

# AH501D

## 4-Channel Bipolar Picoammeter with Bias Voltage Source



### User's Manual



All Rights Reserved  
© CAENels d.o.o.  
Rev. 1.0 – March 2012

---

This product uses technology licensed by Sincrotrone Trieste S.C.p.A.



This product is  certified.



**CAENels d.o.o.**

Kraška ulica, 2

6210 Sežana - Slovenija

Mail: [info@caenels.com](mailto:info@caenels.com)

Web: [www.caenels.com](http://www.caenels.com)

---

---

# Table Of Contents

<b>1. INTRODUCTION.....</b>	<b>7</b>
1.1 THE AH501D PICOAMMETER .....	7
1.2 THE AH501D AT A GLANCE .....	8
1.3 FEATURES .....	9
1.4 ANALOG VOLTAGE MONITORS .....	10
1.5 BIAS VOLTAGE SOURCE.....	11
1.6 DATA FORMAT.....	12
1.7 SAMPLING FREQUENCY.....	14
1.8 OFFSET CALIBRATION.....	16
<b>2. SOFTWARE COMMANDS .....</b>	<b>18</b>
2.1 COMMAND SYNTAX .....	18
2.2 LIST OF COMMANDS.....	20
2.2.1 “ACQ” Command.....	21
2.2.2 “BDR” Command.....	24
2.2.3 “BIN” Command.....	25
2.2.4 “CHN” Command .....	26
2.2.5 “DEC” Command.....	27
2.2.6 “GET” and “G” Commands .....	28
2.2.7 “HVS” Command .....	29
2.2.8 “NAQ” Command.....	30
2.2.9 “RES” Command.....	31
2.2.10 “RNG” Command.....	32
2.2.11 “SYN” Command.....	33
2.2.12 “TRG” Command .....	34
2.2.11 “VER” Command .....	35
2.2.12 Command Table Summary.....	36
2.3 REMOTE HARDWARE RESET .....	37
<b>3. ETHERNET COMMUNICATION .....</b>	<b>38</b>
3.1 COMMUNICATION MODULE .....	38
3.1.1 IP Address Assignment.....	38
3.1.2 Ethernet Module Software Configuration.....	41
<b>4. I/O CONNECTORS.....</b>	<b>45</b>
4.1 POWER CONNECTOR .....	45
4.2 AUXILIARY CONNECTORS .....	45
4.2.1 The TRIGGER-GATE Signal .....	46
4.2.2 The CONV Signal.....	46
4.3 HARDWARE RESET.....	47
<b>5. TECHNICAL SPECIFICATIONS .....</b>	<b>48</b>

---

Document Revision	Date	Comment
1.0	March 10 <sup>th</sup> 2012	First Release



---

## Safety information

Read the instruction manual carefully prior to using the instrument.  
The following precautions should be strictly followed before using the AH501D:

---

### **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. Inspect carefully the outer case for possible cracks or breaks before each use.
- Do not operate the device if explosive gases, vapors or excessive dust is present.
- Always use the device with its original cables.
- Power off the device before establishing any connection to/from it.
- Do not operate the device for any reason with side covers 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 table below reports the general environmental requirements for the instrument:

Environmental Conditions	Requirements
Operating Temperature	0°C to 55°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 AH501D picoammeter.

## 1.1 The AH501D Picoammeter

CAENels AH501D is a 4-channel, 24-bit resolution, wide-bandwidth, ultra-wide input dynamic range picoammeter with an integrated bias voltage source (ranging from 0V to 30V).

It is composed of a specially designed transimpedance input stage for current sensing combined with analog signal conditioning and filtering stages making use of state-of-the-art electronics. This device can perform bipolar current measurements from  $\pm 2.5$  nA (with a resolution of about 300 aA) up to  $\pm 2.5$  mA (resolution of 300 pA) with sampling frequencies up to 26 kHz (for 1 channel and a 16-bit resolution) and 6.5 kHz (4 channels, 16 bit/sample). Low temperature drifts, good linearity and very low noise levels enable users to perform very high-precision current measurements.

This new version has also buffered voltage monitors that are proportional to the measured input current.

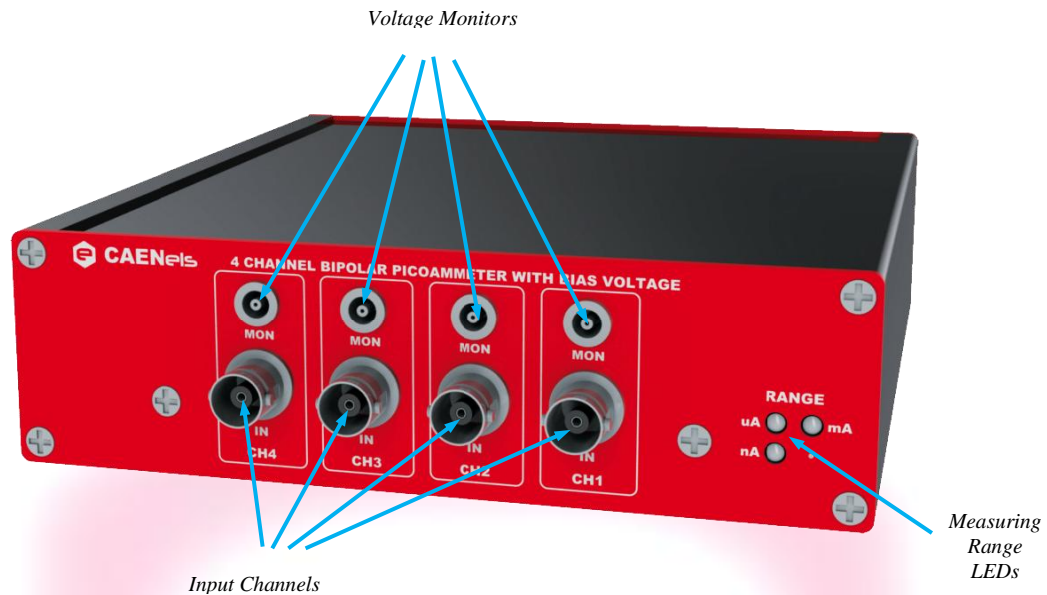
The AH501D is housed in a light, robust and extremely compact metallic box that can be placed as close as possible to the current source (detector), in order to reduce cable lengths and minimize possible noise pick-up. It is specially suited for applications where multi-channel simultaneous acquisitions are required, a typical application being the currents readout from 4-quadrant photodiodes used to monitor X-ray beam displacements.

The AH501D communication is guaranteed by a standard Ethernet (TCP/IP and UDP).



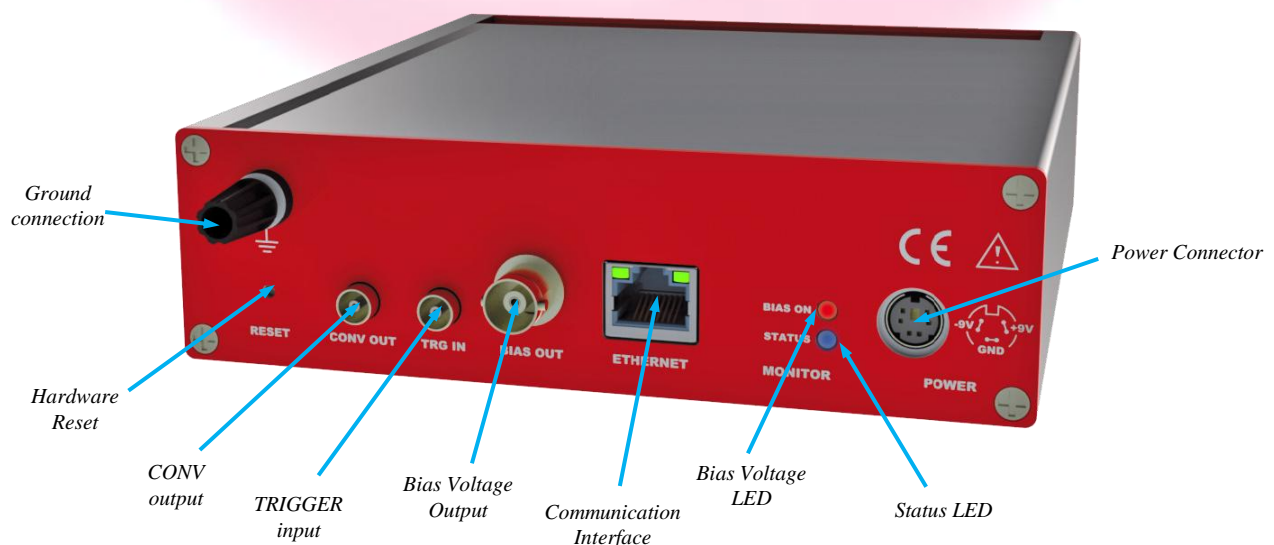
## 1.2 The AH501D at a Glance

The AH501D picoammeter and its I/O connections can be easily seen in **Figure 1** (front) and **Figure 2** (rear):



**Figure 1:** the AH501D front panel and its I/O connections

Analog BNC current input connectors and LEMO voltage monitor ones are placed on the front panel of the device while the other available connections - i.e. power input, communication socket, trigger input, conversion output, bias voltage 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 LEDs are also accessible from the rear panel of the instrument.



**Figure 2:** the AH501D rear panel and its I/O connections



## 1.3 Features

The AH501D input stage is based on a multi-path inverting transimpedance amplifier (I/V converter) cascaded with particular signal conditioning stages.

Three measuring ranges are available as reported in the following table:

Full Scale	
<b>RNG 0</b>	$\pm 2.5 \text{ mA}$
<b>RNG 1</b>	$\pm 2.5 \text{ }\mu\text{A}$
<b>RNG 2</b>	$\pm 2.5 \text{ nA}$

The corresponding gain values for these three input ranges are:

Gain (V/A)	
<b>RNG 0</b>	$-10^3$
<b>RNG 1</b>	$-10^6$
<b>RNG 2</b>	$-10^9$

The maximum and minimum currents that can be measured with the AH501D are reported, along with the LSB resolution for each range, in the following table:

	Full Scale	Resolution @16 bit	Resolution @24 bit
<b>RNG0</b>	$\pm 2.5 \text{ mA}$	76 nA	298 nA
<b>RNG1</b>	$\pm 2.5 \text{ }\mu\text{A}$	76 pA	298 fA
<b>RNG2</b>	$\pm 2.5 \text{ nA}$	76 fA	298 aA

A host PC is necessary in order to operate the AH501D and properly set/check the desired parameters (e.g. range and resolution bits) and to acquire the converted data. Please refer to the “Software Commands” chapter for a complete description of available commands, their purposes and their syntax.

## 1.4 Analog Voltage Monitors

Each input channel of the AH501D picoammeter has its corresponding analog voltage monitor signal available on a LEMO coaxial connector.

These four signals are true analog buffered independent inverting stages and are directly proportional to the input current value with a full-scale range of  $\pm 5V$ .

These voltage monitors, being inverting themselves, automatically compensate for the input stage inversion so that positive output voltage values correspond to input current sources (positive currents) and negative output values to input current sinks (negative currents). Gain values for the three input ranges (in V/A) are presented in the following table:

GAIN [ $V_{OUT} / I_{IN}$ ]	
$G_{RNG\ 0}$	$2 \cdot 10^3$
$G_{RNG\ 1}$	$2 \cdot 10^6$
$G_{RNG\ 2}$	$2 \cdot 10^9$

For example, if a tester/oscilloscope connected to a channel voltage monitor measures a value of -1.500V and the AH501D is set on RNG 1, the corresponding input current for that channel is:

$$I_{IN} = \frac{V_{OSCILLOSCOPE}}{G_{RNG1}} = \frac{-1.5\ V}{2 \cdot 10^6\ \frac{V}{A}} = -750\ nA$$

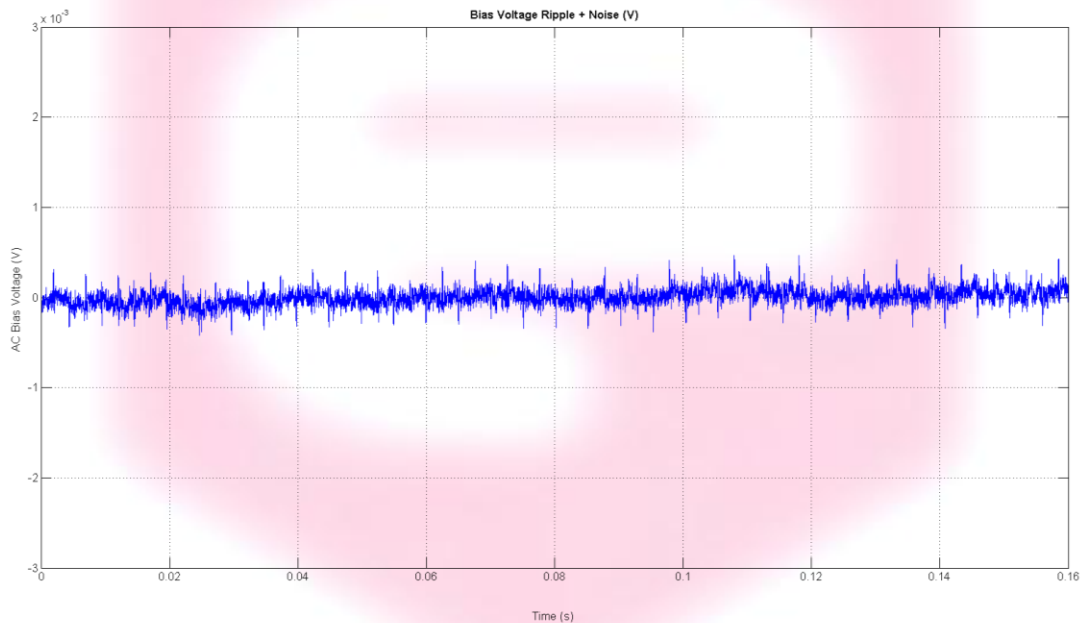
## 1.5 Bias Voltage Source

A low-noise voltage source is also available on a BNC connector placed on the module rear panel.

This voltage source is ground-referred, it can be set remotely, and has a maximum output value of 30V.

It is also possible to disable this source by a specific command ("HVS OFF\r") and set the output to a high-impedance state, thus disconnecting the voltage source from the connected load.

The red BIAS ON LED placed on the rear panel acts as a status indicator for this voltage source: it turns on when output is enabled and turns off as soon as the output is disabled. Typical values of RMS (Root Mean Square) noise are of 0.0005% at rated output voltage value (this noise value was 0.003% for the old AH501C version). An AC-coupled waveform of the bias voltage, set at a 30V output level, is shown in the following figure (where the RMS noise + ripple is less than 0.0003%).



The BIAS voltage output is protected against short-circuits on its outputs and the corresponding short-circuit current value for this output is 3mA. Please note that the output impedance of this voltage source is  $R_{OUT} = 10k\Omega$  and the minimum time constant is 100 ms (it increases along with the load capacitive part).

## 1.6 Data Format

Since the AH501D has three different input gain values and two possible resolution modes (16- and 24-bit), output values depend on the selected configuration. For this reason it is important to properly set the gain value in order to avoid input stage saturation and corresponding data clipping of the output values (to 8388608 or to 8388607 in 24-bit resolution mode and to 32768 or to 32767 in 16-bit resolution mode).

Moreover it is very important to perform an offset calibration procedure before using the picoammeter. In the following table the correspondence between the read value and the full scale range is reported (note that the input stage is inverting):

Data Value	Hex Value	Input Signal
32768	0x8000	+Full Scale
32769	0x8001	+Full Scale - LSB
...	...	...
65535	0xFFFF	LSB
0	0x0000	0
1	0x0001	-LSB
...	...	...
32766	0x7FFE	-Full Scale + LSB
32767	0x7FFF	-Full Scale
<b>Data value in 16-bit resolution mode</b>		
Data Value	Hex Value	Input Signal
8388608	0x800000	+Full Scale
...	...	...
0	0x000000	0
...	...	...
8388607	0x7FFFFFFF	-Full Scale
<b>Data value in 24-bit resolution mode</b>		

The data read from the AH501D are the raw values of the A/D converter, thus the data conversion from the read values to the corresponding current values must be performed by the user applying the following formula for the 16-bit resolution mode:

$$I_{IN} = \begin{cases} \frac{2.5}{G_{RNG_X} \cdot (2^{15} - 1)} \cdot (Value - Offset) = \frac{FSR_X}{2^{15} - 1} \cdot (Value - Offset) & \text{if } Value \leq 32767 \\ \frac{FSR_X}{2^{16} - 1} \cdot [(65535 - Value) - Offset] & \text{if } Value \geq 32768 \end{cases}$$

and the following one when working in 24-bit resolution mode:

$$I_{IN} = \begin{cases} \frac{FSR_X}{2^{23} - 1} \cdot (Value - Offset) & \text{if } Value \leq 8388607 \\ \frac{FSR_X}{2^{24} - 1} \cdot [(16777215 - Value) - Offset] & \text{if } Value \geq 8388608 \end{cases}$$

where:

- $I_{IN}$ : the calculated input current;
- $G_{RNG_X}$ : the selected range gain;
- $FSR_X$ : the selected Full Scale Range;
- $Value$ : the raw data value from the AH501D;
- $Offset$ : the raw data offset. For a proper estimation of this offset a calibration procedure must be performed (please refer to the "AH501D Offset Calibration" paragraph).

## 1.7 Sampling Frequency

The AH501D sampling frequency depends either on resolution, data stream format and number of channels (please refer to “List of Commands” chapter to see how to set these values). When receiving a non-formatted binary data stream, the sampling periods for each channel are represented in the following table:

	16-bit Resolution	24-bit Resolution
<b>1 Channel</b>	38.4 $\mu$ s	38.4 $\mu$ s
<b>2 Channels</b>	76.8 $\mu$ s	153.6 $\mu$ s
<b>4 Channels</b>	153.6 $\mu$ s	307.2 $\mu$ s

**Sampling period when receiving raw binary data**

corresponding to the following sampling frequencies:

	16-bit Resolution	24-bit Resolution
<b>1 Channel</b>	26.042 kHz	13.021 kHz
<b>2 Channels</b>	13.021 kHz	6.510 kHz
<b>4 Channels</b>	6.510 kHz	3.255 kHz

**Sampling frequencies when receiving raw binary data**

The sampling periods dilate when working with ASCII data values (that require computational time to be formatted) reaching the values here listed:

	16-bit Resolution	24-bit Resolution
<b>1 Channel</b>	384 $\mu$ s	499.2 $\mu$ s
<b>2 Channels</b>	806.4 $\mu$ s	998.4 $\mu$ s
<b>4 Channels</b>	1.6128 ms	1.9968 ms

**Sampling frequencies when receiving ASCII-formatted data**

The corresponding sampling frequencies for each channel in this mode are then:

	16-bit Resolution	24-bit Resolution
<b>1 Channel</b>	2.604 kHz	2.003 kHz
<b>2 Channels</b>	1.240 kHz	1.002 kHz
<b>4 Channels</b>	620.0 Hz	500.8 Hz

**Sampling frequencies when receiving ASCII-formatted data**



Adding the offset binary two's complement correction ("DEC ON" command, see section 2.2.5 for additional information), the sampling periods become:

	16-bit Resolution	24-bit Resolution
1 Channel	422.4 $\mu$ s	537.6 $\mu$ s
2 Channels	844.8 $\mu$ s	1.0752 ms
4 Channels	1.6896 ms	2.1504 ms

Sampling periods when receiving ASCII-formatted data with offset binary 2's complement correction

and the sampling frequencies the following ones:

	16-bit Resolution	24-bit Resolution
1 Channel	2.367 kHz	1.860 kHz
2 Channels	1.184 kHz	930.1 Hz
4 Channels	591.9 Hz	465.0 Hz

Sampling frequencies when receiving ASCII-formatted data with offset binary 2's complement correction

## 1.8 Offset Calibration

Due to the internal bias and offset voltages of its electronic components, an offset calibration (in order to eliminate the equivalent input offset current) must be performed on each AH501D module. If a precise estimation of this offset is necessary, the following procedure must be performed:

- Install on each BNC 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 AH501D;
- Let it warm-up for about 15 mins;
- Acquire a set of data (for example 10000 pts.) from each input channel and calculate the mean value;
- Repeat the previous step for each gain range (RNG 0, RNG 1 and RNG 2).

The calculated mean values are the new Data Offsets that must be taken into account in the current evaluation formula that must be applied for each channel.

It may be preferable, in some cases, to calculate this offset as the median of collected data to avoid errors caused by unwanted rectified impulsive noise.



## 1.9 AH501C Compatibility

The AH501D bipolar picoammeter is completely compatible, as command set to the CAENels AH501C. Moreover, the AH501D has some additional features respect to its predecessor:

- active measuring range LED indicators on the front panel;
- ground connection available on the rear panel;
- hardware reset button accessible through a small hole in the rear panel.

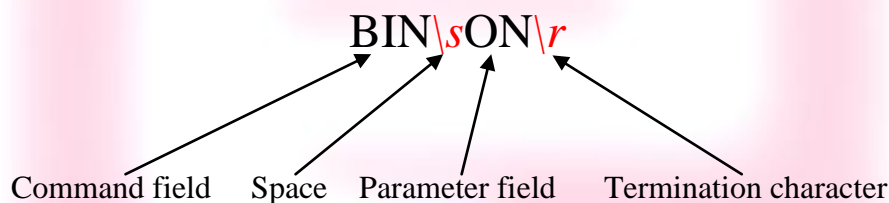
## 2. Software Commands

This chapter describes the software commands used for tuning and readout of the AH501 picoammeter.

### 2.1 Command Syntax

The command syntax used by the AH501 protocol is described in the following paragraphs.

Commands must be sent in ASCII format and are composed by two fields, the “command field” and the “parameter field”, separated by a space (‘\s’ or 0x20 in hexadecimal notation). Instructions are not case sensitive and therefore the command string can freely use either uppercase or lowercase characters. Each instruction is terminated with a “carriage return” character (‘\r’ or 0x0D), e.g.:

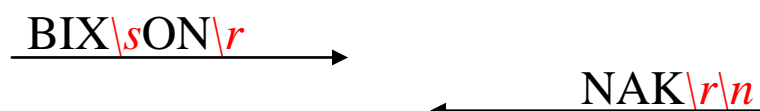


There are two types of software commands: “configuration commands” and “query commands”. The “query commands” usually have the same “command field” as the “configuration commands” and a “?” in the “parameter field”.

The AH501D, after each received command, 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 AH501D will always answer with the string “NAK” terminated with “carriage return/line feed” characters (‘\r\n’ or 0x0A0x0D in hexadecimal notation), e.g.:



example 2:

```

    BIN\sOOG\r
    ───────────→
    ←────────── NAK\r\n
  
```

2) *the command syntax is correct and it is a “configuration command”*: the AH501D will answer with the string “ACK” terminated with “carriage return/line feed” (‘\r\n’) characters, e.g.:

```

    BIN\sON\r
    ───────────→
    ←────────── ACK\r\n
  
```

example 2:

```

    RES\s24\r
    ───────────→
    ←────────── ACK\r\n
  
```

3) *the command syntax is correct and it is a “query command”*: the AH501D will answer with the echo of the “command field” and the value of the requested parameter separated with a space and terminated with “carriage return/line feed” (‘\r\n’) characters, e.g.:

```

    BIN\s?\r
    ───────────→
    ←────────── BIN\sON\r\n
  
```

example 2:

```

    RES\s?\r
    ───────────→
    ←────────── RES\s24\r\n
  
```

## 2.2 List of Commands

Please find hereafter the command list used by the AH501D and the corresponding syntax, the description of each command purpose and any special requirements relating to specific commands.

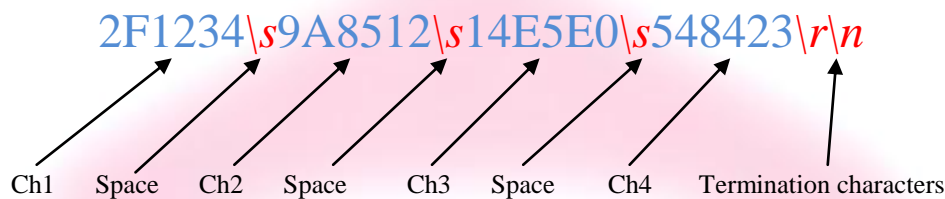


### 2.2.1 “ACQ” Command

The purpose of the ACQ command is to start/stop the acquisition from the AH501. The instrument starts to acquire data as soon as the command is received and immediately sends the generated digital data stream to the host PC.

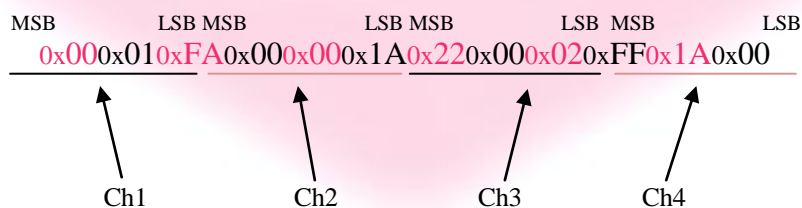
At power-up the instrument boots with the acquisition stopped (*default*), the user is required to start the data acquisition sending the “ACQ ON” command.

The type of transmitted data depends on the setting of the “binary mode” and can be changed using the “BIN” command (see “BIN Command” paragraph). With “BIN OFF”, data is sent in ASCII mode with the format “ch1 ch2 ch3 ch4\r\n”, with a space between each channel value:

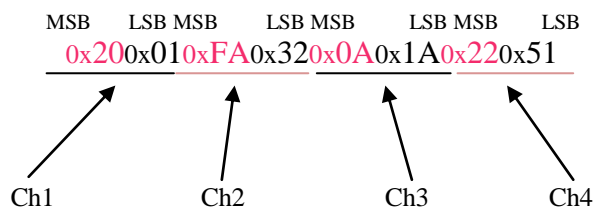


With “BIN ON” (*default*) digital values are transmitted as a continuous binary data stream without any termination or control character. For this reason it is important to keep synchronization with the data flux, otherwise it is possible, if some bytes are missed, to corrupt the data and to get false readings from the instrument. If this happens, acquisition must be stopped with the “S” (without carriage return) command and then restarted, increasing the reliability of the communication channel. The speed of data transmission is directly related to the number of active read channels and the resolution of data samples.

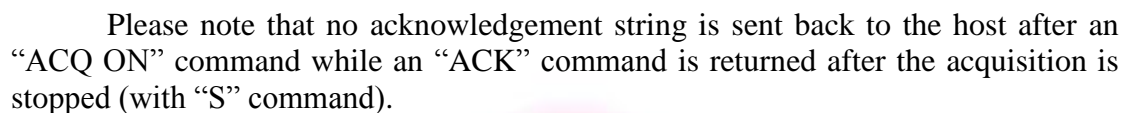
In binary mode, 4 channels and a 24-bit resolution the data output format consists of a continuous sequence of 12 bytes (96-bit packet), three bytes for each channel since each channel sample is 24-bit wide, MSB first:



In binary mode, with 4 active channels and a 16-bit resolution, the data output format consists of a continuous sequence of 8 bytes, two bytes for each channel, MSB first:



3



	16-bit Resolution	24-bit Resolution
1 Channel	2 bytes	3 bytes
2 Channels	4 bytes	6 bytes
4 Channels	8 bytes	12 bytes

*ACQ ON example with ASCII data:*

*ACQ ON example with BINARY data:*

*S* example with ASCII data:

22



*S example with BINARY data:*

← ...0x000x020xFA0x590x000x020xFA0x590x000x020xFA0x590x000x020xFA0x59  
S →

*ACQ ? example:*

ACQ\s?\r →

← ACQ\sOFF\r\n

### 2.2.2 “BDR” Command

The purpose of the BDR command is to set the baudrate between the AH501D and the communication module. The following table shows the allowed baudrates:

Command	Baudrate
<b>BDR 921600</b>	921600
<b>BDR 460800</b>	460800
<b>BDR 230400</b>	230400
<b>BDR 115200</b>	115200
<b>BDR 57600</b>	57600
<b>BDR 38400</b>	38400
<b>BDR 19200</b>	19200
<b>BDR 9600</b>	9600

Since the instrument changes the baudrate right after the BDR command is accepted and the acknowledgement string (ACK) is sent back to the host. The user can verify successful execution of the command 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.

By default the instrument boots with a 921600 baudrate setting.

#### Examples

*BDR example with incorrect parameter:*

BDR\s960000\r

NAK\r\n

*BDR example with correct parameter:*

BDR\s9600\r

ACK\r\n

*Acknowledgement from the AH501 before the change of baudrate.*

*BDR ? example:*

BDR\s?\r

BDR\s921600\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 AH501D picoammeter. At power-up “binary mode” is enabled (“BIN ON” - *default*) and data is sent as a continuous binary data stream. With the “BIN OFF” command the ASCII format is enabled and the output values are sent as strings. The binary format helps to improve the data rate transmission, as it avoids the overhead due to the ASCII format conversion.

In binary mode the data output format is a continuous sequence of bytes, (see “ACQ Command” paragraph for details).

#### Examples

*BIN ON example:*

BIN\SON\r → ACK\r\n

*BIN ? example:*

BIN\s?\r → BIN\sOFF\r\n

### 2.2.4 “CHN” Command

The purpose of the CHN command is to set the number of active input channels to be sampled; the AH501D provides the capability to simultaneously sample 1, 2 or 4 channels.

Channels on which sampling is performed are indicated in the following table (default power-up value is CHN 4):

Sampled Channels	
CHN\s1\r	Ch.1
CHN\s2\r	Ch.1, Ch.2
CHN\s4\r	Ch.1, Ch.2, Ch.3, Ch.4

The overall sampling frequency of the system is determined by the value set with this command.

#### Examples

CHN example:



CHN example with incorrect parameter:



CHN ? example:



### 2.2.5 “DEC” Command

The DEC command can only be used when working in BIN OFF mode, i.e. data is transmitted as ASCII characters, and is a function that, if enabled, performs the two's complement offset correction directly on the AH501D processor.

If this offset correction is enabled, data values are sent in the usual “ch1 ch2 ch3 ch4\r\n” format with a hexadecimal representation:

003234\sF18512\s51EC07\s66A60A\r\n  
when working in 24-bit resolution mode (data width is 6-byte/sample)

0032\sF185\s51EC\s66A6\r\n  
when working in 16-bit resolution mode (data width is 4-byte/sample)

This feature is disabled (“DEC OFF”) at device power-up.

#### Examples

*DEC example:*

DEC\sON\r → ACK\r\n

*DEC ? example:*

DEC\s?\r → DEC\sON\r\n

### 2.2.6 “GET” and “G” Commands

The purpose of the GET command is to read back a single snapshot of the values for the active channels. The “G” command is a useful shortcut fully equivalent to the “GET ?” command and it is implemented to further reduce delays caused by data transmission and handling. The format of the returned values depends on the “binary mode” setting (refer to “BIN Command” paragraph), the resolution settings and the active channels settings.

#### Examples

*GET ? example with ASCII data:*

```
GET\s?\r → 448231\s4A3567\s9EE803\s711996\r\n
```

*G example with ASCII data:*

```
G\r → 448231\s4A3567\s9EE803\s711996\r\n
```

*GET ? example with binary data:*

```
GET\s?\r → 0x000x020xFA0x590x000x020xFA0x590x000x020xFA0x590x000x020xFA0x59
```

*? example with binary data:*

```
G\r → 0x000x020xFA0x590x000x020xFA0x590x000x020xFA0x590x000x020xFA0x59
```

### 2.2.7 “HVS” Command

The HVS command let the users set and read the Bias Voltage output status/value. It is necessary to enable the bias voltage circuitry first in order to set a voltage value, i.e. send the command “HVS ON”.

The red LED on the AH501D rear panel should turn on. The command “HVS OFF” disables the bias voltage output, putting it in an high impedance state, and turns off the BIAS ON LED on the rear panel.

The voltage value (up to 30V) can be set by sending a “HVS xx.xx” command to the AH501D, where xx.xx is the desired voltage value in Volts. It is also possible to check the bias voltage circuitry status by sending a “HVS ?” command.

Please note that the Bias voltage resolution on its setting is about 0.025% of its full-scale value – i.e. BIAS setpoint can be changed by minimum steps of 7 mV.

#### Examples

*HVS ? example:*



*HVS ON example:*



*HVS “value” example:*



*HVS ? example:*



### 2.2.8 “NAQ” Command

The purpose of the NAQ command is to read a fixed number of samples, ranging from 1 to 2000000000, without having to manually stop the acquisition (i.e. with the “S” command) when the desired number of samples has been read.

The format of the returned values depends on the “binary mode” setting (refer to “BIN Command” paragraph), the resolution settings and the active channels settings.

#### Examples

*NAQ example with ASCII data:*

NAQ\s12\r

```

← 448231\s4A3567\s9EE222\s714596\r\n
← 448234\s4A3976\s9EE323\s711912\r\n
← 448566\s4A3433\s9E1A10\s714955\r\n
← 448243\s4A3567\s9EE803\s71A116\r\n
← 441332\s4A3555\s9E4543\s711888\r\n
← 448231\s4A3B65\s9E5802\s710990\r\n
← 448231\s4A35F4\s9E2AC5\s711946\r\n
← 448431\s4A1111\s9EE661\s71C750\r\n
← 448230\s4A3421\s9EBD13\s713216\r\n
← 448001\s4CC569\s9EE663\s71432C\r\n
← 448234\s4AB451\s9E124A\s71B0B0\r\n
← 448324\s4A6564\s9EAA03\s732436\r\n
← ACK\r\n

```

### 2.2.9 “RES” Command

The purpose of the RES command is to select whether to use 16 bits or 24 bits to represent sampled values obtained from the on-board delta-sigma modulator ADCs.

The use of this feature determines the maximum data transfer rate of the AH501D when running in continuous mode, i.e. “ACQ ON” and “BIN ON”.

The default value at power-up is set to 24 bits.

## Examples

*RES example:*

RES\textcolor{red}{s}24\textcolor{red}{r}

## ACK

*RES ? example:*

RES\(*s*\)?\(*r*\)

RES\textcolor{red}{s}16\textcolor{red}{r}\textcolor{red}{n}

### 2.2.10 “RNG” Command

The purpose of the RNG command is to set the gain and therefore the full scale range of the AH501D. The parameter field is a number representing the selected gain range as reported in the following table:

	Full Scale	Resolution (@ 24-bit)
<b>RNG 0</b>	±2.5 mA	298 nA
<b>RNG 1</b>	±2.5 µA	298 fA
<b>RNG 2</b>	±2.5 nA	298 aA

The parameter value can be set from 0 to 2; at power-up the AH501D range is set to its lowest gain value (0, *default*) in order to avoid possible damages to the device in case some of its inputs are connected to a high current source/sink at start-up.

#### Examples

*RNG example for a ±2.5nA Full Scale Range:*

RNG\s2\r → ACK\r\n

*RNG example for a ±2.5mA Full Scale Range:*

RNG\s0\r → ACK\r\n

*RNG ? example:*

RNG\s?\r → RNG\s0\r\n



### 2.2.11 “SYN” Command

The purpose of the SYN command is to synchronize the four on-board analog to digital converters. The task performed by this command is automatically executed at device power-up and shall not be performed again when using the AH501D device. This is a command to be used only for debugging purposes.



### 2.2.12 “TRG” Command

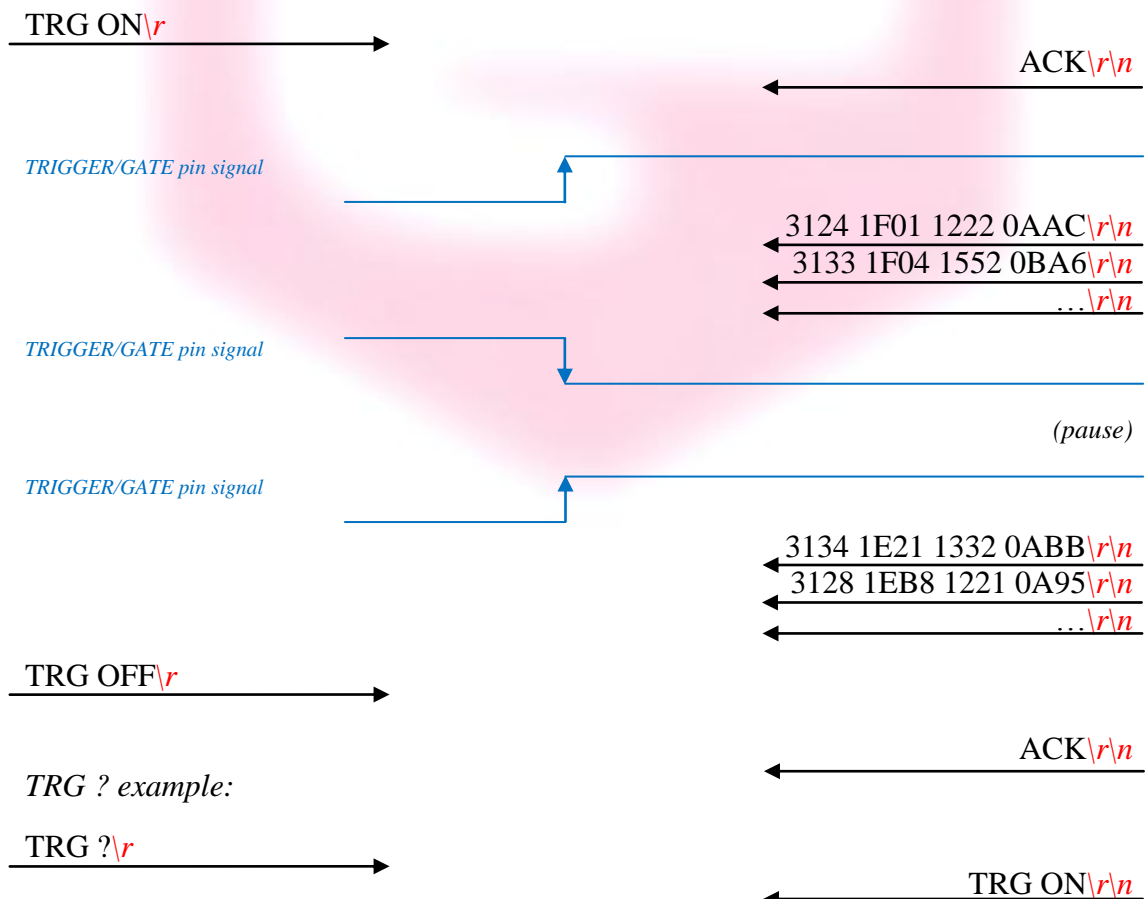
The purpose of the TRG command is to enable/disable the “trigger/gate input” of the AH501D. This feature, when enabled (TRG ON), is useful when the picoammeter data acquisition must be synchronized to an external event (for instance laser pulses).

The “trigger mode” operation is described hereafter. As soon as the TRG ON command is received the AH501D stops the acquisition and waits to receive, on the corresponding TRIGGER/GATE pin (see “I/O Connectors” chapter), a trailing edge signal transition. As soon as this is detected, the AH501D starts to acquire data and to continuously send them to the host; data are sent to the host as long as the TRIGGER/GATE signal is kept in high state. As soon as a falling edge signal transition (i.e. signal goes to low level state) is encountered, the acquisition stops and no more data are sent to the host. This behavior continues whether until the “trigger mode” is disabled with the “TRG OFF” (*default*) command (see “TRIGGER/GATE Signal” paragraph in the “I/O Connectors” chapter) or the driving signal is kept at low level.

Please note that an acknowledgement string is sent back to the host after a “TRG ON” or “TRG OFF” command. The format of the data sent depends on the “BIN”, “CHN”, “RES” and “DEC” settings previously configured for the picoammeter. Activating the “trigger mode” (“TRG ON”) while the trigger/gate input pin on the I/O connector is not driven has no effects.

#### Examples

*TRG example with ASCII data:*



### 2.2.11 “VER” Command

The purpose of the VER command is to report the firmware version currently flashed into the AH501D on-board processor.

#### *Examples*

*VER ? example:*

VER\s?\r



VER\sAH501D\s v.1.0\r\n



## 2.2.12 Command Table Summary

Command	Purposes	Parameters	Power-Up default value
<b>ACQ</b>	Start continuous acquisition	ON	
	Query acquisition status	?	
<b>BDR</b>	Set baudrate	921600	<i>default</i>
	Set baudrate	460800	
	Set baudrate	230400	
	Set baudrate	115200	
	Set baudrate	57600	
	Set baudrate	38400	
	Set baudrate	19200	
	Set baudrate	9600	
	Query baudrate setting	?	
<b>BIN</b>	Select binary mode	ON	<i>default</i>
	Select ASCII mode	OFF	
	Query “binary mode” status	?	
<b>CHN</b>	Set readings to only 1 channel	1	
	Set readings to 2 channels	2	
	Set readings to 4 channels	4	<i>default</i>
	Query channel settings	?	
<b>DEC</b>	Select offset correction	ON	
	De-select offset correction	OFF	<i>default</i>
	Query offset correction status	?	
<b>GET</b>	Read a single snapshot	?	
<b>G\r</b>	Read a single snapshot		
<b>HVS</b>	Set Bias Voltage On	ON	
	Set Bias Voltage Off	OFF	<i>default</i>
	Set Bias Voltage to “value”	value	
	Query Bias Voltage Status	?	
<b>NAQ</b>	Read a fixed number of samples	1 ... 2000000000	
<b>RES</b>	Set resolution to 16 bits	16	
	Set resolution to 24 bits	24	<i>default</i>
	Query resolution setting	?	
<b>RNG</b>	Set Full Scale Range to $\pm 11\text{mA}$	0	<i>default</i>
	Set Full Scale Range to $\pm 6.4\mu\text{A}$	1	
	Set Full Scale Range to $\pm 2.5\text{nA}$	2	
<b>S</b>	Stops continuous acquisition		<i>default</i>
<b>SYN\r</b>	Synchronize internal ADCs		
<b>TRG</b>	Enable trigger/gate input	ON	
	Disable trigger/gate input	OFF	<i>default</i>
	Query “trigger mode” status	?	
<b>VER</b>	Query firmware version	?	

Table 1: List of Commands summary



## 2.3 Remote Hardware Reset

An hardware reset of the AH501D 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 AH501D 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):
  - 27 (i.e. byte 0x1B)
  - 7 (i.e. byte 0x07)
  - 0 (i.e. byte 0x00)
  - 0 (i.e. byte 0x00)
  - 0 (i.e. byte 0x00)
  - 3 (i.e. byte 0x03)
  - 0 (i.e. byte 0x00)
  - 0 (i.e. byte 0x00)
  - 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):
  - 27 (i.e. byte 0x1B)
  - 7 (i.e. byte 0x07)
  - 0 (i.e. byte 0x00)
  - 0 (i.e. byte 0x00)
  - 0 (i.e. byte 0x00)
  - 0 (i.e. byte 0x00)
  - 0 (i.e. byte 0x00)
  - 0 (i.e. byte 0x00)
  - 0 (i.e. byte 0x00)
- D. 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 AH501D module IP address standard port - i.e. 10001 - must be established.**



## 3. Ethernet Communication

This chapter describes the Ethernet communication module for the AH501D 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 AH501D. Please refer to the Xport® documentation and configuration software available at the Lantronix site [www.lantronix.com](http://www.lantronix.com) for a complete description.

#### 3.1.1 IP Address Assignment

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](http://www.lantronix.com).

Even if the AH501D 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 AH501D should reside on the same Ethernet subnet, e.g.:

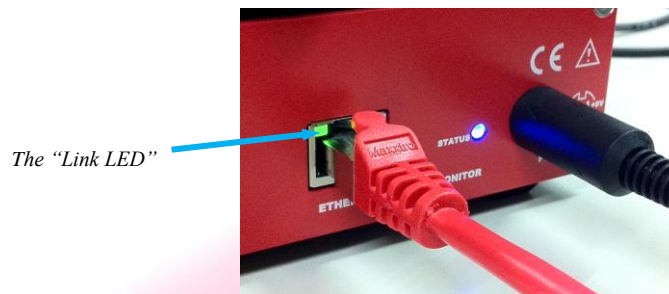
**Host PC address: 192.168.10.100 → AH501D address: 192.168.10.200**

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

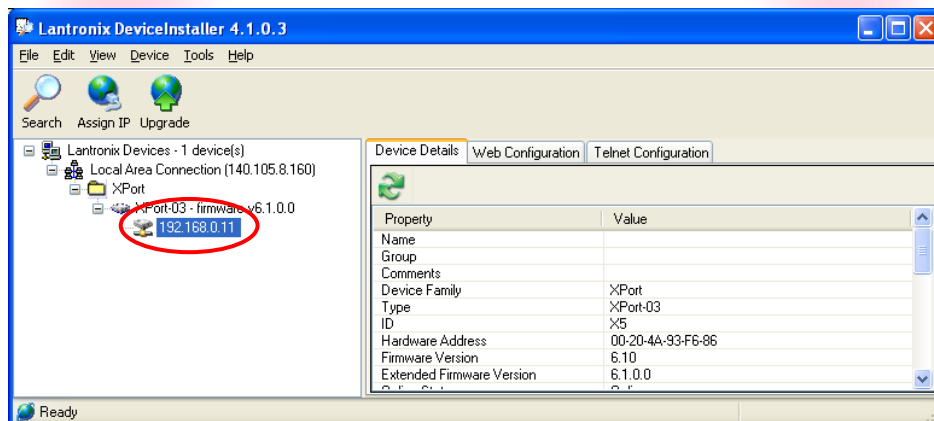


The next few steps must be followed in order to assign a new IP address to the module:

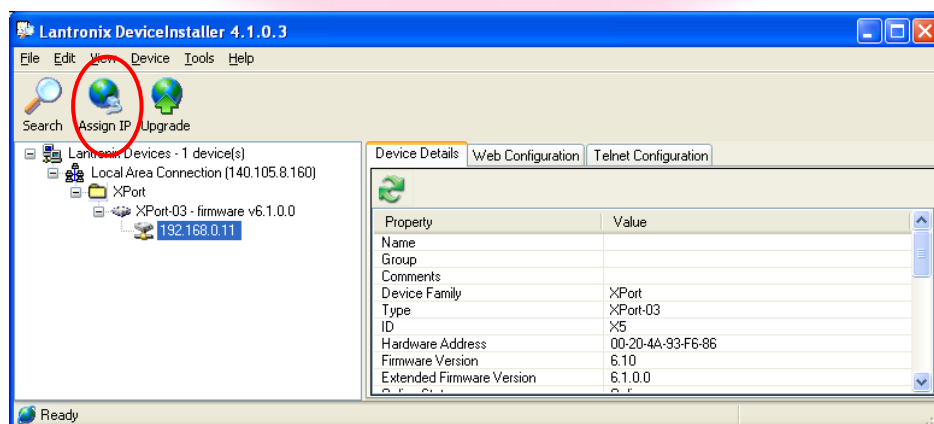
- Connect the host PC and the AH501D with a twisted Ethernet cable;
- Switch on the AH501D;
- Verify that the “Link LED” on the RJ45 connector is turned on (amber for a 10Mbps connection, or green for a 100Mbps connection) and the corresponding “Network Connection” is active on the host PC;



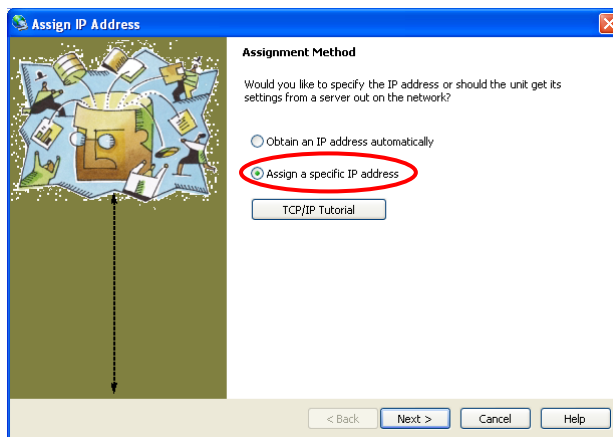
- Launch the “DeviceInstaller” program;
- Select the XPort device where you want to change the IP address;



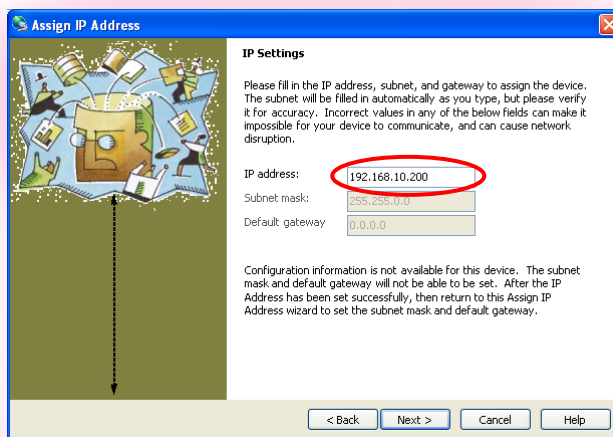
- Click on the “Assign IP” icon;



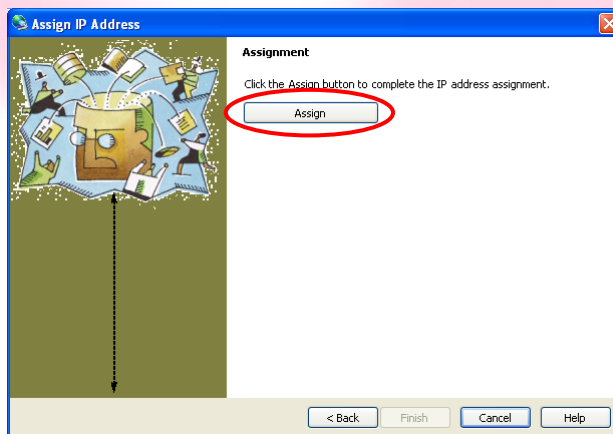
- Select “Assign a specific IP address” and then click “Next”;



- 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

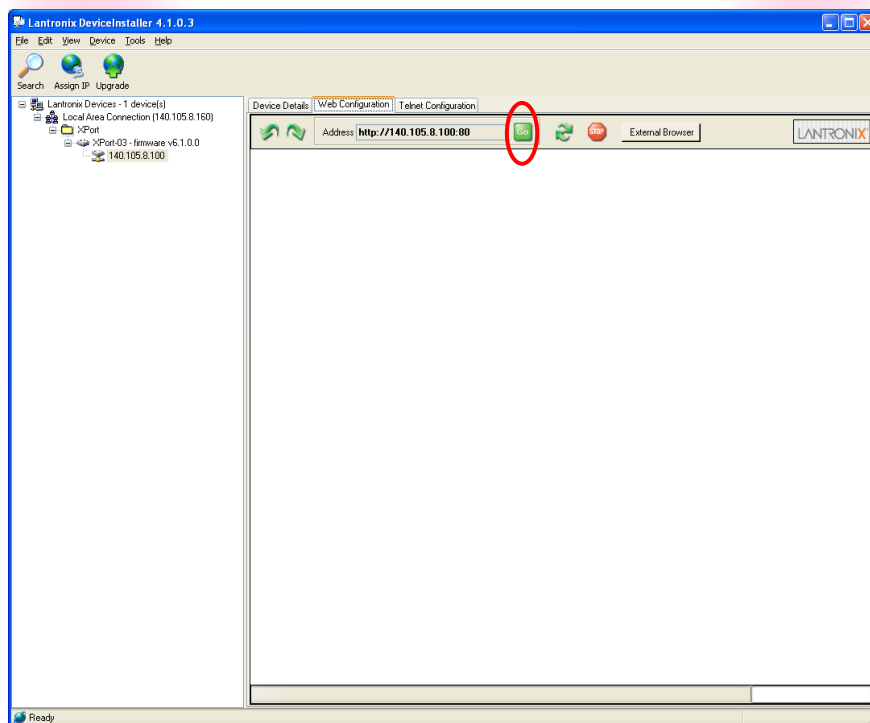
After assigning the IP address, the user must configure some other parameters on the XPort® device. There are two possible ways to configure such parameters:

- 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.

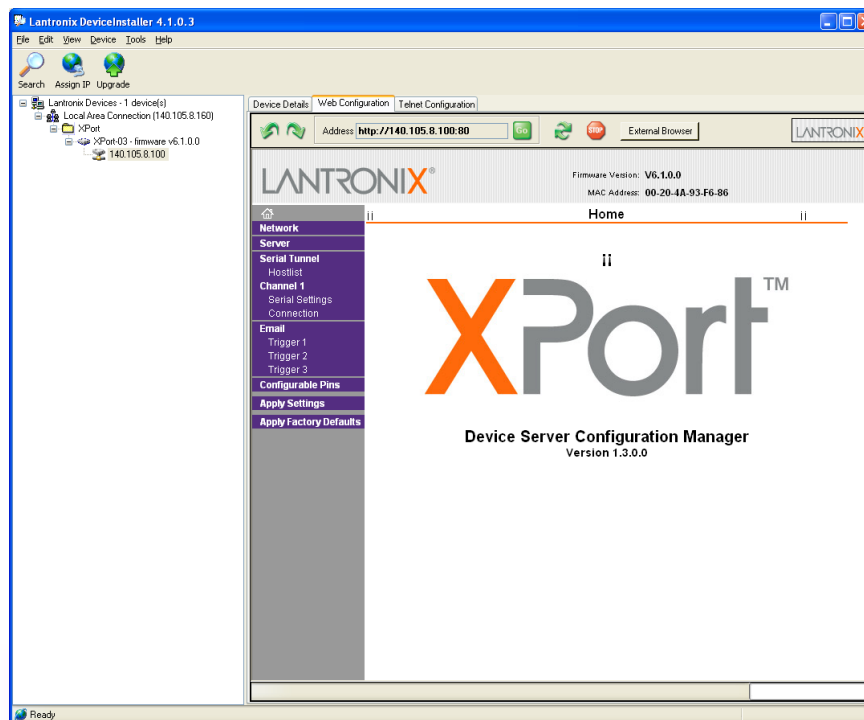
Follow the next instructions to properly setup your AH501D communication module:

- 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;

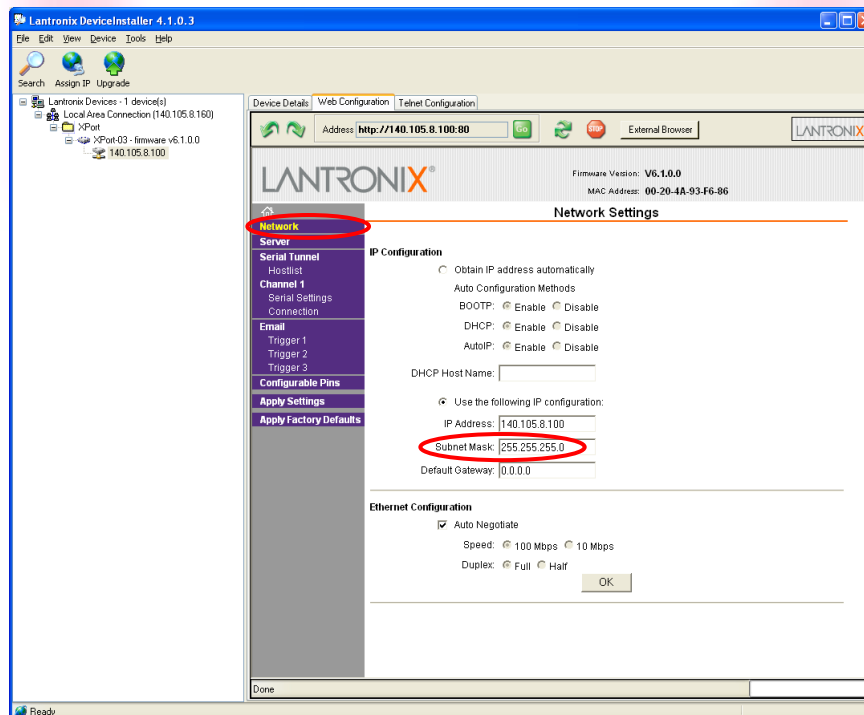


- A dialog window asking for user name and password will appear, simply click on the “OK” button;

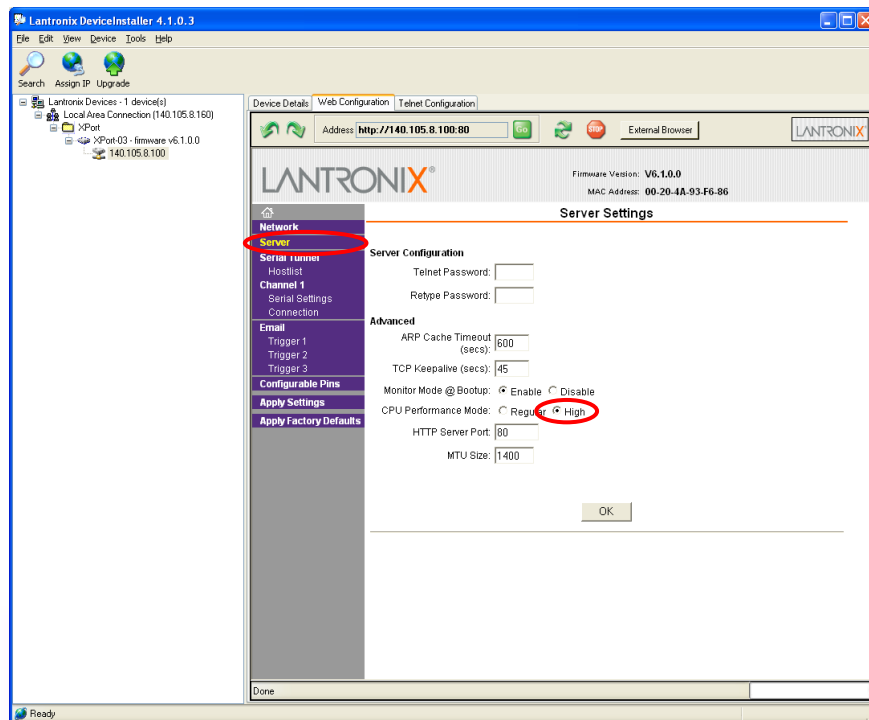
- The Lantronix web server interface will now appear:



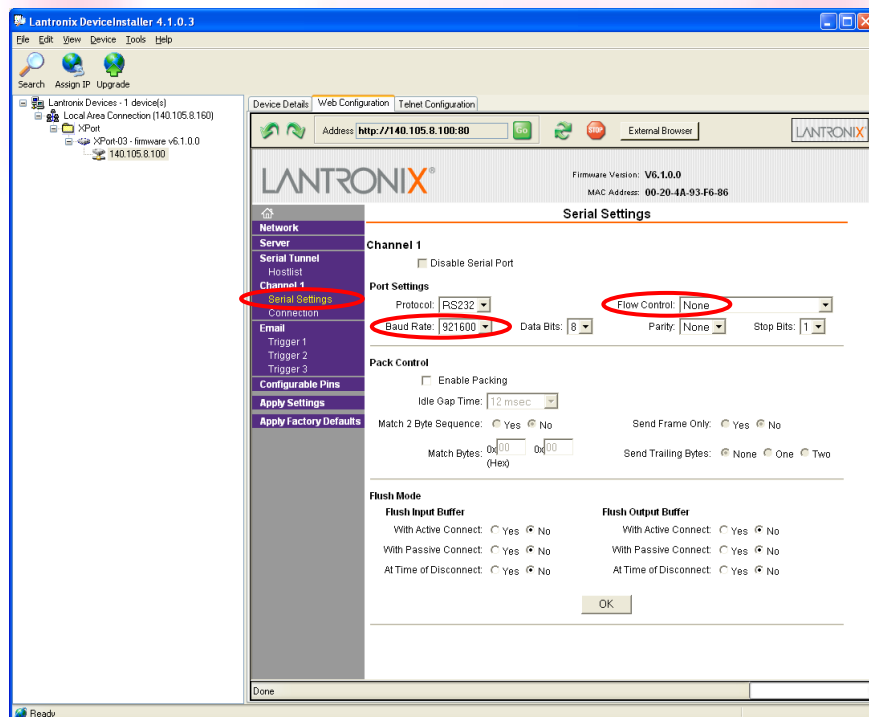
- Click on the “Network” button and set the “Subnet Mask” to “255.255.255.0”, then click on the “OK” button:



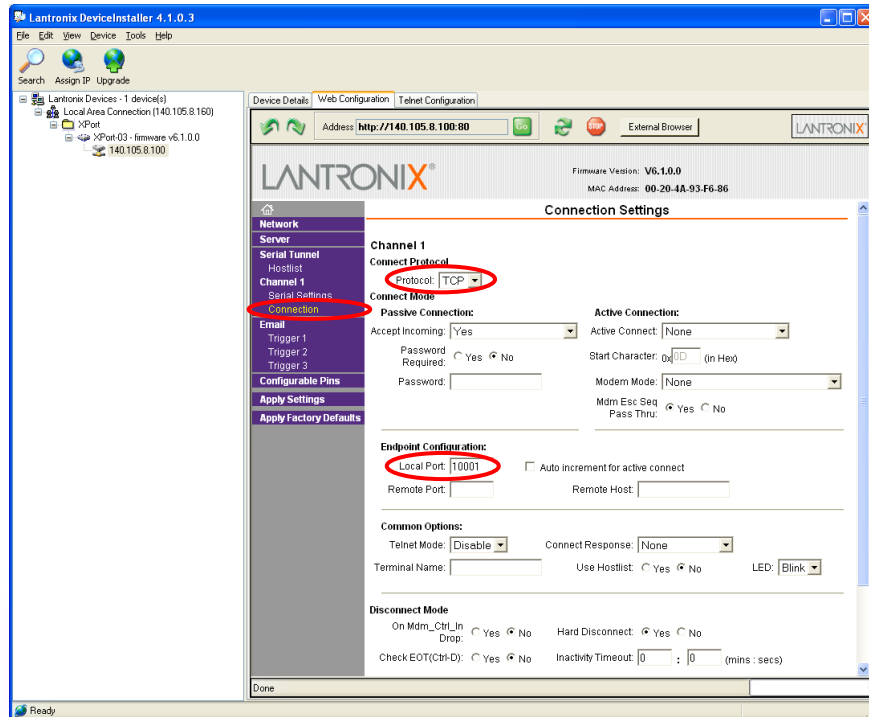
- Click on the “Server” button. Set the “CPU Performance Mode” to “High” and then click on the “OK” button:



- 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 AH501D picoammeter. If you need to change any other XPort parameter, please refer to the XPort® user's guide.

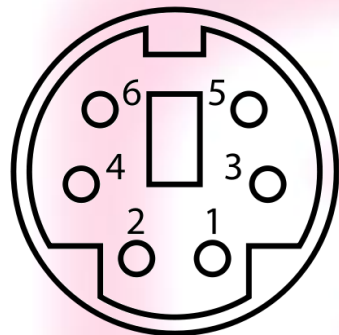
# 4. I/O Connectors

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

## 4.1 Power Connector

The input power connector is shown in **Figure 3** with its corresponding pinout. The input voltage range is rated at  $\pm 9V$  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	-9V

Figure 3- Power Connector

## 4.2 Auxiliary Connectors

The AH501D 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-GATE Signal

The purpose of the TRIGGER-GATE signal is to synchronize the acquisition of the AH501D with external events. 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 rising edge signal on the TRIGGER input starts the acquisition of the picoammeter. As soon as the TRG IN line is driven low again the acquisition stops and no more 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.



Figure 5 – Trigger input connector

### 4.2.2 The CONV Signal

The CONV signal is an output signal that toggles at every conversion-cycle from the internal ADCs. 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.

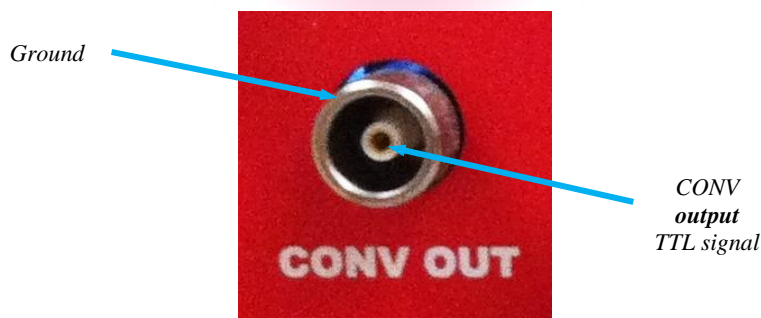
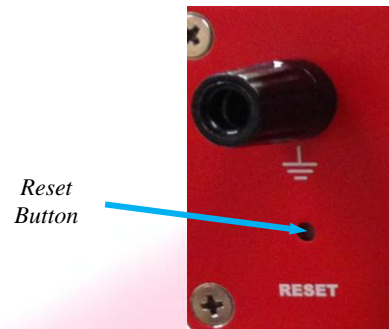


Figure 6 – CONV output connector

---

## 4.3 Hardware Reset

An hardware reset of the AH501D 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**).



**Figure 7 – Hardware reset button**

Once the RESET button has been pressed and released, the AH501D 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 2.3 for further details).

## 5. Technical Specifications

<b>Input Channels</b>	4
<b>Current Measuring Range</b>	from $\pm 2.5$ nA to $\pm 2.5$ mA
<b>Voltage Monitors</b>	Yes ( $\pm 5$ V)
<b>Current Polarity</b>	bipolar
<b>Data rate</b>	up to 26 ksamples/s
<b>Resolution Bits</b>	16 or 24
<b>RMS Noise (@RNG2, <math>C_{IN} = 5</math> pF)</b>	120 fA (typ.)
<b>Bias Voltage RMS Noise</b>	0.0005%
<b>Communication</b>	Ethernet 10/100 TCP-IP and UDP
<b>I/O Signal</b>	TRIGGER-GATE input CONV output
<b>Supply Voltage</b>	from $\pm 6$ V to $\pm 15$ V
<b>Bias Voltage Output</b>	0 to 30V
<b>Dimensions</b>	$155 \times 165 \times 50$ mm
<b>Weight</b>	580 g
<b>Input Connectors</b>	BNC
<b>Voltage Monitor Connectors</b>	LEMO
<b>Status Indicators</b>	5 LEDs