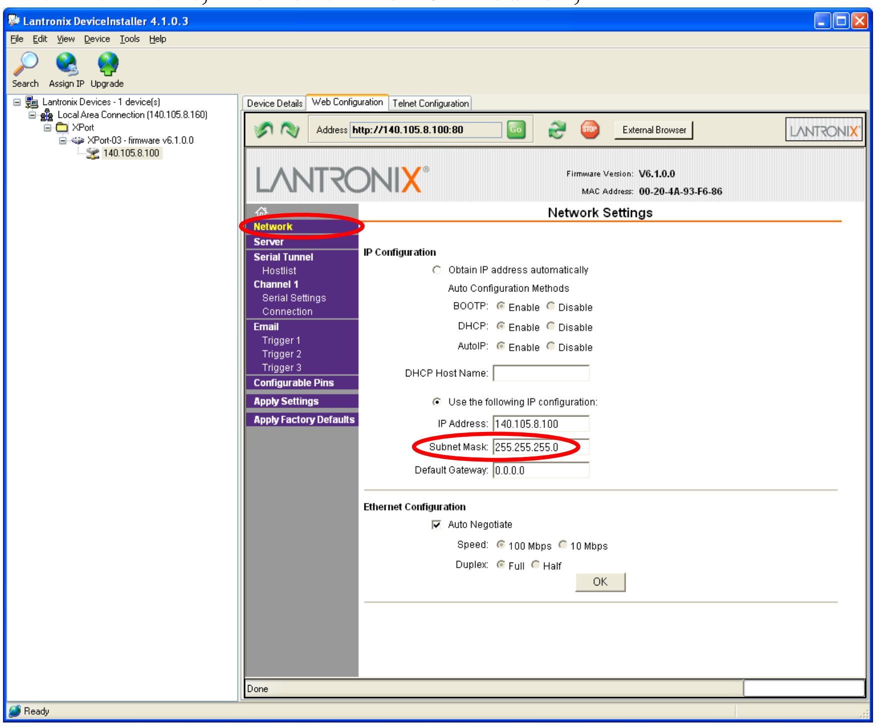


- A dialog window will appear asking for user name and password, simply click the "OK" button;

- Then, the Lantronix web server interface will appear;



- Click on the "Network" button and set the "Subnet Mask" to "255.255.255.0".; Then click the "OK" button;



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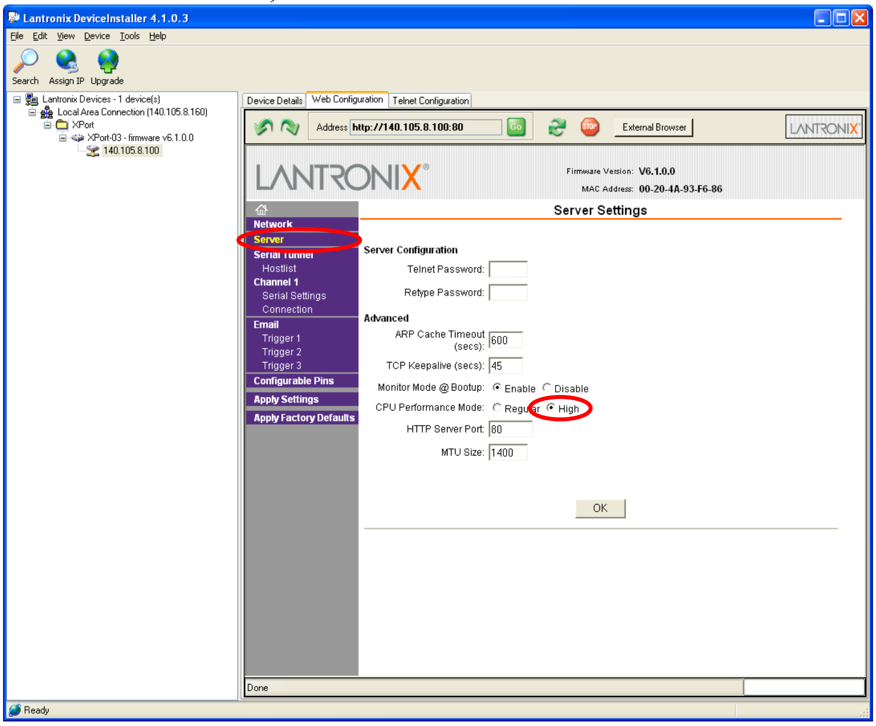
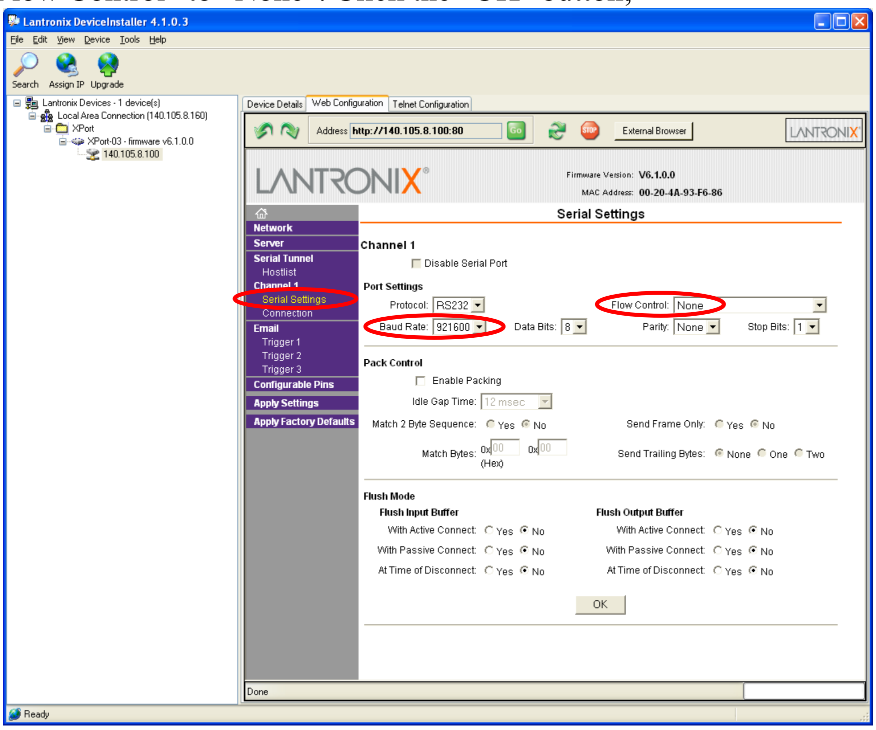
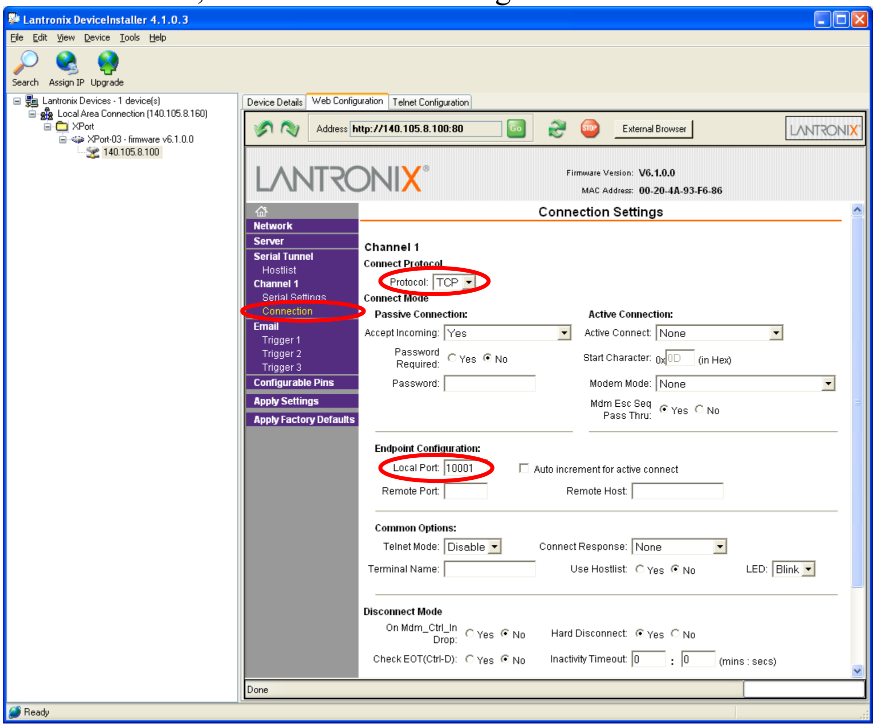
- Click on the "Server" button. Set the "CPU Performance Mode" to "High". Click the "OK" button;



- Click on the "Serial Settings" button. Set the "Baud Rate" to "921600" and the "Flow Control" to "None". Click the "OK" button;



- Click on the "Connection" button. Set the "Protocol" to "TCP" and the "Local Port" to "10001", this value can be changed as needed. Click the "OK" button;



- Click the "Apply Settings" button.

Now the Xport® Ethernet device should be correctly configured to work with the AH401B. If you need to change any other XPort® parameter, please, refer to the Xport® user's guide.

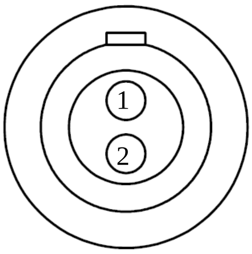
4. I/O Connectors

This chapter describes the I/O connectors, their corresponding pinout and the purposes of each signal.

4.1 Power Connector

In Fig. 4 the input Power Connector is shown with its corresponding pinout. The input voltage range from 9V up to 15V with a max input current of 350mA (depending on the communication module).

The connector type is a LEMO – "EGG.0B.302" series. The corresponding matching connector plug is a LEMO – "FGG.0B.302" series.



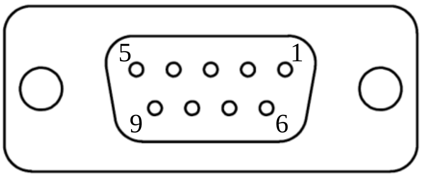
Pin	Signal
1	$+V_{CC}$
2	GND

Fig. 4 - Power Connector

4.2 I/O Interface Connector

In Fig. 5 the I/O Interface Connector is shown with its corresponding pinout. The signal levels are 5V TTL and CMOS compatible. The minimum output current is 24mA.

The connector type is a DSub 9-pin socket.



Pin	Signal
1	GND
3	CONV
5	TRIGGER

Fig. 5 - I/O Interface Connector

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4.2.1 The CONV Signal

The CONV signal is a copy of the internal Integration Time signal. For example with an Integration Time of 100ms the CONV output will be a square wave with the half-period equal to 100ms. It can be used as a monitor of the internal timing or as synchronization signal for external devices.

The output voltage level is 5V TTL and CMOS compatible, with a minimum output current of 24mA.

4.2.2 The TRIGGER Signal

The purpose of the TRIGGER signal is to synchronize the acquisition of the AH401B with external events (e.g. laser pulses). It works in combination with the TRG command (please refer to "TRG Command" paragraph for more details).

When the "trigger mode" is enabled by software, a falling edge signal on the TRIGGER input starts the acquisition of the picoammeter. As soon as a new TRIGGER signal is received on the corresponding input, the acquisition stops and no data is sent to the host. This behavior continues until the "trigger mode" is disabled by software.

The input voltage level is 5V TTL and CMOS compatible.

5. Technical Specifications

Input Channels	4	
Current Measuring Range	from 50 pA to 1.8µA	
Current Polarity	positive only	
Integration Time	from 1ms to 1s	
Data Transfer	up to 1 ksamples/s	
Resolution Bits	20	
Noise (@1ms, 200pC$_{FS}$)	<7ppm	
Communication Modules	RS-232/422/485, USB, Ethernet TCP/IP and UDP	
I/O Signal	CONV output - TRIGGER input	
Supply Voltage	from 9 V to 15 V	
Max Supply Current	**RS-232/422/485**	100 mA
	USB	150 mA
	Ethernet (TCP/IP and UDP)	350 mA
Dimensions	140 × 110 × 28 mm	
Weight	420 g	
Input Connectors	BNC	