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Acton Research Corporation

NCL Electronic Interface

Operating Instructions

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I. Description

The Acton Research Corporation NCL Electronics Interface is a 32 bit microprocessor based data acquisition and spectrometer controller module for use with ARC SpectraSense software, all ARC SpectraPro monochromators including accessories and all ARC air path and vacuum monochromators controlled by the SpectraDrive scan controller. The NCL controls one or two monochromators and associated motorized accessories such as slits, diverter mirrors, and filter wheels. The NCL can acquire data from two or optionally three individual analog data channels with 20 bit resolution or digital photon counting channels.

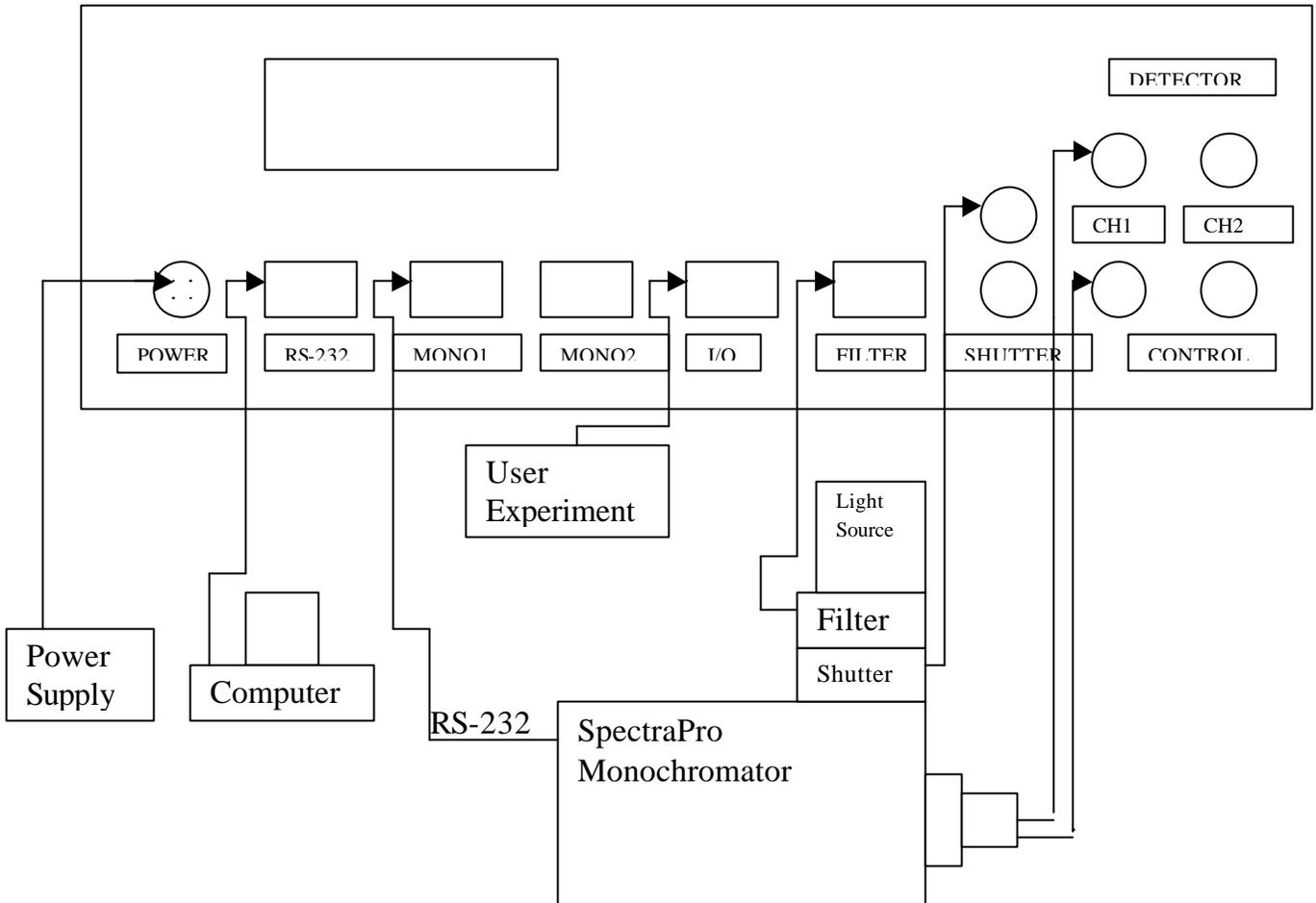
II. Installation and Setup

The NCL is supplied with the following items:

- NCL Electronics Interface Module
- 12 Volt DC power supply
- AC line cord
- Serial communications cable
- I/O mating connector
- Operators Manual

Shown below is a diagram of illustrating the connections of the NCI with the Acton Research Corporation SpectraPro monochromator and other ARC accessories such as PD-471 PMT detector, FA-448 filter wheel and SH1 shutter plus the connection to the user's computer.

NCL Rear Panel



If the experiment utilizes two monochromators, the RS-232 port on the second monochromator is connected to the MONO2 port on the NCL using the serial cable supplied with the monochromator.

III. Specifications

NCL Electronic Interface - 32 bit microprocessor

Data Acquisition:

Two independent data acquisition channels

(third channel optional with NCL-3CH)

Each channel can accept:

Current from a PMT, Silicon Diode or IR detector

Voltage from a preamplifier

(current and voltage with 20 bit resolution)

Photon counting TTL pulses from an amplifier-discriminator such as the ARC model # PD-473-1 Photon Counting detector module

Sensitivity:

Current: +/-10nA to +/-1.0uA full scale

Voltage: +/-100mV to +/-10V full scale

(note: full scale readings are dependent on range setting and integration time)

Photon Counting: 20 nanosecond pulse pair resolution or up to 35MHz continuous frequency input

Integration Time: 5ms to 64 seconds

Control of PMT High Voltage:

Two D/A outputs with 12 bit resolution for controlling the voltage in standard ARC PMT housings with built in high voltage power supplies from 0 to -1250 volts. Actual output voltage 0 to +5 VDC or 0 to +1.25 VDC jumper selectable (Third D/A output with NCL-3CH option)

Internal Data Memory: 8000 data points for all combined data channels

Communications:

RS-232 standard

Default baud rate 9600; can be set from 1200 baud to 38.4Kbaud

GPIB and USB options

Power:

12 Volts 750 mA DC from separate power supply provided with NCL. Optional rechargeable battery pack available.

Size: 12 in wide x 3.5 in. high x 8 in. deep

IV. Operation

The NCL typically is operated from a PC running Acton Research Corporation SpectraSense software and in conjunction with other Acton Research Corporation modules to comprise a complete spectroscopic system. Refer to the SpectraSense Operation Manual for a complete description of this system software. When beginning operation of the system, the modules of the system must all be powered on. While this can occur in any order, the following turn on sequence is recommended:

1. light sources
2. monochromators
3. filter wheels and other accessories
4. NCL
5. Computer

The SpectraSense software will guide the operator through the normal spectroscopic data acquisition modes. For special applications, it is possible to control the NCL directly through its own communications port using the commands found in section V. This is most easily tested by connecting the RS-232 port of the NCL to the COM port of the computer. Use the Hyperterm program found in Windows Applications and set to 9600 baud, 1 stop bit, 8 data bits, no parity and no flow control. Refer to the command set in section V for additional details.

The data acquisition channels of the NCL read the signals from the detector or detectors in the system. The NCL measures current from photomultipliers and silicon diodes and voltage from preamplifier circuits. The range and polarity of detector currents and voltages are user selectable from the SpectraSense software and from the NCL command set. The ranges in the SpectraSense software are as follows: X1, X2, X5, X50 and X200. The full scale readings on each of these ranges are determined by the polarity and integration time. Polarity can be set to unipolar for negative current and voltage input from 0 to full scale (PMT's and some silicon diodes have negative current outputs) or bipolar current and voltage input for negative full scale to positive full scale. The full scale raw count output for unipolar readings is 0 to 2^{20} or 1048576 and the full scale raw count output for bipolar readings is -2^{19} to 2^{19} or -524288 to 524288 . Note that unipolar provides one additional bit of resolution on negative inputs, however, bipolar must be used for all positive readings. Examples of maximum current and voltage inputs are shown below:

Full Scale Values for Unipolar Current Vs. Integration Time

<u>Range</u>	<u>10ms</u>	<u>100ms</u>	<u>1000ms</u>
X1	$-2 \times 10^{-5} \text{ A}$	$-2 \times 10^{-6} \text{ A}$	$-2 \times 10^{-7} \text{ A}$
X2	$-1 \times 10^{-5} \text{ A}$	$-1 \times 10^{-6} \text{ A}$	$-1 \times 10^{-7} \text{ A}$
X5	$-4 \times 10^{-6} \text{ A}$	$-4 \times 10^{-7} \text{ A}$	$-4 \times 10^{-8} \text{ A}$
X50	$-4 \times 10^{-7} \text{ A}$	$-4 \times 10^{-8} \text{ A}$	$-4 \times 10^{-9} \text{ A}$
X200	$-1 \times 10^{-7} \text{ A}$	$-1 \times 10^{-8} \text{ A}$	$-1 \times 10^{-9} \text{ A}$

(e.g. X1 range, 100ms integration time, $-2 \times 10^{-6} \text{ A}$ input = 1048576 raw counts)

Full Scale Values for Bipolar Current Vs. Integration Time

<u>Range</u>	<u>10ms</u>	<u>100ms</u>	<u>1000ms</u>
X1	+1 to $-2 \times 10^{-5} \text{ A}$	+1 to $-2 \times 10^{-6} \text{ A}$	+1 to $-2 \times 10^{-7} \text{ A}$
X2	$\pm 1 \times 10^{-5} \text{ A}$	$\pm 1 \times 10^{-6} \text{ A}$	$\pm 1 \times 10^{-7} \text{ A}$
X5	$\pm 4 \times 10^{-6} \text{ A}$	$\pm 4 \times 10^{-7} \text{ A}$	$\pm 4 \times 10^{-8} \text{ A}$
X50	$\pm 4 \times 10^{-7} \text{ A}$	$\pm 4 \times 10^{-8} \text{ A}$	$\pm 4 \times 10^{-9} \text{ A}$
X200	+0.5 to $-1 \times 10^{-7} \text{ A}$	+0.5 to $-1 \times 10^{-8} \text{ A}$	+0.5 to $-1 \times 10^{-9} \text{ A}$

(Note that the X1 and X200 ranges are limited to half the expected value for positive input or 262144 raw counts)

Full Scale Values for Unipolar Voltage Vs. Integration Time

<u>Range</u>	<u>10ms</u>	<u>100ms</u>	<u>1000ms</u>
X1	*	-5V	-0.5V
X2	*	-2.5V	-0.25V
X5	-10V	-1V	-0.1V
X50	-100mV	-100mV	-10.0mV
X200	-250mV	-25mV	-2.5mV

(Note: input voltages greater than ± 10 Volts should not be used)

Full Scale Values for Bipolar Voltage Vs. Integration Time

<u>Range</u>	<u>10ms</u>	<u>100ms</u>	<u>1000ms</u>
X1	*	+2.5 to -5.0V	+0.25V to -0.5V
X2	*	$\pm 2.5 \text{ V}$	$\pm 0.25 \text{ V}$
X5	$\pm 10 \text{ V}$	$\pm 1 \text{ V}$	$\pm 0.1 \text{ V}$
X50	$\pm 1.0 \text{ V}$	$\pm 100 \text{ mV}$	$\pm 10.0 \text{ mV}$
X200	+125 to -250mV	+12.5 to -25mV	+1.25mV to -2.5mV

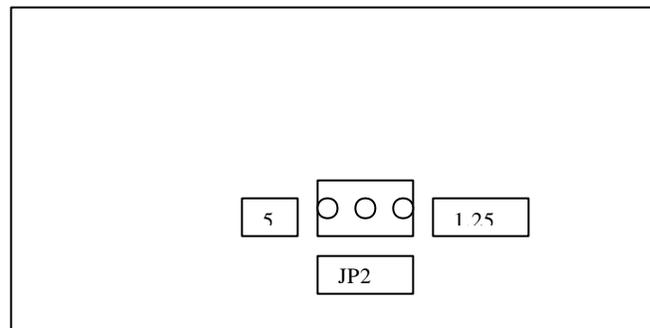
(Note: input voltages greater than ± 10 Volts should not be used and positive voltages on X1 and X200 ranges are limited to half the expected value or 262144 raw counts)

The NCL also measures the counts from photon counting modules which include an internal amplifier/discriminator such as the ARC models PD-473 side window photon counting module and the PD-474 end window photon counting module.

The photon counting input circuits in the NCL will measure pulse pair resolutions to 20nS or continuous frequency input to approximately 35 mHz. However, as the light intensity increases random distribution of pulses causes some pulses to overlap which affects linearity. As a general rule, as the average frequency approaches 2 to 3 mHz, pulse overlap begins to occur. As the light intensity increases the pulse overlap or “pulse pile-up” can become severe enough to cause the output to go to zero. Photon counting is intended for low level light readings. Caution is advised as intensity increases since results can be misleading.

Each input channel has associated with it a 12 bit D/A converter for controlling the PMT voltage in the ARC PMT Detector Modules such as the PD-471. This voltage is controlled by setting the PMT high voltage value in the SpectraSense software or by the VOLTS, PMT-ON and PMT-OFF commands in the NCL command set. The maximum value of the D/A voltage output is jumper selectable on the NCL printed circuit board between 1.25 volts and 5.0 volts maximum. The jumper is set at the factory for 1.25 volts maximum for use with the PD-471. If the NCL is being used with an existing ARC PHV-400 PMT High Voltage Power Supply, the jumper should be changed to the 5 volt setting. If it is necessary to operate both a PD-471 and a PHV-400, contact ARC for instructions. The jumper is located at JP2 on the main NCL PC board as shown below.

Front Panel



Back Panel

When the jumper is on the right two posts looking from the rear panel, the D/A output voltage is 1.25 volts when the PMT voltage is set to 1250 volts and when the jumper is on the left two posts, the D/A output voltage is 5 volts when the PMT voltage is set to 1250 volts.

There are four digital inputs and four digital outputs located in I/O connector on the rear panel of the NCL. Refer to section VI of this manual for a diagram of the connector and description of each line. These inputs and outputs can be used to synchronize the users experiment with the actions of the NCL. These lines are

controllable through the SpectraSense software and by commands in the NCL command set as described in section VI. All I/O inputs and outputs are opto-isolated. The power supply for the isolated side of the I/O is located in the NCL and isolated from the remainder of the supplies. The inputs are TTL or switch contact compatible and the outputs are TTL with the capability of sinking 10mA.

V. Command Set

I. Detector Readout Commands:

.2READ (- n₁n₂) takes 2 simultaneous readings for 2 channel system and returns both values.

.3READ same as above except 3 readings for 3 channel system

CH1 selects readout channel #1. Once set, remains selected until another channel is selected.

CH2 selects readout channel #2

CH3 selects optional readout channel #3

?CH (n) returns selected channel #.

.READ (- n) takes 1 reading from selected channel. Uses CH1, CH2 or CH3.

VOLTAGE sets input for selected channel to accept voltage signals used with CH1, CH2, CH3

CURRENT sets input for selected channel to accept current signals used with CH1, CH2, CH3

PHOTON sets input for selected channel to accept photon counting signals used with CH1, CH2, CH3

?INPUT (- s) returns the string "voltage", "current" or "photon" for the selected channel. Used CH1, CH2, CH3

ITIME (n) sets integration time for all channels in ms.

?ITIME (- n) returns the value for the integration time

ICAP (n) sets cap value for all current integrators. 0 = 20,000 pf, -1 = 100 pf.

?ICAP (n) returns value of cap size. See values above.

RANGE (n) sets A/D converter gain for selected channel.
0 RANGE corresponds to X1 range in SpectraSense
1 RANGE corresponds to X2 range in SpectraSense
2 RANGE corresponds to X5 range in SpectraSense
3 RANGE corresponds to X50 range in SpectraSense
4 RANGE corresponds to X200 range in SpectraSense
Uses CH1, CH2, CH3

?A/DGAIN (- n) returns A/D converter gain for selected channel. See A/DGAIN for values. Uses CH1, CH2, CH3.

UNIPOLAR sets the polarity for the A/D converter in the selected channel for unipolar readings. Uses CH1, CH2, CH3

BIPOLAR sets the polarity for the A/D converter in the selected channel for bipolar or negative readings. Uses CH1, CH2, CH3

?POLARITY (- n) returns 0 for unipolar and -1 for bipolar for the selected channel. Uses CH1, CH2, CH3

II. PMT High Voltage Commands:

VOLTS (n) sets the PMT voltage for the selected channel. Uses CH1, CH2, CH3.

?VOLTS (- n) returns the PMT voltage for the selected channel. Uses CH1, CH2, CH3 above.

PMT-ON turns on the PMT supply for the selected channel. Uses CH1, CH2, CH3.

PMT-OFF turns off the PMT supply for the selected channel. Uses CH1, CH2, CH3.

III. Monochromator Commands:

MONO1 selects monochromator #1 to receive commands.
Monochromator #1 remains selected until monochromator #2 is selected.

MONO2 selects monochromator #2 to receive commands.

PASS After issuing MONO1 or MONO2, PASS allows the standard monochromator commands such as GOTO, NM, ?NM GRATING ect. to be passed through to the selected monochromator.

for example: MONO1 PASS 345.6 GOTO

sends the monochromator #1 to 345.6nm with the GOTO command.

CCD (1,2) Sets a pass through mode which allows monochromator commands to pass directly through to monochromator #1 or #2 depending on which parameter is used. When pass through mode is no longer desired, a control W character (hex 97, decimal 151) is sent to the NCL.

for example: 1 CCD

sets the NCL into pass through mode and allows commands to pass directly from the NCL serial port to the MONO1 monochromator port.

Auto Scan-and-Store Commands:

The following commands control automatic scans. These commands move the monochromator and store the data in the Readout system memory. Scans use a start and end wavelength and monochromator movement is at goto speed. The commands MONO1 and MONO2 are used to select which monochromator scans.

The monochromator not selected does not scan and is set to a fixed wavelength before using these commands.

STARTWAVELENGTH (n) sets the start wavelength of the scan using units above.

ENDWAVELENGTH (n) sets the end wavelength of the scan.

INCREMENT (n) wavelength increment for scan to nearest 0.001nm

START-SCAN starts the scan previously set up.

STOP-SCAN aborts the scans saving data acquired to that point.

INTERVAL (n) the time in ms to nearest 5 ms between readings of rapid IvsT scans. Must be less than $ITIME + 30\%$.

*READ (n) takes n IvsT readings and stores them in internal NCL RAM. Maximum number of data points is 8000.

*2READ (n₁,n₂) takes n pairs of IvsT readings and stores them in internal NCL RAM. Maximum number of total data points is 8000 (4000 pairs).

.*READ (n) reads n values which have been stored in NCL memory by START-SCAN with a 1CHAN-SCAN or *READ.

.*2READ (n₁,n₂) reads n pairs of values which have been stored in NCL memory by *2READ. Format is ch1 reading space ch2 reading cr lf

MORE reads the remaining number of stored values which have been stored in NCL memory.

2MORE reads the remaining number of pairs of values which have been stored by START-SCAN with a 2CHAN-SCAN or *2READ. Format is ch1 reading space ch2 reading cr lf

IV. Filter Commands:

FILTER (n) sets filter position for selected monochromator to designated position. Uses MONO1 or MONO2

?FILTER (- n) returns filter position for selected monochromator. Uses MONO1, MONO2

FHOME causes filter on selected monochromator to initialize to home position.

V. Shutter Commands:

SHUTTER1 selects shutter #1 to receive commands. Shutter #1 remains selected until shutter #2 is selected.

SHUTTER2 selects shutter #2 to receive shutter commands. Shutter #2 remains selected until shutter #1 is selected.

OPEN opens shutter for selected monochromator. Uses SHUTTER1, SHUTTER2

CLOSE closes shutter for selected monochromator. Uses SHUTTER1, SHUTTER2

?SHUTTER (- n) returns shutter state for selected monochromator.
Uses SHUTTER1, SHUTTER2

VI. Digital I/O Commands:

1IN (- n) returns 1 or 0 representing state of #1 input.

2IN (- n) returns 1 or 0 representing state of #2 input.

3IN (- n) returns 1 or 0 representing state of #3 input.

4IN (- n) returns 1 or 0 representing state of #4 input.

1OUT (n) sets state of #1 output. n = 1 or 0

2OUT (n) sets state of #2 output.

3OUT (n) sets state of #3 output.

4OUT (n) sets state of #4 output.

I/O-IN (- n) returns state of all inputs and outputs.

I/O-OUT (n) sets state of all digital outputs. (uses 4 least significant bits)

TRIGGER-DOES (n) takes input trigger # (0,1,2,3) and executes a single word command. e.g. 2 TRIGGER-DOES 400.0 GOTO

TRIGGERED-BY (n) takes input trigger # (0,1,2,3) and designates which action by the trigger causes the specified result in TRIGGER-DOES described above. Allowed actions: LOW, HIGH, RISING, FALLING
e.g. 2 TRIGGERED-BY LOW

DO-TRIGGERS activates all triggers which are set-up

NO-TRIGGERS deactivates all triggers

?TRIGGERS (- bbbb) returns the state of the four input trigger lines.
0101 indicates triggers 0 and 2 are high,
triggers 1 and 3 are low.

VII. Readout System Commands:

VER (- s) returns string representing software version.

MODEL (- s) returns string representing model # of readout system.

SERIAL (- s) returns string representing serial # of readout system.

READ-CHECKSUM (- s) returns checksum of readout EPROM.

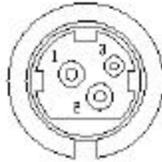
READ-EESTATUS (- s) returns status of parameters in EEPROM.

?MONO-MODEL (- s) returns model numbers of all monochromators
attached.

VI. Connector Description

POWER CONNECTOR J1

Pin#	Description
1-----	+12 VOLTS
2-----	GND
3-----	+12 VOLTS



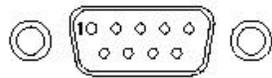
COMPUTER CONNECTOR J2

Pin#	Description
2-----	RDX
3-----	TDX
5-----	GND



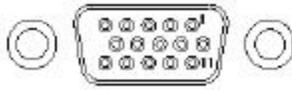
MONOCHROMATOR CONNECTORS J3 & J4

Pin#	Description
2-----	RDX
3-----	TDX
5-----	GND



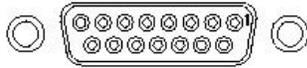
I/O CONNECTOR J5

Pin#	Description
1-----	Input# 2
2-----	GND
3-----	Input# 3
4-----	GND
5-----	Input# 4
6-----	GND
7-----	Output# 2
8-----	GND
9-----	Output# 3
10-----	GND
11-----	Output# 1
12-----	GND
13-----	Input# 1
14-----	GND
15-----	Output# 4



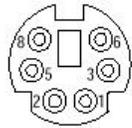
FILTER CONNNECTOR J6

Pin#	Description	Pin#	Description
1-----	Motor 1A	7 -----	Motor 2B
2-----	Motor CT	10-----	LED PWR
3-----	Motor 1B	11-----	OUT
4-----	No Connection	12-----	5 V
5-----	Motor 2A	13-----	GND
6-----	Motor CT	14-----	GND



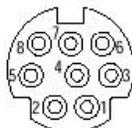
SHUTTER CONNECTORS J7 & J8

Pin#	Description
1-----	A
2-----	B



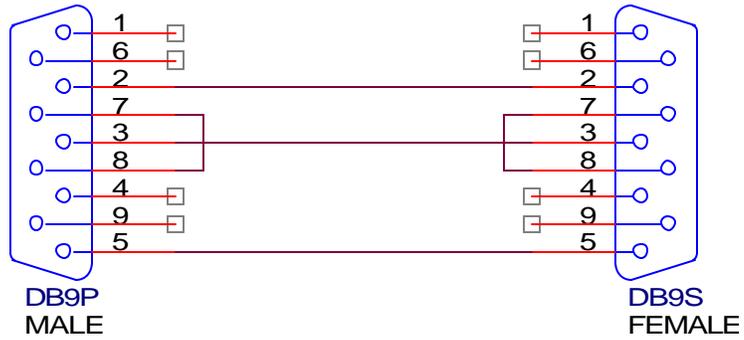
CONTROL CONNECTORS J9 & J10

Pin#	Description
1-----	+5V Digital Switched
2-----	PMT Control Voltage
3-----	+15V
4-----	Analog Ground
5-----	Photon Counting In
6-----	Digital Ground
7-----	-15V
8-----	+5V Analog



Shown below is a diagram of the cable used for communication between the NCL and the Computer COM port as well as for communication between the NCL and the SpectraPro Monochromator.

SP228
AT--SP
CC-499-2



Troubleshooting

The NCL operates from an external +12 Volt DC supply provided with the NCL at time of shipment. This +12 volts DC is converted to +5VDC digital, +5VDC analog, and +/-15VDC analog voltages internally using board mounted isolated DC to DC converters. The NCL operates using an internal 32 bit microprocessor. Shown below are a list of possible symptoms, what to check and action to take. Refer to the diagram showing test points.

<u>Symptom</u>	<u>Check</u>
1. Green power indicator LED does not come on when NCL is switched on.	<p>Make sure power supply is connected to an AC source and the power supply is connected to the NCL.</p> <p>If connected properly, check the +12V and +5V at the labeled test points on the NCL pc board.</p>
2. The SpectraSense software cannot find the NCL.	<p>Make sure amber communications light on the flashes as the NCL is turned on. Set the computer to terminal emulation mode at 9600 baud and test communications.</p>
3. SpectraSense software cannot find monochromators.	<p>Check cables from Mono1 and/or Mono2 connector to the monochromator. Be sure monochromator is on and fully initialized.</p> <p>Connect the computer in terminal emulation mode directly to the monochromator and test communications</p> <p>.</p>