AH401D

4-Channel Charge-Integration Picoammeter

CAENels
Gear For Science

User's Manual

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This product is CE certified.

Table Of Contents

Document Revision	Date	Comment
1.0	March 8th 2012	First Release
1.1	April 16th 2012	Layout update
1.2	July 5th 2012	Data transmission format corrected
1.3	November 7th 2013	2.2.3 and 2.2.9 sections changed and HW Reset
1.4	September 10th 2014	Maintenance release
1.5	October 29th 2014	Manual graphics changed

Safety information - Warnings

Read over the instruction manual carefully before using the instrument.
The following precautions should be strictly observed before using the AH401D:

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 AH401D picoammeter.

1.1 The AH401D Picoammeter

The AH401D is a 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 AH401D performs current measurements from 50 pA (with a resolution of 50 aA) up to 2.0 µA (with a resolution of 2.0 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 AH401D 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 AH401D allow obtaining very high precision current measurements.

The AH401D with its standard Ethernet communication capability allows the users to easily control the instrument with different types of programming languages and/or operating systems.

The efficient integration realized in the AH410D 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.

1.2 The AH401D at a Glance

The AH401D picoammeter and its I/O connections can be easily seen in **Figure 1** (front) and **Figure 2** (rear):

Input Channels

Figure 1: the AH401D front panel and its I/O connections

Analog BNC current input connectors are placed on the front panel of the device while the other available connections - i.e. power input, communication socket, trigger input, conversion output and ground connection - are placed on the rear panel.

The reset button (accessible only with a thin pen-tip or a needle) and the status LED are also accessible from the rear panel of the instrument.

Ground connection

Hardware Reset

CONV output

TRIGGER input

Communication Interface

Status LED

Power Connector
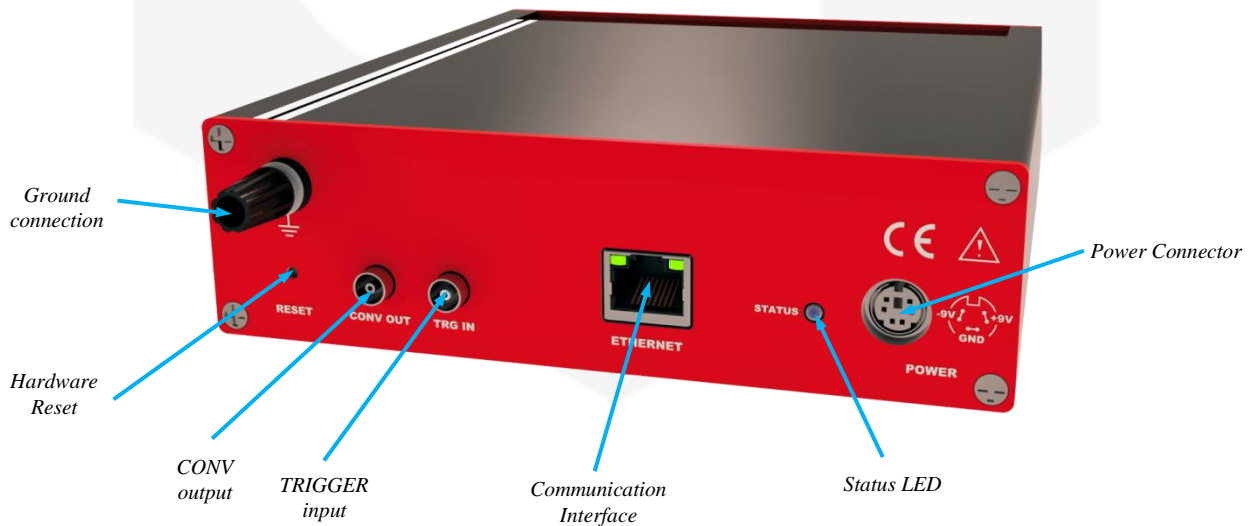
Figure 2: the AH401D rear panel and its I/O connections

1.3 Features

The AH401D 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
Table 1.

Please note that the AH401D, respect to its predecessors AH401 and AH401B, has the capability to handle different gain ranges between couples of channels - i.e. gain of channel 1 and 2 can be different from the one of channel 3 and 4:

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

Table 1: Full-scale ranges

The integration time t_{INT} can be varied between 1ms and 1s in incremental steps of 100 μs (0.1 ms).

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

$$I_{IN} = \frac{Q_{IN}}{t_{INT}}$$

In **Table 2** the maximum and minimum currents that can be measured with the AH401D 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	2 nC	2 μA	2 pA	2 nA	2 fA
RNG 1	50 pC	50 nA	50 fA	50 pA	50 aA
RNG 2	100 pC	100 nA	100 fA	100 pA	100 aA
RNG 3	150 pC	150 nA	150 fA	150 pA	150 aA
RNG 4	200 pC	200 nA	200 fA	200 pA	200 aA
RNG 5	250 pC	250 nA	250 fA	250 pA	250 aA
RNG 6	300 pC	300 nA	300 fA	300 pA	300 aA
RNG 7	350 pC	350 nA	350 fA	350 pA	350 aA

Table 2: maximum and minimum currents and resolution by range

A host PC is necessary in order to operate the AH401D 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 AH401D 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 AH401D 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.

1.4 Data Format

Since the AH401D 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 AH401D 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 AH401D. The correspondence between the read value and the full scale range is reported in
Table 3:

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

Table 3: digital code and input signal correspondence

The data read from the AH401D 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:

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

with:
- I_{IN}: the calculated input current;
- FSR: the selected Full Scale Range;
- Value: the raw data value from the AH401D;
- Offset: the data offset (~4096). For a proper estimation of this offset a calibration procedure must be performed (see "AH401D Offset Calibration" paragraph);
- t_{INT}: the selected Integration Time.

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 AH401D 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 AH401D;

- Let it warm-up for about half an hour;

- Acquire a set of data (for example 100 pts.) 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.

1.6 AH401B Compatibility

The AH401D picoammeter guarantees a strong compatibility with its predecessor AH401B for most of the commands with one exception.

Having the AH401D the availability to have different ranges on couples of channels - i.e. channels 1-2 can have a different gain than channels 3-4 - the RNG command syntax is slightly different (please refer to 'RNG Command' section for further details).

The RNG command is still supported and changes simultaneously range for all the four channels while the replies from the device to a RNG ? command are in the format:

$$\text{RNG XY}\backslash r\backslash n$$

where X is the actual measuring range for channels 1-2 and Y the one for channels 3-4.

2. Software Commands

This chapter describes the software commands used to tune and read the AH401D picoammeter.

2.1 Command Syntax

The command syntax used by the AH401D 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 a "carriage return" character ('\r' or 0x0D in hexadecimal notation), e.g.:


Command field   Space   Parameter field   Termination character
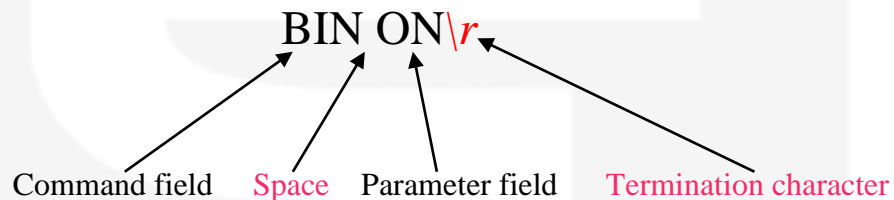
There are two types of software commands: "configuration commands" and "query commands". The "query commands" usually have the same "command field" as the "configuration commands" with a "?" in the "parameter field".

After each received command the AH401D 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 AH401D will always answer with the string "NAK" terminated with a "carriage return/line feed" characters (*'\r\n'* or 0x0A0x0D in hexadecimal notation), e.g.:

BIX ON*\r*

NAK*\r\n*

example 2:

BIN OOG*\r*

NAK*\r\n*
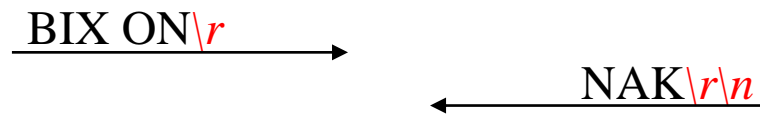
2) *the command syntax is correct and it is a "configuration command":* the AH401D will answer with the string "ACK" terminated with a "carriage return/line feed" (*'\r\n'*) characters, e.g.:
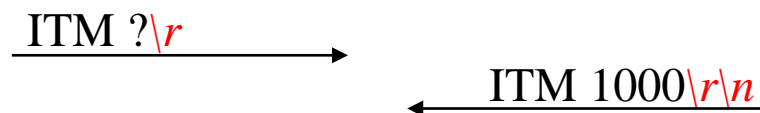
BIN ON*\r*

ACK*\r\n*

example 2:

ITM 1000*\r*

ACK*\r\n*

3) *the command syntax is correct and it is a "query command":* the AH401D will answer with the echo of the "command field" and the value of the requested parameter, separated with a space and terminated with a "carriage return/line feed" (*'\r\n'*) characters, e.g.:

BIN ?*\r*

BIN ON*\r\n*
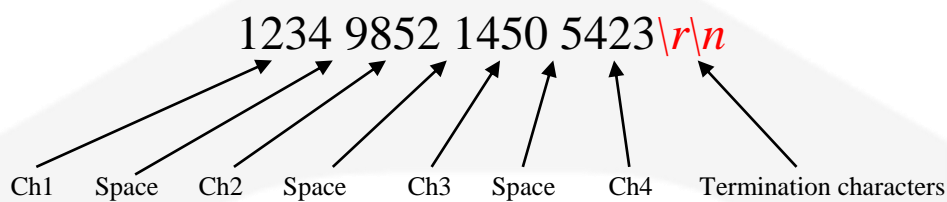
example 2:

ITM ?*\r*

ITM 1000*\r\n*
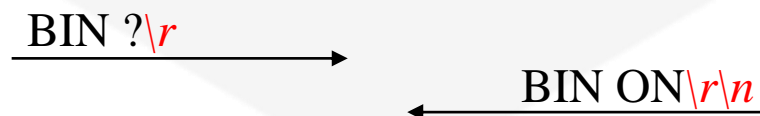
2.2 Command List

Please find hereafter the command list used by the AH401D with their syntax, the description of their purpose and the description of any special requirements.

2.2.1 "ACQ" Command

The purpose of the ACQ command is to start/stop the acquisition from the AH401D. As soon as the command is received the instrument starts to acquire data and immediately sends the generated digital data stream to the host PC. At power-up the instrument boots with the acquisition stopped ("ACQ OFF" - *default*), the user is thus required to start the data acquisition sending the "ACQ ON" command.
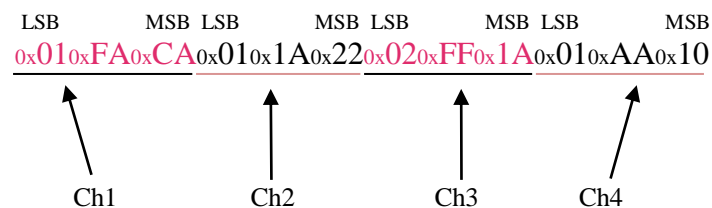
The type of data transmitted depends on the setting of the "binary mode" that can be changed using the "BIN" command (see "BIN Command" paragraph). With "BIN OFF" (*default*), data is sent in ASCII mode with the following format: "ch1 ch2 ch3 ch4\r\n", with a space between each channel value:

$$1234\ 9852\ 1450\ 5423 \backslash r \backslash n$$

| Ch1 | Space | Ch2 | Space | Ch3 | Space | Ch4 | Termination characters |

With "BIN ON" the values are transmitted as a continuous binary data stream without any termination or control character. For this reason it is important to keep synchronization with the data flux otherwise it is possible, if some bytes are missed, to corrupt the data and to get false readings from the instrument. If this happens, data acquisition must be stopped, with the "ACQ OFF" command, and then restarted again slowing down the data throughput rate or increasing the reliability of the communication channel. The speed of data transmission is directly given by the selected integration time and the "half mode" selection (see "HLF Command" paragraph for more information).

The value corresponding to each channel must be interpreted considering the set range (see RNG command for further details) for the specific channel. Please note that range of channel 1-2 is independent from the one of channel 3-4 - i.e. channel 1-2 range can be different from the one of channel 3-4.
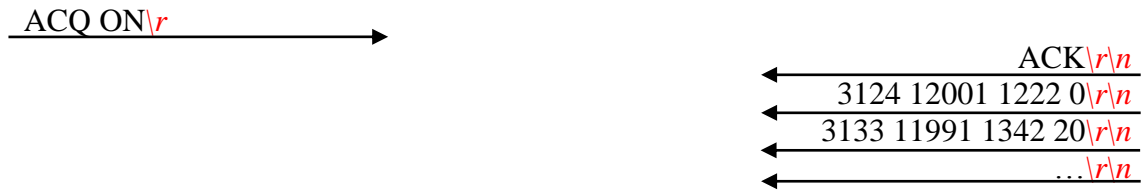
In binary mode the data output format consists of a continuous sequence of 12 bytes, three bytes for each channel with LSB first (for each channel sample):
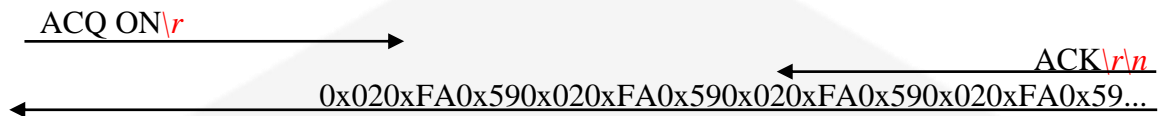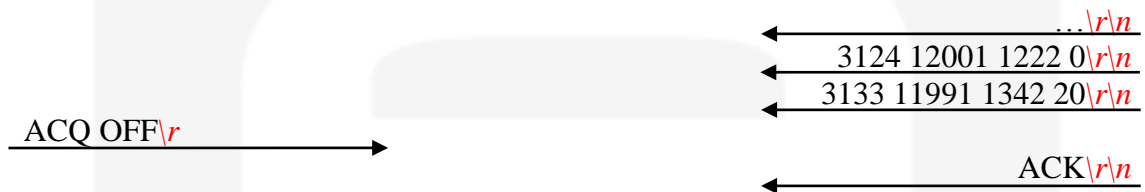
LSB MSB LSB MSB LSB MSB LSB MSB
0x01 0xFA 0xCA 0x01 0x1A 0x22 0x02 0xFF 0x1A 0x01 0xAA 0x10

| Ch1 | Ch2 | Ch3 | Ch4 |

Examples:

ACQ ON example with ASCII data:

ACQ ON\r →

← ACK\r\n
← 3124 12001 1222 0\r\n
← 3133 11991 1342 20\r\n
← …\r\n

ACQ ON example with BINARY data:

ACQ ON\r →

← ACK\r\n
← 0x020xFA0x590x020xFA0x590x020xFA0x590x020xFA0x59...

ACQ OFF example with ASCII data:

← …\r\n
← 3124 12001 1222 0\r\n
← 3133 11991 1342 20\r\n

ACQ OFF\r →

← ACK\r\n

ACQ OFF example with BINARY data:

← ...0x020xFA0x590x020xFA0x590x020xFA0x590x020xFA0x59

ACQ OFF\r →

← ACK\r\n

ACQ ? example:

ACQ ?\r →

← ACQ OFF\r\n
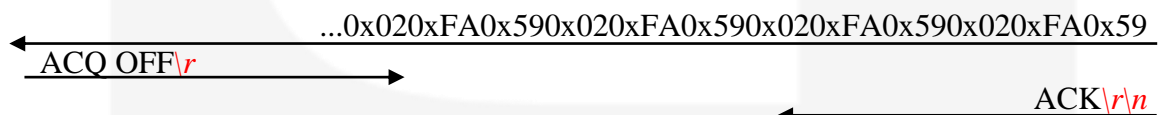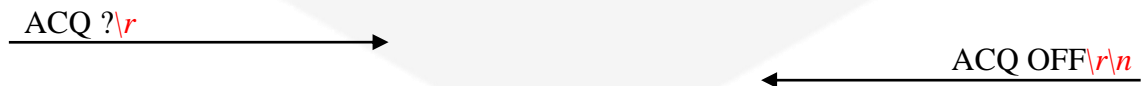
2.2.2 "BDR" Command

The purpose of the BDR command is to set the baudrate between the AH401D and the communication module. **Table 4** shows the allowed baudrates:

Command	Baudrate
BDR 921600	921600
BDR 460800	460800
BDR 230400	230400
BDR 115200	115200
BDR 57600	57600
BDR 38400	38400
BDR 19200	19200
BDR 9600	9600

Table 4: allowed baudrate values

By default the instrument boots with a 921600 baudrate setting.

Since the instrument immediately changes the baudrate when the BDR command is accepted, no acknowledgement string (ACK) is sent back to the host. The user should verify successful execution of the command by sending another command after changing the host baudrate (e.g.: "BDR ?").

The baudrate change procedure strictly depends on the communication interface module used. Please refer to the "Communication Module Interfaces" chapter for more information.

Examples:

BDR example with incorrect parameter:

BDR 960000\r

NAK\r\n

BDR example with correct parameter:

BDR 9600\r

No acknowledgement from the AH401D but the baudrate has been changed. In order to verify that the baudrate was effectively changed the "BDR ?" command should be sent.

*BDR ? example:*

BDR ?\r

BDR 921600\r\n

2.2.3 "BIN" Command

The purpose of the BIN command is to change the format of the digital data stream generated by the AH401D picoammeter. At power-up "binary mode" is disabled ("BIN OFF" - *default*) and data is sent by default in ASCII format. With the "BIN ON" command binary format is enabled and the output values are sent as a continuous binary data stream. The binary format helps to improve the data rate transmission, as it avoids the overhead due to the ASCII format generation.
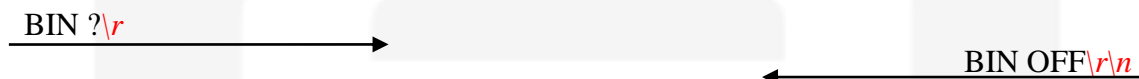
In binary mode the data output format is a continuous sequence of 12 bytes, three bytes for each channel (see "ACQ Command" paragraph for details).

Examples:

BIN ON example:

BIN ON\r

ACK\r\n

BIN ? example:

BIN ?\r

BIN OFF\r\n
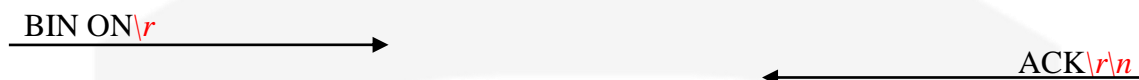
2.2.4 "GET" and "?" Command

The purpose of the GET command is to read back a single snapshot of the four channels values. The "?" command is a useful shortcut fully equivalent to the GET command. The format of the returned values depends on the "binary mode" setting (refer to "BIN Command" paragraph).

Examples:

GET ? example with ASCII data:

GET ?\r

8232 43567 9803 7996\r\n

? example with ASCII data:

?\r

8232 43567 9803 7996\r\n

GET ? example with binary data:

GET ?\r

0x020xFA0x590x020xFA0x590x020xFA0x590x020xFA0x59

? example with binary data:

?\r

0x020xFA0x590x020xFA0x590x020xFA0x590x020xFA0x59

2.2.5 "HLF" Command

The purpose of the HLF command is to select whether to process data from both integrator circuits - i.e. maximum speed - or only from one integrator circuit – i.e. best noise performance - of the AH401D.

In order to explain the functionality of the HLF command it is useful to describe how the integrator input stage operates. A basic feature of the AH401D is that each input channel consists of two parallel integrators (A and B) so that the current-to-voltage integration can be performed continuously in time: when one of the integrators (i.e. A) is digitized by the ADC, the input channel is switched to the other integrator circuit (i.e. B) and the input current can thus be continuously integrated. At the end of the integration time, also the second integrator (i.e. B) is disconnected from the input and the ADC can start the digitization of the integrated current from B. At the same time, the input is connected to the previous integrator (i.e. A) and therefore the current can continue to be integrated by A.

This sequence is continuously repeated as long as the AH401D is in acquisition mode ("ACQ ON"). Dead time in the data throughput is thus avoided and the sampled values are continuously sent to the host. This mode of operation ("HLF OFF" - *default*) is useful when the maximum sampling rate is required since at the end of each integration cycle a digitized data set is sent to the host PC. The drawback is a slightly higher noise level on the sampled values due to the integrator capacitors mismatch between A and B and to the charge injection introduced by the internal switches.

If lowest noise performance is of uttermost importance, the "HLF ON" command must always be used. In this operation mode only the integrated current of one integrator (i.e. A) is sampled, digitized and sent to the host. Using only and always the same integrator any capacitors mismatch and charge injection is avoided and the best signal to noise ratio is achieved. The operating sequence of this mode is as follow: the current is integrated on integrator A for the integration time (i.e. 100ms), then the value is digitized and sent to the host. During the following integration time (i.e. 100ms) no data is digitized (the value on the integrator B is discarded) and then the sequence repeats itself. Therefore a set of data is sent to the host every two integration times (i.e. 200ms). The drawback of this mode is that only "half" sampled values are sent to the host and hence the sampling rate is halved.

Please note that the data rate throughput is directly related to the integration time and the "half mode" selection. For example, setting the integration time to 10ms and the "half mode" to disabled (HLF OFF) generates a data stream at 100Hz. Whereas, setting the integration time to 10ms and the "half mode" to enabled (HLF ON), generates a data stream at 50Hz.

Examples:

HLF ON example:

HLF ON\r ⟶

⟵ ACK\r\n

HLF ? example:

HLF ?\r ⟶

⟵ HLF ON\r\n

2.2.6 "ITM" Command

The purpose of the ITM command is to set the integration time of the AH401D. The parameter field is **<u>time expressed in hundreds of microseconds</u>**, i.e. if a 100ms integration time is needed the parameter must be set to 1000. The range of the integration time spans from 1ms to 1s, so the parameter range goes from 10 to 10000. At power-up the AH401D integration time is set to 100ms (ITM 1000 - *default*) by default.

Examples:

ITM example for 1ms integration time:

ITM 10\r

ACK\r\n

ITM example for 200ms integration time:

ITM 2000\r

ACK\r\n

ITM ? example:

ITM ?\r

ITM 1000\r\n

2.2.7 "NAQ" Command

The purpose of the NAQ command is to read a fixed number of samples, ranging from 1 to 20.000.000, without having to manually stop the acquisition (i.e. "ACQ OFF" command) when the desired number of samples has been read. This function has to be used in combination with the ACQ command (refer to "ACQ Command" paragraph) or the TRG command (refer to "TRG Command" paragraph) in order to start the acquisition. The format of the returned values depends on the "binary mode" setting (refer to "BIN Command" paragraph). The NAQ function is disabled when the number of samples is set to 0.

If a number of acquisitions larger than 4096 is set, the SUM mode is automatically disabled.

Examples:

NAQ example for 4 samples:

NAQ 4\r

ACK\r\n

ACQ ON example with ASCII data:

ACQ ON\r

ACK\r\n

3124 12001 1222 10\r\n

3143 11991 1342 20\r\n

3185 12891 1349 25\r\n

3213 10091 1448 35\r\n

NAQ ? example:

NAQ ?\r

NAQ 4\r\n

2.2.8 "RNG" Command

The purpose of the RNG command is to set the full scale range of the AH401D. The parameter field is a number representing the selected charge integration range as reported in **Table 5**.

	Full Scale	**Equivalent Current FS @1ms**	**Equivalent Current FS @1s**
RNG 0	2 nC	2 μA	2 nA
RNG 1	50 pC	50 nA	50 pA
RNG 2	100 pC	100 nA	100 pA
RNG 3	150 pC	150 nA	150 pA
RNG 4	200 pC	200 nA	200 pA
RNG 5	250 pC	250 nA	250 pA
RNG 6	300 pC	300 nA	300 pA
RNG 7	350 pC	350 nA	350 pA

Table 5: RNG commands and equivalent input full-scale range

Command syntax is the following:

$$RNG\ XY\backslash r$$

where X is the selected range for channels 1 and 2 and Y the selected range for channels 3 and 4. Please not that X and Y does not need to be equal.

X and Y value can be set from 0 to 7. At power up the AH401D ranges are set to 1 (*default*), corresponding to a full scale range of 50pC for all channels.

The following syntax is also recognized by the AH401D picoammeter:

$$RNG\ Z\backslash r$$

where Z is interpreted as the desired range for all four channels (Z = 0 ... 7).

Examples:

RNG example for 100-pC Full Scale Range on all four channels:

RNG 2\r

ACK\r\n

RNG example for 2-nC Full Scale Range on channels 1-2 and for 100-pC Full Scale Range on channels 3-4:

RNG 02\r

ACK\r\n

RNG ? example:

RNG ?\r $\longrightarrow$

$\longleftarrow$ RNG 63\r\n

RNG ? example with wrong values:

RNG 48\r $\longrightarrow$

$\longleftarrow$ NAK\r\n

2.2.9 "SUM" Command

The purpose of the SUM command is to add the values of "N" data samples configured with the NAQ command (refer to "NAQ Command" paragraph) and hence to get a single channel value representing the summed samples. This function has to be used in combination with the NAQ command (refer to "NAQ Command" paragraph). The format of the returned values depends on the "binary mode" setting (refer to "BIN Command" paragraph). When in "BIN ON" mode, the command returns 4 bytes for each channel – i.e. 16 bytes total. In order to avoid data overflow, the AH401D unit does not accept the "SUM ON" command – i.e. it replies with a non-acknowledgment – whenever the <u>number of acquisitions set via the NAQ command is larger than 4096</u>.
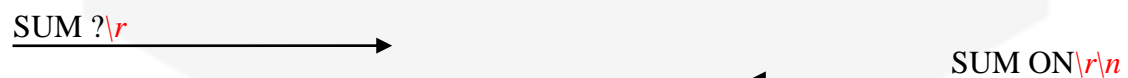
Examples:

SUM example with 4 samples configured:

NAQ 4\r
ACK\r\n

SUM ON\r
ACK\r\n

ACQ ON example with ASCII data:

ACQ ON\r
ACK\r\n
12124 40001 43122 12400\r\n

SUM ? example:

SUM ?\r
SUM ON\r\n

SUM example with 5500 samples configured (larger than 4096):

NAQ 5500\r
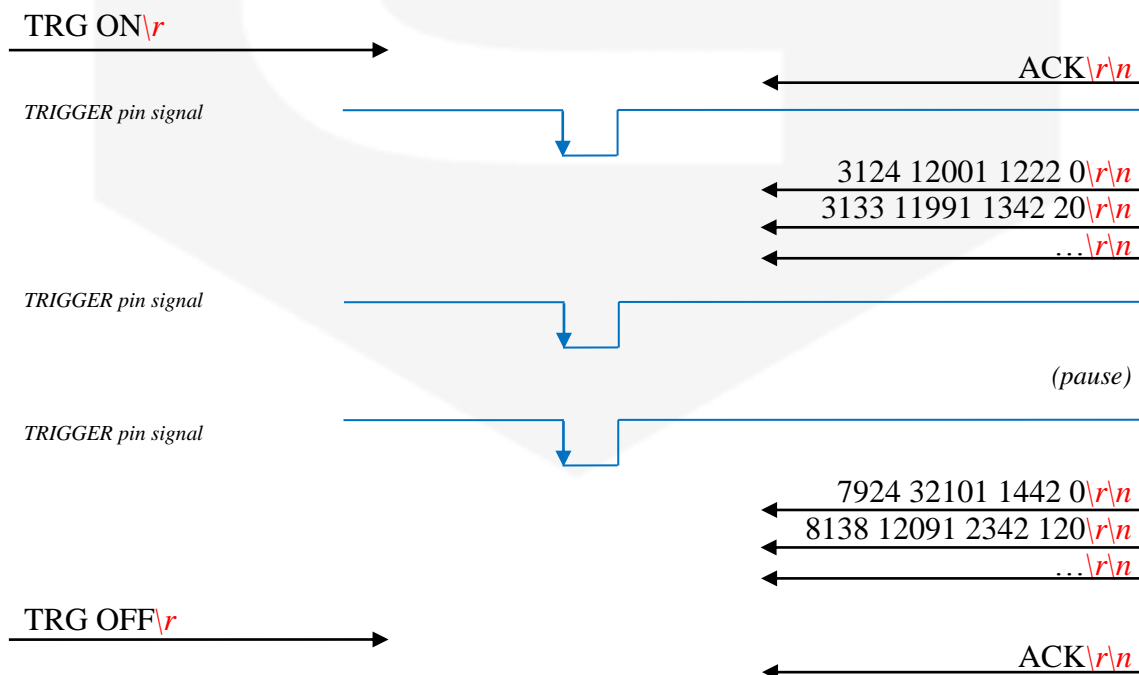ACK\r\n

SUM ON\r
NAK\r\n

2.2.10 "TRG" Command

The purpose of the TRG command is to enable/disable the "trigger mode" of the AH401D. The "trigger mode", when enabled (TRG ON), allows synchronizing the picoammeter data acquisition with an external event (for instance laser pulses). The "trigger mode" operation is described in the next paragraph.

As soon as the TRG ON command is received the AH401D stops data acquisition and waits to receive, on the corresponding TRIGGER pin (see "I/O Connectors" chapter), a falling edge signal. As soon as this signal is detected, the AH401D starts to acquire data and immediately and continuously sends it to the host until a new TRIGGER signal is received on the corresponding input. If the NAQ function is enabled (refer to "NAQ Command" paragraph), the acquisition automatically stops after the configured number of samples is transmitted and the instrument waits for a new TRIGGER signal. Moreover, if the NAQ function is used in combination with the SUM mode (refer to "SUM Command" paragraph) only the summed values of the samples are returned. This behaviour continues until the "trigger mode" is disabled with the "TRG OFF" (*default*) command (see "TRIGGER Signal" paragraph in the "I/O Connectors" chapter).
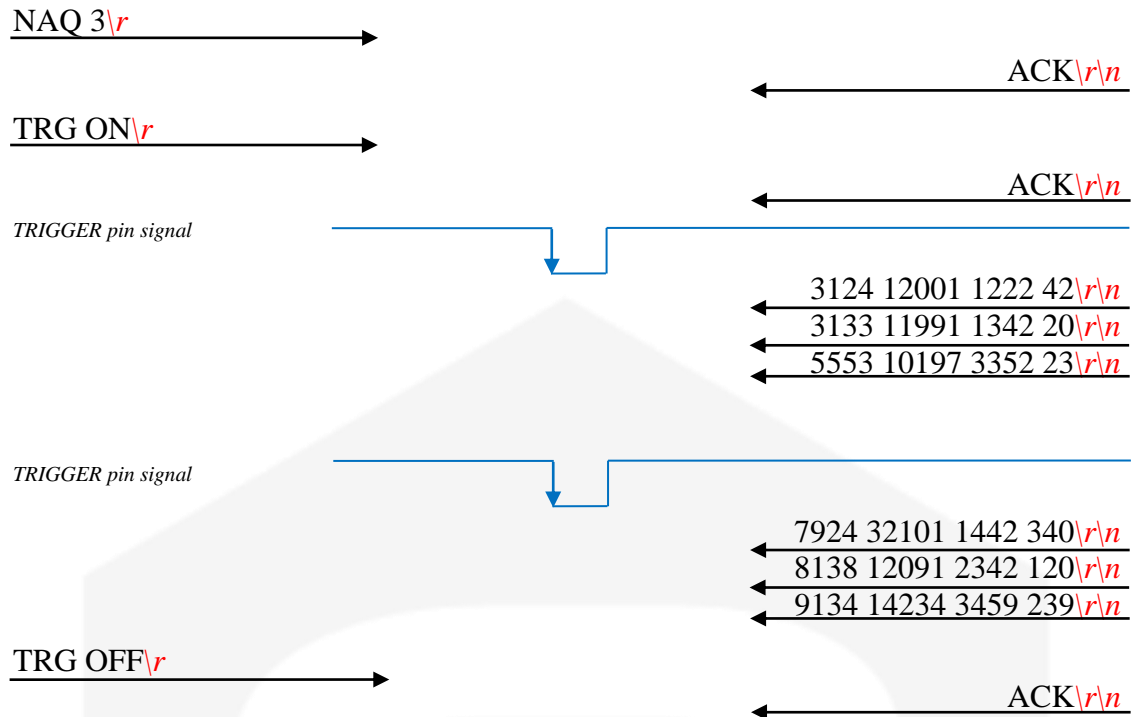
The format of the data sent depends on the "binary mode" setting that can be changed using the "BIN" command (see "BIN Command" paragraph).
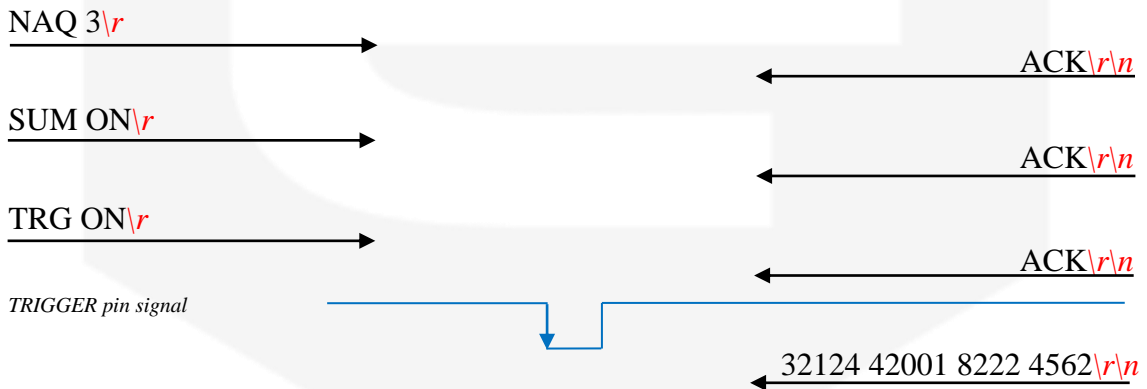
Examples:

TRG example with ASCII data:

TRG ON\r

ACK\r\n

TRIGGER pin signal

3124 12001 1222 0\r\n
3133 11991 1342 20\r\n
…\r\n

TRIGGER pin signal

(pause)

TRIGGER pin signal

7924 32101 1442 0\r\n
8138 12091 2342 120\r\n
…\r\n

TRG OFF\r

ACK\r\n

TRG example with NAQ function enabled (ASCII data):

NAQ 3*\r* →

← ACK*\r\n*

TRG ON*\r* →

← ACK*\r\n*

TRIGGER pin signal

← 3124 12001 1222 42*\r\n*
← 3133 11991 1342 20*\r\n*
← 5553 10197 3352 23*\r\n*

TRIGGER pin signal

← 7924 32101 1442 340*\r\n*
← 8138 12091 2342 120*\r\n*
← 9134 14234 3459 239*\r\n*

TRG OFF*\r* →

← ACK*\r\n*

TRG example with NAQ and SUM functions enabled (ASCII data):

NAQ 3*\r* →

← ACK*\r\n*

SUM ON*\r* →

← ACK*\r\n*

TRG ON*\r* →

← ACK*\r\n*

TRIGGER pin signal

← 32124 42001 8222 4562*\r\n*

TRG ? example:

TRG ?*\r* →

← TRG ON*\r\n*

2.2.11 "VER" Command

The purpose of the VER command is to report the firmware version currently installed in the AH401D on-board microcontroller.

Examples:

VER ? example:

VER ?$\backslash r$

VER AH401D 1.0.0$\backslash r \backslash n$

2.3 Command Table Summary

Command	Purposes	Parameters	Power-Up *default* value
ACQ	Start continuous acquisition	ON	
	Stop continuous acquisition	OFF	*default*
	Query acquisition status	?	
BDR	Set baudrate	921600	*default*
	Set baudrate	460800	
	Set baudrate	230400	
	Set baudrate	115200	
	Set baudrate	57600	
	Set baudrate	38400	
	Set baudrate	19200	
	Set baudrate	9600	
	Query baudrate setting	?	
BIN	Select binary mode	ON	
	Select ASCII mode	OFF	*default*
	Query "binary mode" status	?	
GET	Read a single snapshot	?	
?	Read a single snapshot	?	
HLF	Select half mode	ON	
	Select full mode	OFF	*default*
	Query "acquisition mode" status	?	
ITM	Set integration time	1000	*default*
	Set integration time	10 to 10000	
	Query integration time	?	
NAQ	Read a fixed number of samples	1 to 20000000	
	Disable NAQ function	0	*default*
RNG	Set Full Scale Range to 2 nC	0	
	Set Full Scale Range to 50 pC	1	*default*
	Set Full Scale Range to 100 pC	2	
	Set Full Scale Range to 150 pC	3	
	Set Full Scale Range to 200 pC	4	
	Set Full Scale Range to 250 pC	5	
	Set Full Scale Range to 300 pC	6	
	Set Full Scale Range to 350 pC	7	
	CH1-2 Range to X and of CH3-4 to Y	XY	
	Query Full Scale Range	?	
SUM	Sum the NAQ configured samples	ON	
	Disable Sum mode	OFF	*default*
TRG	Set trigger mode	ON	
	Disable trigger mode	OFF	*default*
	Query "trigger mode" status	?	
VER	Query firmware version	?	

Table 6: List of Commands summary

2.4 Remote Hardware Reset

An hardware reset of the AH401D device can be performed remotely by following the herein presented procedure. This operation is equivalent to performing an hardware reset, as explained in section 4.3.

The procedure to remotely reboot the module is the following:

A. connect to the AH401D picoammeter module IP address to **port 30704** (hex = 77F0);

B. write to the module port the following nine bytes (one at a time – i.e. one for each packet):
  - o 25 (i.e. byte 0x19)
  - o 7 (i.e. byte 0x07)
  - o 0 (i.e. byte 0x00)
  - o 0 (i.e. byte 0x00)
  - o 0 (i.e. byte 0x00)
  - o 3 (i.e. byte 0x03)
  - o 0 (i.e. byte 0x00)
  - o 0 (i.e. byte 0x00)
  - o 0 (i.e. byte 0x00)

C. wait for 500ms and then write to the module port the following nine bytes (one at a time – i.e. one for each packet):
  - o 26 (i.e. byte 0x1A)
  - o 7 (i.e. byte 0x07)
  - o 0 (i.e. byte 0x00)
  - o 0 (i.e. byte 0x00)
  - o 0 (i.e. byte 0x00)
  - o 0 (i.e. byte 0x00)
  - o 0 (i.e. byte 0x00)
  - o 0 (i.e. byte 0x00)
  - o 0 (i.e. byte 0x00)

D. wait for 500ms and then write to the module port the following nine bytes (one at a time – i.e. one for each packet):
  - o 27 (i.e. byte 0x1B)
  - o 7 (i.e. byte 0x07)
  - o 0 (i.e. byte 0x00)
  - o 0 (i.e. byte 0x00)
  - o 0 (i.e. byte 0x00)
  - o 1 (i.e. byte 0x01)
  - o 0 (i.e. byte 0x00)
  - o 0 (i.e. byte 0x00)
  - o 0 (i.e. byte 0x00)

E. wait for 500ms and then write to the module port the following nine bytes (one at a time – i.e. one for each packet):

- o 27 (i.e. byte 0x1B)
- o 7 (i.e. byte 0x07)
- o 0 (i.e. byte 0x00)
- o 0 (i.e. byte 0x00)
- o 0 (i.e. byte 0x00)
- o 0 (i.e. byte 0x00)
- o 0 (i.e. byte 0x00)
- o 0 (i.e. byte 0x00)
- o 0 (i.e. byte 0x00)

F. now the device should reboot, re-load the firmware from its internal FLASH memory and will be ready for operation in about 2s.

It is important to notice that after executing point C., connection to port 30704 must be closed and, in order to correctly operate the picoammeter again, a new connection to AH401D module IP address standard port - i.e. 10001 - must be established.

3. Ethernet Communication

This chapter describes the Ethernet communication module for the AH401D and gives hints on how to configure it.

3.1 Communication Module

The communication 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 AH401D. Please refer to the Xport® documentation and configuration software available at the Lantronix site www.lantronix.com for a complete description.

3.1.1 IP Address Assignement

The module is shipped with a default IP address. Factory settings are:

- **IP address: 192.168.0.10;**
- **port: 10001.**

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 AH401D can be connected to the global LAN, a point-to-point Ethernet connection is strongly recommended in order to obtain minimum delay, maximum speed performance and to avoid possible communication problems. This implies that the host PC and the AH401D should reside on the same Ethernet subnet, e.g.:

**Host PC address: 192.168.10.100 → AH401D address: 192.168.10.200**

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

The next few steps must be followed in order to assign a new IP address to the module:

- Connect the host PC and the AH401D with a twisted Ethernet cable;
- Switch on the AH401D;
- Verify that the "Link LED" on the RJ45 connector is turned on (amber for a 10Mbps connection, or green for a 100Mbps connection) and the corresponding "Network Connection" is active on the host PC;
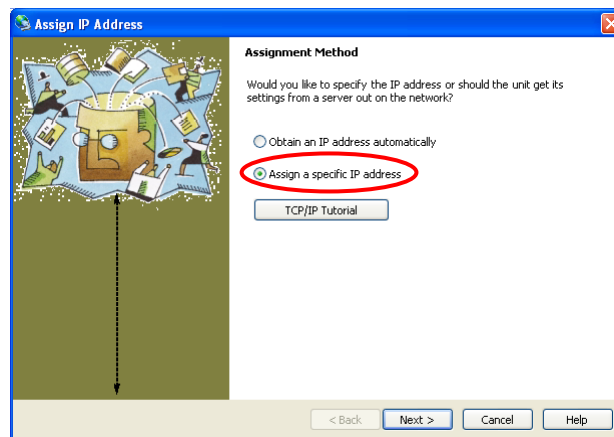

The "Link LED"
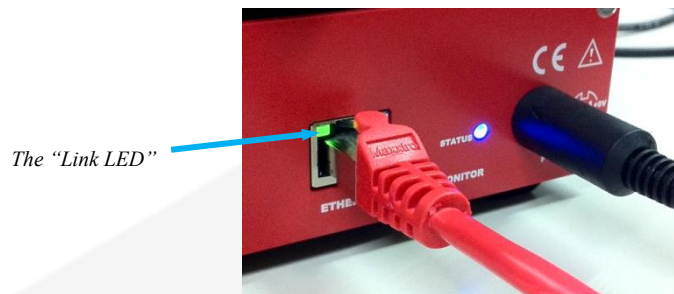
- Launch the "DeviceInstaller" program;
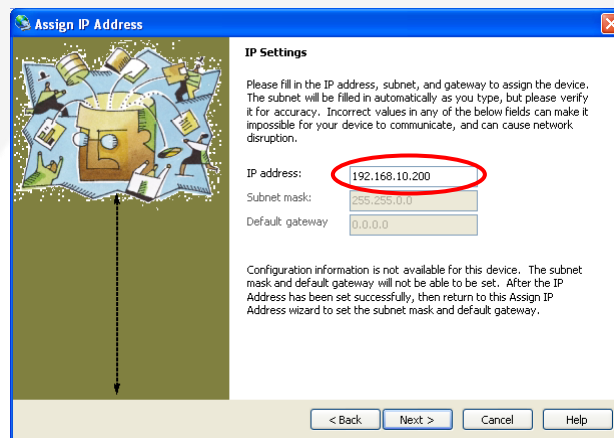- Select the XPort device where you want to change the IP address;
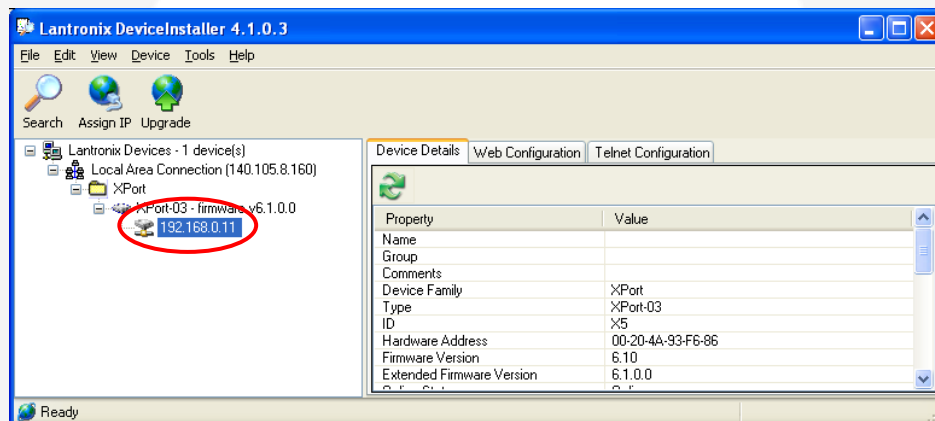
- Click on the "Assign IP" icon;
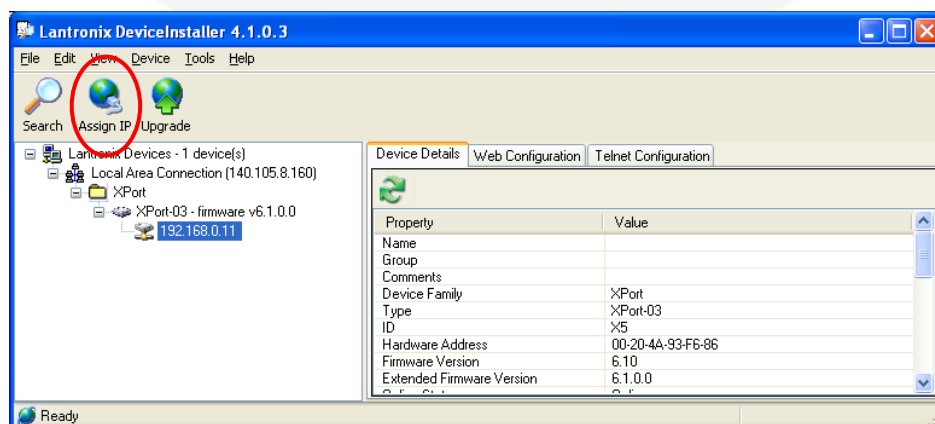
- Select "Assign a specific IP address" and then click "Next";

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

- Click the "Assign" button;
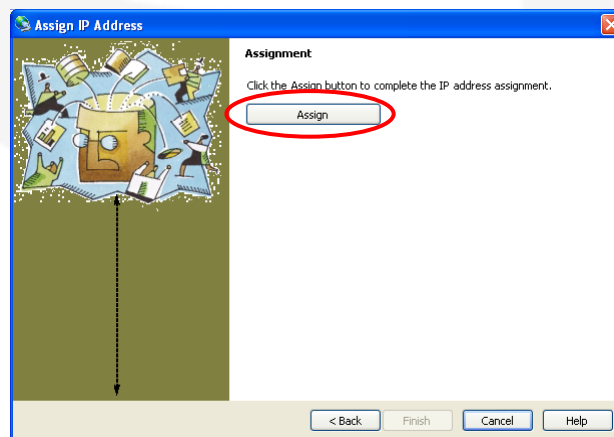
- Wait for the assignment procedure to end, then click "Finish"

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

### 3.1.2 Ethernet Module Software Configuration

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

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

In this manual only the web interface procedure is described, if you need to configure the module using a telnet connection please refer to the XPort® user guide.

Follow the next instructions to properly setup your AH401D communication module:

- Select the "Web Configuration" tab and then click on the "Go" button. Be sure to disable the "proxy server" option in your "Internet Options" application. To do so, 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;
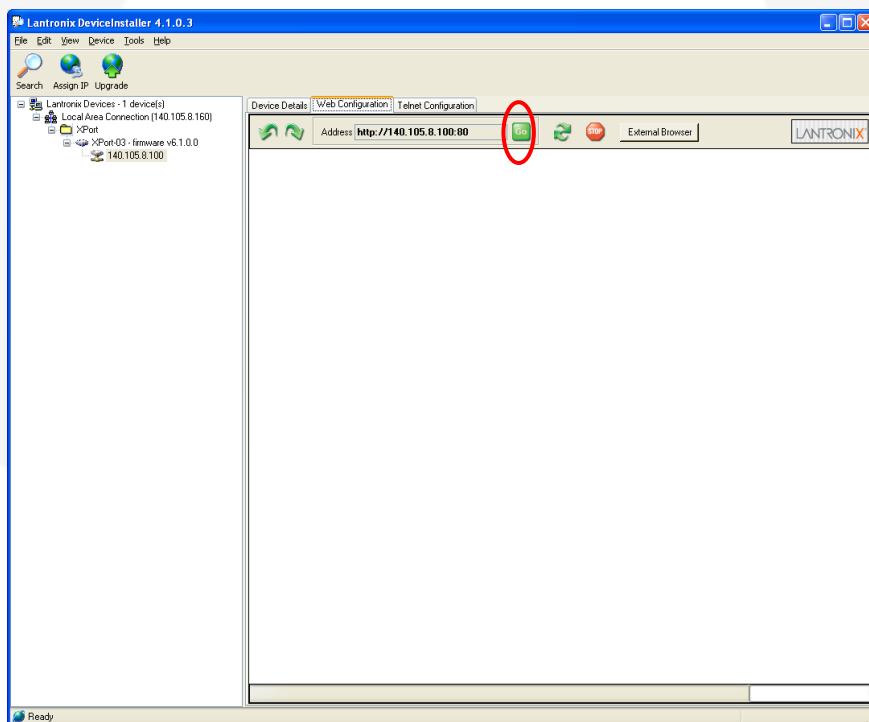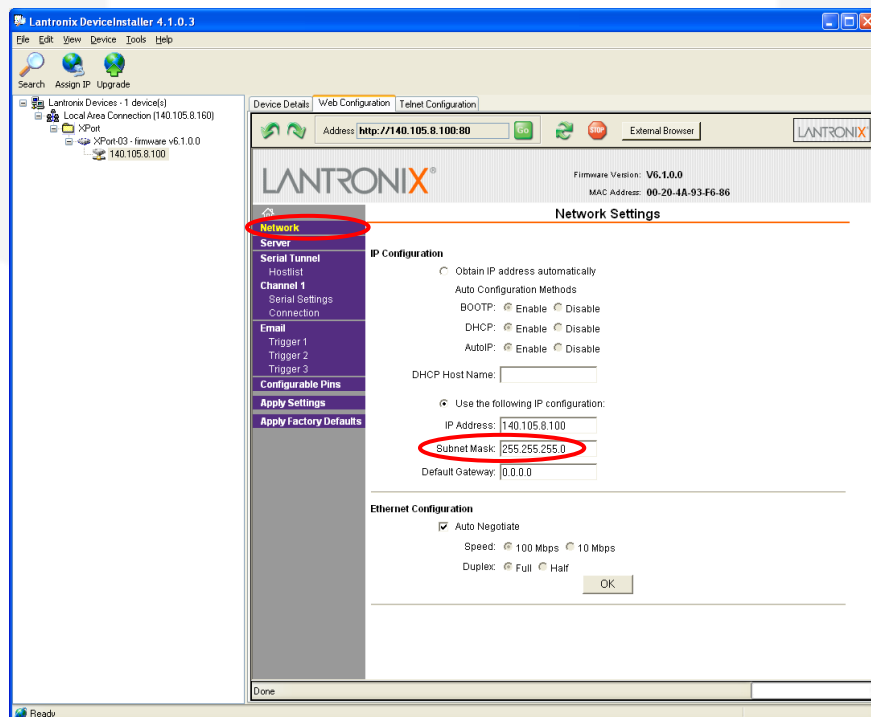

- A dialog window asking for user name and password will appear, simply click on the "OK" button;
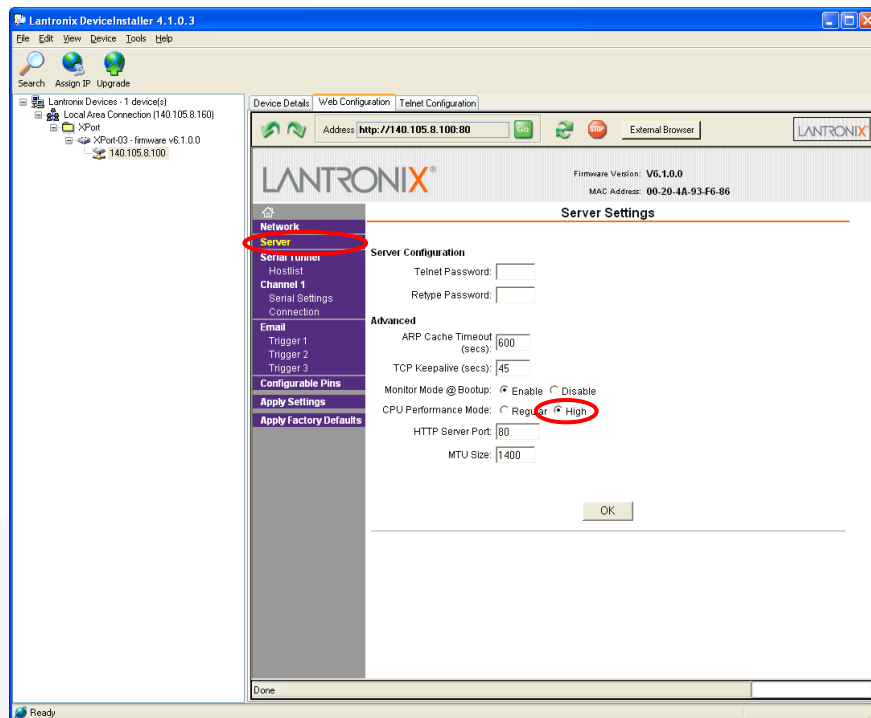
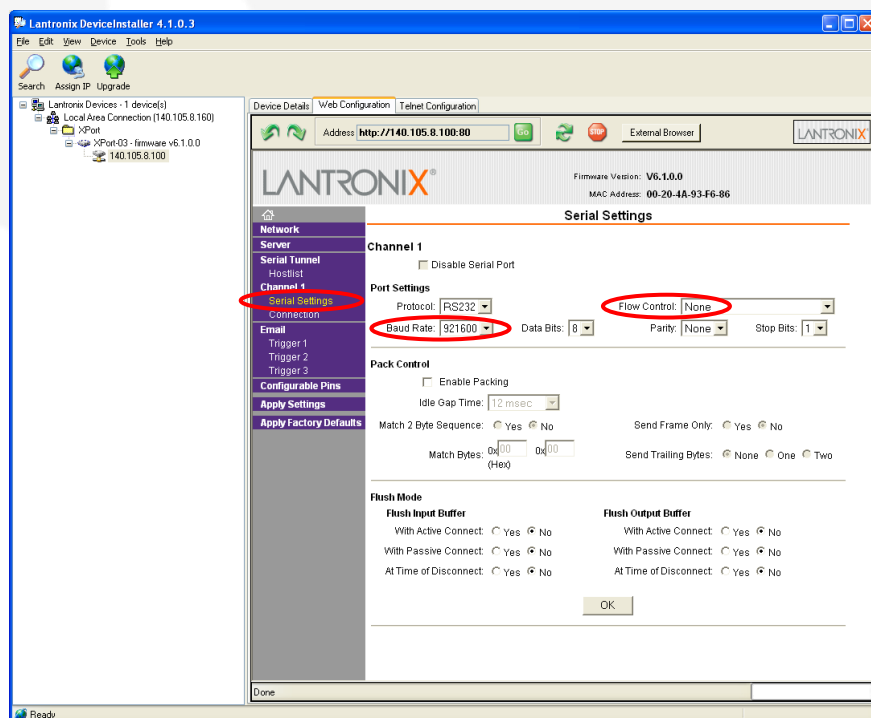- The Lantronix web server interface will now appear:
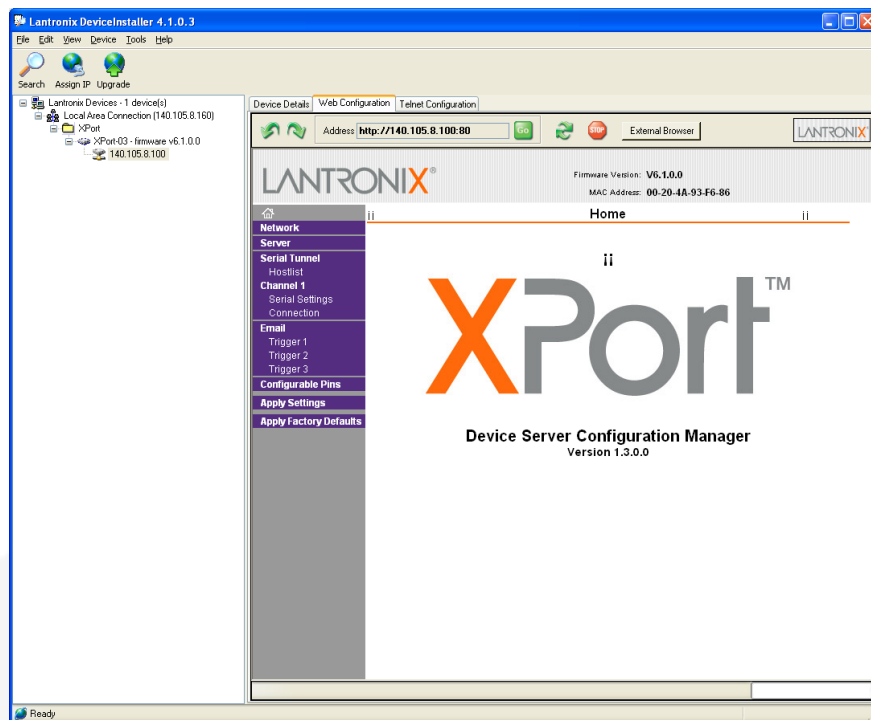
- Click on the "Network" button and set the "Subnet Mask" to "255.255.255.0", then click on the "OK" button:
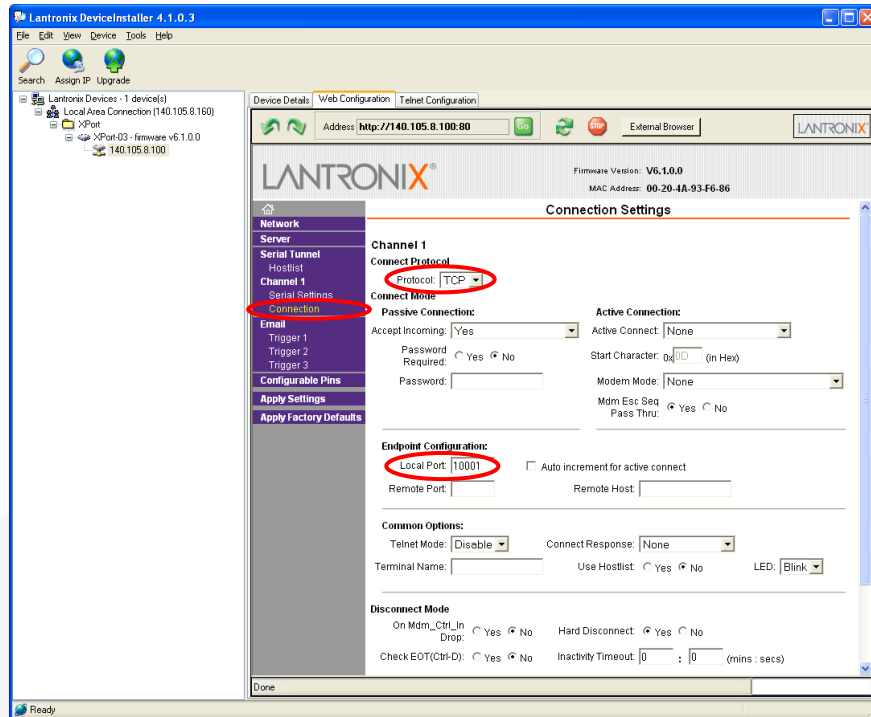
- Click on the "Server" button. Set the "CPU Performance Mode" to "High" and then click on the "OK" button:

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

The XPort® Ethernet device should now be correctly configured to work with the AH401D picoammeter. If you need to change any other XPort parameter, please refer to the XPort® user's guide.
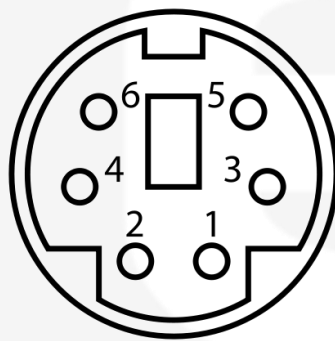
4. I/O Connectors

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

4.1 Power Connector

The input power connector is shown in **Figure 3** with its corresponding pinout. The input voltage range is rated at 9V with a maximum input current of 350mA.

The connector type is a 6-pin DIN.

Pin	Signal
1, 2	GND
3, 5	+9V
4, 6	*not connected*

Figure 3- Power Connector

4.2 Auxiliary Connectors

The AH401D has two LEMO coaxial connectors for the CONV output signal and the TRIGGER input signal as shown in **Figure 4**. Signal levels are 5V TTL and CMOS compatible. The maximum rated output current is 24mA.

Figure 4 - I/O Interface Connector

4.2.1 The TRIGGER Signal

The purpose of the TRIGGER signal is to synchronize the acquisition of the AH401D 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 behaviour continues until the "trigger mode" is disabled by software.

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

Ground

TRIGGER input TTL signal

Figure 5 – Trigger input connector

4.2.2 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.
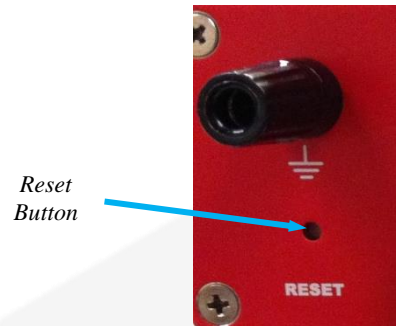
The output voltage level is 5V TTL and CMOS compatible, with a minimum output current of 24mA.

Ground

CONV output TTL signal

Figure 6 – CONV output connector

4.3 Hardware Reset

A hardware reset of the AH401D picoammeter can be performed by pushing the RESET button, accessible with a thin pen-tip or a needle through a small hole on the rear panel of the device (**Figure 7**).

*Reset
Button*

Figure 7 – Hardware reset button

Once the RESET button has been pressed and released, the AH401D internal processor re-initializes, reloading its firmware from the FLASH memory and starts operation again.

Performing this reset operation is equivalent to executing the Remote Hardware Procedure (see section 2.4 for further details).

5. Technical Specifications

Input Channels	4
Current Measuring Range	from 50 pA to 2.0 μA
Current Polarity	positive only
Data Rate	up to 1 kSPS/channel
Integration Time	from 1 ms to 1 s
Resolution Bits	20
Noise (@1ms, 200pC$_{FS}$)	< 7 ppm/FS
Communication Interface	Ethernet 10/100 TCP-IP and UDP
I/O Signal	TRIGGER input CONV output
Extra Features	Firmware Remote Update Selectable measuring range *(CH1-CH2 and CH3-CH4 ranges may be different)*
Supply Voltage	9 V
Dimensions	155 × 165 × 50 mm
Weight	560 g
Input Connectors	BNC
LED indicators	Status

Table 7: AH401D main technical specifications