



FMB Oxford

Fast Scintillation Detector and Pulse Processing Unit



Operating & Service Manual

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2. Warranty

1. FMB OXFORD warrants that the Equipment shall be free from defects by reason of faulty design, workmanship or materials and that if within the guarantee period set out in sub-clause 3 the Equipment proves defective for such reason FMB OXFORD shall adjust, repair or replace it as it sees fit free of charge, provided that:
 - 1.1 The Equipment has been used solely for the purpose for which FMB OXFORD understands it is to be used and in accordance with the operating instructions;
 - 1.2 The defect has not been caused by fire, accident, misuse, neglect, incorrect installation by the customer, its customers, agents or servants or unauthorised repair or maintenance or by use of sub-standard consumables;
 - 1.3 The defect has not arisen from any design, specification, component or material supplied by the customer;
 - 1.4 No part of the Equipment has been replaced with a part not supplied by FMB OXFORD or approved as suitable by it;
 - 1.5 Payment in full of all sums due in respect of the Equipment has been made;
 - 1.6 The customer shall be liable for any costs incurred by FMB OXFORD in responding to claims made in respect of erroneous results caused by operator error or incorrect application;
 - 1.7 Upon the customer making a claim under sub-clause 1 it shall accord sufficient access to the Equipment to enable FMB OXFORD staff to inspect and adjust, repair, remove or replace the Equipment;
 - 1.8 FMB OXFORD will co-operate with the customer in the assessment of reported defects but the final decision regarding the applicability of this guarantee shall rest with FMB OXFORD.
2. FMB OXFORD shall decide if the Equipment should be repaired pursuant to sub-clause 1 at its site or returned.
3. The applicable guarantee period shall be 12 months after delivery save where the Equipment is installed and/or commissioned by or under the supervision of FMB OXFORD in which case it shall be 12 months from the date of the installation certificate or 18 months after the date of delivery, whichever is the earlier.

3. FMB Oxford Software Licence Agreement and Limited Warranty

3.1 Licence Agreement

As part of the sales package for the FMB OXFORD pulse processing units, the customer will receive from FMB OXFORD a licence to use the accompanying software subject to the following terms and conditions;

- The software package may be used, without time limit, on one personal computer or workstation.
- A separate licence agreement and fee is required for each additional personal computer or workstation on which the package is used.
- The software package may not be duplicated or copied except for archive purposes or to replace defective media, and each copy made must bear the copyright notices carried on the original. The software package may not be transferred in any event to a third party unless written consent is obtained from FMB OXFORD.
- This software package is protected under copyright law and FMB OXFORD reserves the right to terminate this licence upon any violation of these laws. In the event of termination, the customer will be required to return all copies of the software package to FMB OXFORD.
- Some parts of the software package are specially protected in order to be read or modified only by FMB OXFORD engineers. Under no circumstances will FMB OXFORD be under obligation to disclose information relating to these parts of the software.

3.2 Limited Warranty

The standard software is fully tested and under normal use is guaranteed to be free of bugs and defects on pulse processing units.

This insurance is not valid for special software adaptations on non-standard pulse processing units. In this case, FMB OXFORD agrees to correct at its own expense, during a one year warranty period, any defect arising during the use of the modified software package.

In no event will FMB OXFORD be liable for any direct or indirect incidental or consequential damages arising from a software failure.

4. Fast Scintillation Detector

Caution :

LETHAL VOLTAGE PRESENT INSIDE DEVICE WHEN OPERATED:

1250 VOLTS MAXIMUM High Voltage supply .

USER MUST DISCONNECT DEVICE BEFORE OPENING HOUSING FOR ANY REASON.

Please note that permanent damage to the phototube can occur if rated High Voltage supply value (above) is exceeded.

Disturbing ground loops warning : In order to avoid unwanted effects, the body of the phototube should always be electrically *isolated* from the experiment where it is installed.

Shielding ground warning : In order to obtain the best signal shielding, the body of the phototube must always be electrically *connected* to the ground of the pulse processing electronics used .

4.1 Scintillator

Type	Various scintillation crystals* are available with a variety of thicknesses (minimum 1 mm). The current selection includes: NaI, YAP, LaCl ₃ , BGO, BaF ₂ , CsI, CsI(Tl), CsF, * crystals are easily interchangeable
Detector aperture	A full suite of dimensions are available – please see the FMB Oxford catalogue for the full range. Standard heads have a Φ 32 mm active area.
Energy	up to 50 KeV - NaI(Tl), 10 MeV - BGO
Window	Beryllium, 0.2 mm thickness, Kapton or aluminium, depending on the crystal
Background	< 0.2 cps at 5 KeV - NaI(Tl)

4.2 Photomultiplier

Diameter	This varies depending on head type. Standard units with a Φ 32 mm scintillator have 38 mm tubes.
Photocathode	Bialkali adapted to most of scintillator emission wavelength (NaI(Tl), YAP, BGO ...)
Structure	10 dynodes
Gain	10 ⁶ typical

Anode signal Rise time 2.8 ns.

4.3 Housing

Precisely machined from aluminium alloy and can be opened for easy access to every component

External dimensions (standard unit only) Φ 48 mm, L 138 mm

O rings for light tightness

μ metal shielding

4.4 Connectors

High voltage Lemo ERA size zero

Signal and low voltage Amphénol 17DMW (or Lemo depending on head)

Other connectors on customer request

4.5 Voltage Divider

Principle Passive dynode chain (active on request)

Impedance 1.8 M Ω

4.6 Preamplifier

For low noise and improved speed this is directly attached to the dynode chain

Output impedance 50 Ω

Gain bandwidth product 300 MHz

Slew rate 2000 V/ μ s

Driving capability Short circuit protected

4.7 Power Requirement

High voltage supply + 1250 V maximum

High voltage current 0.7 mA

Preamplifier supply NIM standard \pm 12 V

Current required 35 mA on the + 12 V

35 mA on the - 12 V

4.8 Cables

High voltage, signal, preamplifier supply standard 5 metre length
Other cable lengths available

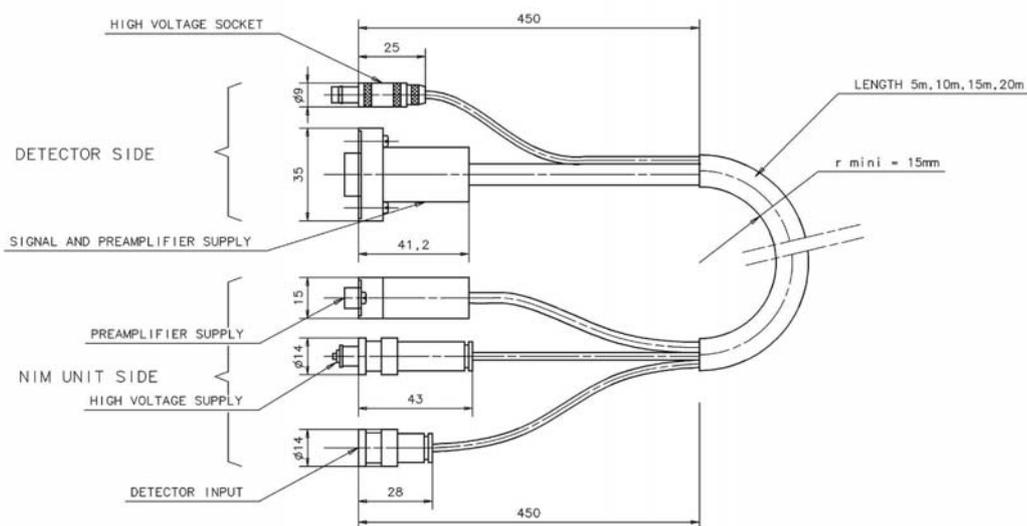
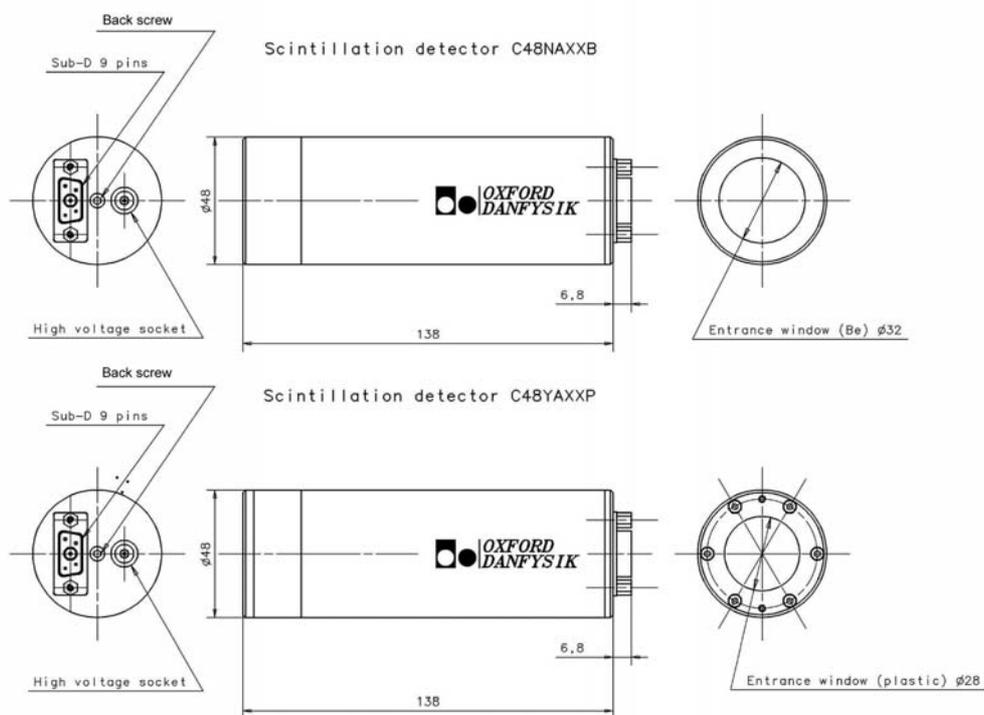
5. Scintillator

A large range of scintillators is available and the procedure for changing crystals is relatively straight forward..

5.1 Procedure for Changing a Scintillator

- Disconnect the detector from its cables.
- Remove the two M 2.5 screws. Labelled “back screw” on the detector drawing.
- The connector plate is pushed externally by a spring situated inside the detector. Disengage the connector back plate from the detector body. Do not twist and break the connecting cables, these are Teflon wires and welding points are fragile.
- Holding the front scintillator housing steady in one hand, unscrew the detector body. During this operation the disengaged connector back plate must not rotate.
- When unscrewed, slide the scintillator along the front face of the phototube to a position where it touches the scintillator housing internal thread.
- The phototube is coupled to the scintillator window by optical grease. This coupling must be broken, for this operation, grasp the detector body in one hand and the scintillator housing in the other and apply a constant gentle force, after some seconds the optical coupling will disconnect. Pull out backwards the phototube from the housing.
- Clean the phototube and the scintillator windows with alcohol. Store them in a safe, dry and dark place.
- Thread the new scintillator on to the detector body.
- On the centre of the phototube window apply $\frac{1}{4} \text{ cm}^3$ of optical grease, do not spread this. We recommend the thixotropic product from Dow Corning, Q2-3067. Never use a non-thixotropic grease.
- Re-insert the phototube assembly inside the detector body and tighten the M 2.5 back screws on the connector plate, being careful not to wear the threads. The internal spring will gently squeeze the silicon optical couplant.
- After five - ten hours the detector will be ready to use.

Detector Drawing



6. Pulse Processing Unit

Caution :

LETHAL VOLTAGE PRESENT INSIDE DEVICE WHEN OPERATED:

1250 VOLTS MAXIMUM High Voltage supply

USER MUST DISCONNECT DEVICE BEFORE OPENING HOUSING FOR ANY REASON

Please note that permanent damage to the phototube can occur if rated High Voltage supply value (above) is exceeded.

Disturbing ground loops warning : In order to avoid unwanted effects, the body of the phototube should always be electrically *isolated* from the experiment where it is installed.

Shielding ground warning : In order to obtain the best signal shielding, the body of the phototube must always be electrically *connected* to the ground of the pulse processing electronics used .

6.1 Dimensions

External double NIM unit, 6.86 cm x 22.13 cm
or 19 inches - 3U Europe-standard rack.

6.2 Shaping Amplifier

- Advantages fast speed dc-coupling
- Gain adjustable by a front panel scroll key
- Shaping constant adjustable by a front panel scroll key
- Dead time correction peaking time of 50 ns, 100 ns, 300 ns or 1000 ns gaussian smooth and predictable counting loss leading to an easy dead time correction up to 3.10^6 cps (peaking time 50 ns).
- Base line restorer innovative base line restorer, virtually no base line shift at high counting rate, active even on undershoot of high energy saturating pulse.
- BNC pulse output unipolar pulses output available on the front panel. Can be connected to a multi-channel analyser.
- Output level maximum output voltage of 4 volts.
1 ns override recovery time.
- Display LCD 2 lines * 8 characters displays gain and shaping constant

6.3 Single Channel Analyser

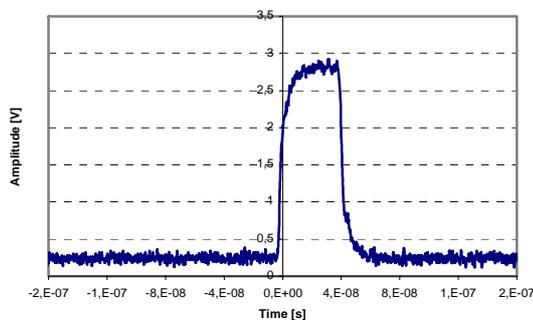
1) Independant upper and lower adjustments by front panel scroll keys

- Lower level adjustable between 0 V and 4 V
- Precision of the reading ± 10 mV
- Linearity error ± 10 mV
- Thermal drift $0.1 \text{ mV}/^\circ\text{C}$ over the range of 10 to 50°C

- Upper level adjustable between 0 V and 4 V
- Precision of the reading ± 10 mV
- Linearity error ± 10 mV
- Thermal drift $0.1 \text{ mV}/^\circ\text{C}$ over the range of 10 to 50°C
- Display LCD 2 lines * 8 characters displays upper and lower adjustments

2) BNC output signal – CBY02202 single channel units

- protection every output is short circuit protected
- standard signal TTL or NIM signal through jumper selection (SW105, SW106 and SW107) are available to synchronise external counter acquisition system
TTL output positive going 4 ns rise time
zero: 300 mV; logical 1: 2 volts minimum into a 50Ω load
NIM output negative going; logical 1: 2 volts minimum into a 50Ω load
- front panel upper level, lower level and window output
- current NIM pulses available on the BNC output through a jumper selection for location of this jumper refer to 6.7.
logical 1 between - 36 mA and - 12 mA



typical single channel analyser
TTL output

6.5 Phototube Preamplifier Power

Rear panel NIM standard 9 pins sub D female connector

6.6 Current Consumption of NIM version

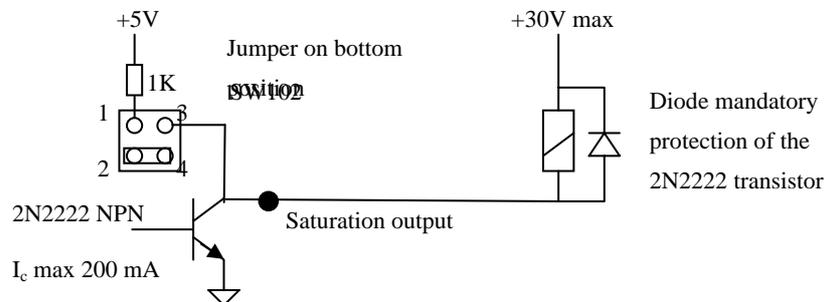
240 mA on the + 6 V
130 mA on the - 6 V
220 mA on the + 12 V
20 mA on the - 12 V
120 mA on the + 24 V

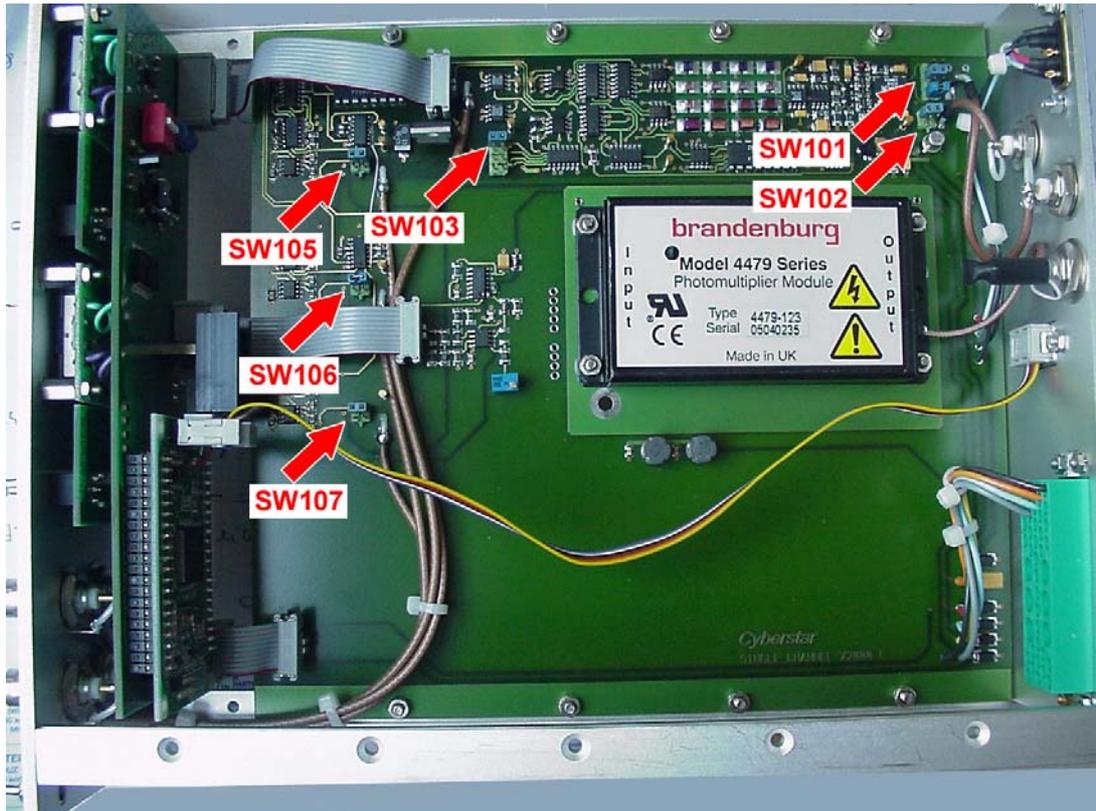
6.7 Miscellaneous

Saturation output signal, for actuating a beam shutter (**CBY02202 only**):

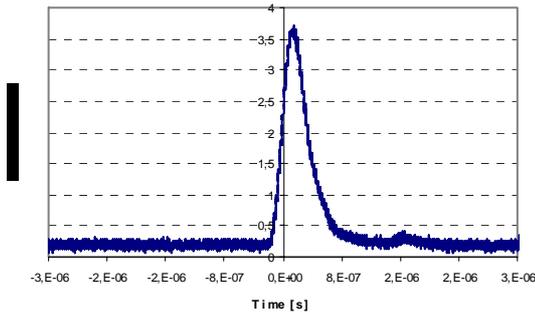
- NPN open collector
- 30 V maximum voltage, 500 mA available when ON
- Available on a rear panel BNC connector

Saturation is detected when a percentage of pulses (6.25%, 12.5%, 25% and 50% according to the jumper selection, see picture next page for location) reach an amplitude which saturates the first pre-amplification stage. If the saturation output is connected to a relay proceed as shown below:





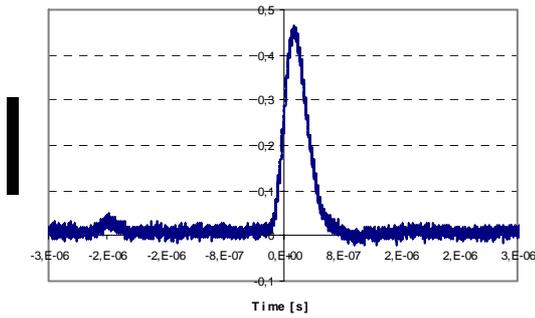
- Jumper SW101 / input pulse polarity:
 - jumpers positions 1 and 3 (from top to bottom): positive input
 - jumpers positions 2 and 4: negative input
 Default position: straps on positions 2 and 4: negative input
- Jumper SW105 / Upper Level Single channel analyser output :
 - upper position: TTL
 - lower position: NIM
 Default position: top TTL
- Jumper SW106 / Lower Level Single channel analyser output :
 - upper position: TTL
 - lower position: NIM
 Default position: top TTL
- Jumper SW107/ Discrimination Single channel analyser output :
 - upper position: TTL
 - lower position: NIM
 Default position: top TTL



Typical signal output

Pulse height measurement performed with a ^{109}Cd (22 keV) source and **NaI(Tl)** detector head.

The settings of the X2000 were: gain of 70, peaking time of 300 nS, high voltage of 1000V.



Typical signal output

Pulse height measurement performed with a ^{55}Fe (5.9 keV) source and **NaI(Tl)** detector head.

The settings of the X2000 were: gain of 100, peaking time of 300 nS, high voltage of 1000V.

7. Front panel Description

7.1 High Voltage (CBY02202 only)

Four digit display indicates the value of the set voltage. Voltage can vary between 1 and 1250 V (other ranges on request).

When high voltage is increased, gain of the phototube increases but natural noise increases also. When a low noise is required at low energy, the best trade off must be found between gain of the preamplifier and magnitude of the high voltage.

Normal condition for the photomultiplier is between 800 and 1000 V.

7.2 Preamplifier and Shaping Amplifier

The preamplifier gain scroll key adjusts the amplitude of the shaped pulses available on the signal out of the BNC front panel socket. These pulses are 4V maximum amplitude.

This signal can be directly sent to a multichannel analyser, it is a positive signal without negative undershoot.

The peaking time scroll key adjusts the shaping constant. Instead of this not “directly measurable parameter” the peaking time is indicated. This is the time elapsed between the arrival of an X or γ photon inside the scintillator and the peak value of the signal out pulse.

Peaking time of 50, 100, 300 and 1000 ns are obtained by four different 5th order filters. Coefficient of these filters were selected for minimum delay and ringing.

7.3 Single Channel Analyser (SCA)

Upper level and lower level adjustment is available on the front panel. The mode of selection is provided through a jumper selection. For location of this jumper refer to 6.7.

	<u>Range of Variation</u>	<u>Front Panel BNC Logic Output</u>
Lower level	0 to 4 V	out when leading edge of the shaped pulse crosses lower level voltage
Upper level	0 to 4 V	out when leading edge of the shaped pulse crosses upper level voltage
Window BNC output	/	out when falling edge of the shaped pulse crosses lower level only

The TTL or negative current fast NIM logic is jumper selected. For location of these jumpers refer to 6.7.

8. Communication Board

Enables RS232 communication, allowing cascading of up to 16 units.

For each unit, the following parameters can be independently controlled:

- Phototube high voltage
- Preamplifier gain
- Single channel analyser lower and upper levels
- Shaping constant

Windows™ operated software is supplied.

8.1 General Construction

The communication board is designed around a C programmable miniature controller, Hitachi AE3048.

If a user requires a special operating algorithm it can be programmed with the integrated C development environment, which can be supplied.

9. Remote Control Software for Pulse Processing Electronic

9.1 Introduction

The pulse processing units can be remotely controlled by a host computer (PC or workstation) through a serial link (RS232). A network of up to 16 units can be built, requiring only one serial port on the host computer.

The communication protocol is a subset of the SCPI (Standard Commands for Programmable Instruments) language.

A communication software example is provided showing various possible command lines. This can help users to develop their own remote control interface software.

CONTROL software is also provided, which enables users to immediately setup a complete run-time interface link between a Windows™ PC and one or more X2000 units.

Both pieces of software can be installed on the same computer (just run Setup.exe from the floppy disc).

9.2 Description

The pulse processing unit holds a C programmable miniature controller. The program is factory stored in its EPROM. This program is able to drive the unit, by controlling the gain, the peaking time and the single channel analyser upper and lower levels. The high voltage power supply (CBY02202 units only) can also be controlled. Saturation threshold detection is also provided.

When turning on the power the unit is reset and a message "Init OK" is displayed. The high voltage, the gain, the peaking time and the single channel analyser upper and lower levels are set to the saved values. These values are stored into the EPROM every time one is modified. Do not forget to increase the gain in order to get a signal.

Every unit has an address given by DIP switches 1 through 4 (SW1 on the front panel communication board) where switch 1 corresponds to address bit 0, and switch 4 corresponds to bit 3. A switch setting of OFF determines a bit value of 1 and a setting of ON determines a value of 0.

Factory address setting is 0. Always switch the unit off before changing its address. A unit address 7 corresponds to switches 1 OFF, 2 OFF, 3 OFF, 4 ON.

9.3 Commands List

Commands list for the CBY-2206 module

<u>Syntax</u>	<u>Meaning</u>
*RSTad	reset the electronics
:INPad:GAIN x	set channel X gain value to x
:SENSad:SCA:UPP x	set single channel analyser (SCA) of channel X upper level to x

:SENSad:SCA:LOW x	set single channel analyser (SCA) of channel X lower level to x value
:SENSad:PKT x	set peaking time of channel X to x value
:SENSad:SATX?	reply '1' if saturation is detected, on channel X, '0' otherwise

Commands list for the CBY-2202 module

<u>Syntax</u>	<u>Meaning</u>
*RSTad	reset the electronics
:INPad:GAIN x	set gain to x value
:SENSad:SCA:UPP x	set single channel analyser (SCA) upper level to x value
:SENSad:SCA:LOW x	set single channel analyser (SCA) lower level to x value value
:SENSad:PKT x	set peaking time to x value
:SOURad:VOLT x	set high voltage to x value (if the power supply option is installed)
:SENSad:SAT?	reply '1' if saturation is detected, '0' otherwise
:SENSad:HVFAIL?	reply '1' if high voltage failure is detected, '0' otherwise

ad (unit address): an integer value from 0 to 15. It may be left out of the command when unit is set to address 0. For example, *RST and *RST0 are both valid commands.

Values range for x parameter

High voltage (CBY02202 only)	from 0 V to 1249 V
Gain	from 0% to 100%
Peaking time	50 ns, 100 ns, 300 ns or 1000 ns
SCA upper level	from SCA lower level to 4 V
SCA lower level	from 0 V to SCA upper level

Examples

:INPO:GAIN 12.5 :SENS0:SCA:LOW 1.5

These commands set the gain at 12.5% and the SCA lower level at 1.5 V (the address of the unit being 0)

:INP15:GAIN 12.5 :SENS15:SCA:LOW 1

Same command with a different address (15)

All commands but consist of two distinct parts; a header and a value. They have an additional query form, in which a question mark replaces the value (do not insert a space character between header and question mark).

When a query form is received, the program sends the current value associated with the command. Query responses do not include the command header.

Examples

:INP0:GAIN?	query from the host computer
12.5	value sent to the host computer

Warning: The program waits for strings ending with a special character (ASCII code = 10). This character must be transmitted by the host computer. When the program sends a current value, it also sends this character after the value.

Every time this special character is acknowledged, the program sends a single character (ASCII code = 6) to the host.

9.4 Syntax rules

Upper and lower case characters are accepted.

At least one space character is mandatory before a decimal data or before ON and OFF.

9.5 Connecting with a Host Computer

This unit can be connected to a RS232 port of a host computer. Only three wires are needed. The RS232 connector is located on the rear panel of the unit. Standard RS232 pinout is used: ground signal is pin 5, receive signal pin 2 and transmit signal pin 3.

If the host computer is a PC, pins 4, 6 and 8 must be tied together on the cable connector (PC side).

The following protocol is supported by the unit:

- baud rate 9600
- data format 8 bits ASCII data and 1 stop bit
- parity none

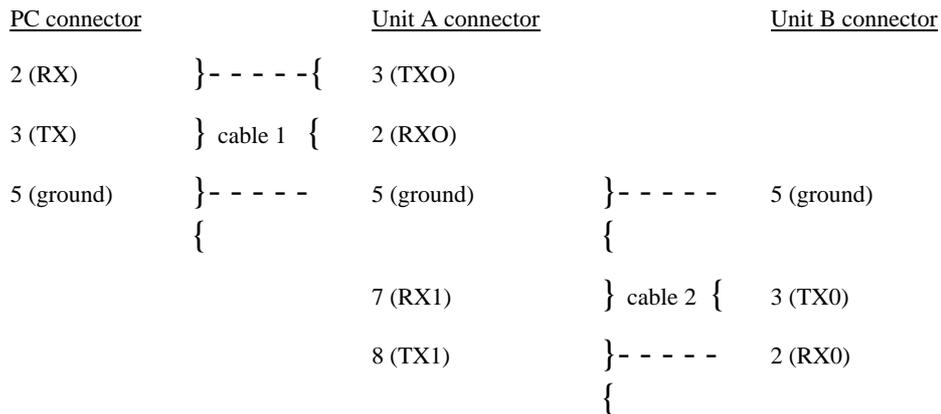
CTS, RTS signals are disabled.

9.6 Network Configuration

These units are designed to operate in a network. Up to 16 units can be linked together using only one RS232 port of the host computer.

When a unit is linked to the network, its address must not be already in use by any of the other units.

The wiring for a network (including two units) connected to a PC, is detailed hereafter.



When the unit B is disconnected, pins 2 and 3 of the connector located at the end of cable 2 must be grounded with a 1000 Ω resistor.

When a unit is in local mode, it does not stop communication with other units in remote or forced remote mode.

For example, if unit A is in local mode and unit B is in remote mode, the PC can send commands to unit B and receive data from unit B.