



LIA-150

Dual Phase Lock-in Amplifier

- **Dual-Phase Architecture: Simultaneous Measurement at 0 deg and 90 deg Reference Phase**
- **Measurement of 0 deg and 90 deg Signal Components or Measurement of Amplitude and Phase**
- **Amplitude Measurement Independent of Reference Phase**
- **Wide Frequency Range: 10 Hz to 1 MHz**
- **Low Noise: Typical $4.5 \text{ nV}/\sqrt{\text{Hz}}$**
- **Plug-in Module for PC 386, 486 or Pentium**

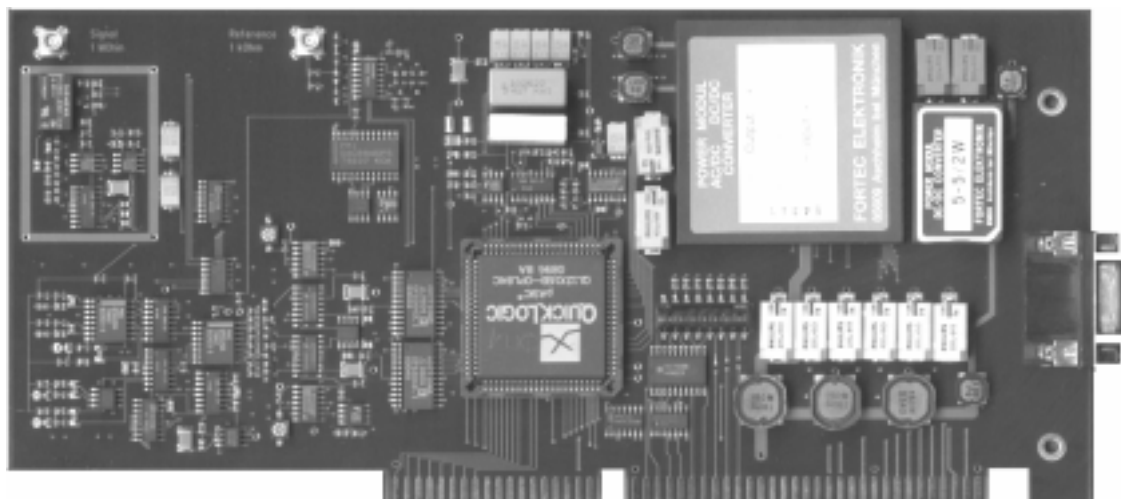


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Introduction

The LIA-150 is a complete dual phase lock-in-amplifier on a single PC plug-in card. It can be operated in the frequency range from 10 Hz to 1 MHz.

It contains a low noise preamplifier with selectable low pass and high pass filters, a reference input discriminator with adjustable threshold, a PLL which tracks the reference input frequency, two phase sensitive rectifiers for the 0° and 90° signal components, two ultra-high resolution ADCs and two combined analog / digital / software output filters.

The LIA-150 works up to a reference frequency of more than 1 MHz.

Up to four LIA-150 modules can be operated in one computer by the same software package. For experiment control an optional step motor controller card is available.

The LIA-150 software is available for Windows 3.1, Windows 95, Windows 98 and Windows NT. The software allows for measurement control, setting of measurement parameters, display and evaluation of results, loading and saving of measurement and setup data, mathematical operations on the measurement results and experiment control via the optional step motor controller STP-240. For special applications a DLL library for user programming under Borland C++ is available.

Specification

Signal Channel *

Input Impedance	1 M Ω / 30 pF*
Input Voltage Range	500 μ V to 100 mV*, other values from 50 μ V to 100 mV by display scaling factor
Input Voltage Noise	100 Hz: 9 nV / \sqrt Hz 1kHz: 6 nV / \sqrt Hz 10kHz: 4,5 nV / \sqrt Hz
Input Current Noise (100 Hz)	2 fA / \sqrt Hz
Low Pass Filter	3 MHz 1 MHz 300 kHz 100 kHz 30 kHz 10 kHz
High Pass Filter	3 Hz 10 Hz 100 Hz 1 kHz

Reference Channel *

Source	external or internal
Input Impedance (external reference)	1 k Ω *
Threshold (external reference)	-2.5 V to +2.5 V
Sensitivity (external reference)	50 mV
Threshold (internal reference)	-100 % to +100 % of input voltage range
PLL Lock Frequency	10 Hz to >1 MHz (typ. 2 MHz)
Quadrature Accuracy	5 ns

Signal Processing

Output Filter	0.01 Hz to 50 Hz
ADC Resolution	24 Bit

Operation Environment

Computer	PC 386, 486 or Pentium
Bus Connection	ISA 16 Bit
Dimensions	PC board 241 x 114 mm

* Preamplifiers available

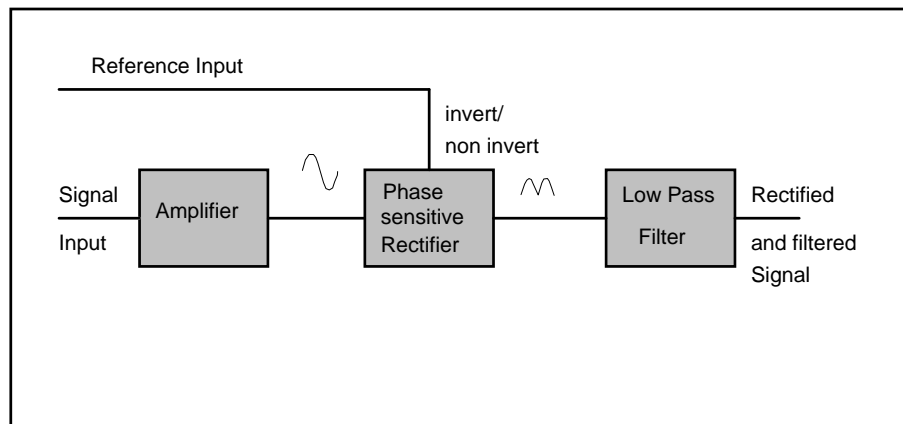
Options and Accessories

Voltage and current preamplifiers, optical detectors (PMTs and Photodiode Modules), step motor controller STP-240. Please refer to individual data sheets.

Theory of Operation

Single Phase Lock-in-Amplifier

The basic working principle of a lock-in amplifier is shown in the figure below.

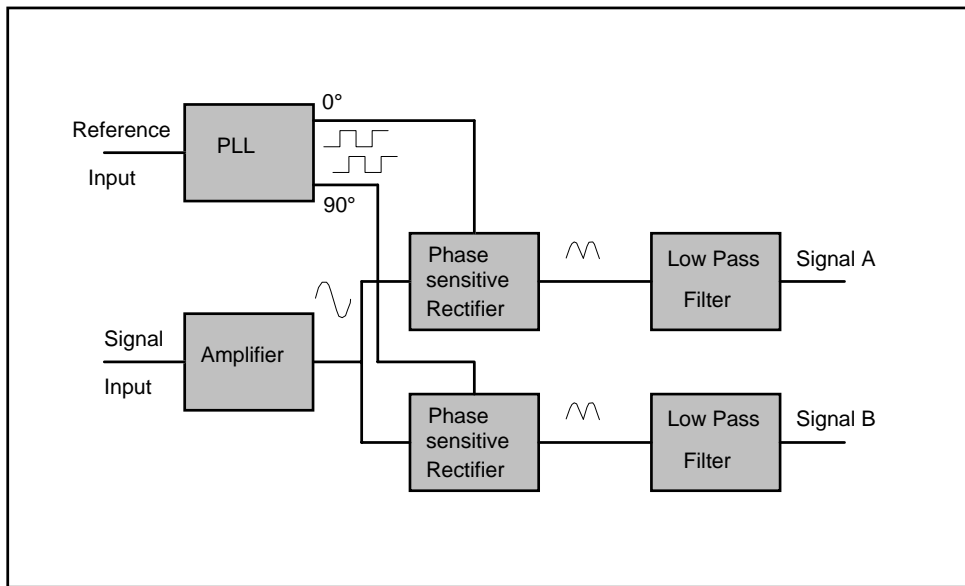


The kernel of a lock-in amplifier is the phase sensitive rectifier. This is a circuit which - dependent on a reference signal - either inverts or not inverts the input signal. If the input signal is in phase with the control signal the circuit acts as a rectifier. To remove the noise from the rectified signal the output signal of the phase sensitive rectifier is fed through a low pass filter. The lock-in amplifier acts like a filter with the bandwidth of the low pass filter centred around the frequency of the reference signal. Assume that the low pass filter has a bandwidth of 0.1 Hz (i.e. a rise time of about 3.5 s) and the reference frequency is 100 kHz. Then the system is a filter with a Q value (Bandwidth/centre frequency) of 10^6 - a value which is far beyond the reach of a conventional filter. Compared to an unfiltered measurement the SNR improves by a factor of $\sqrt{10^6} = 1000$.

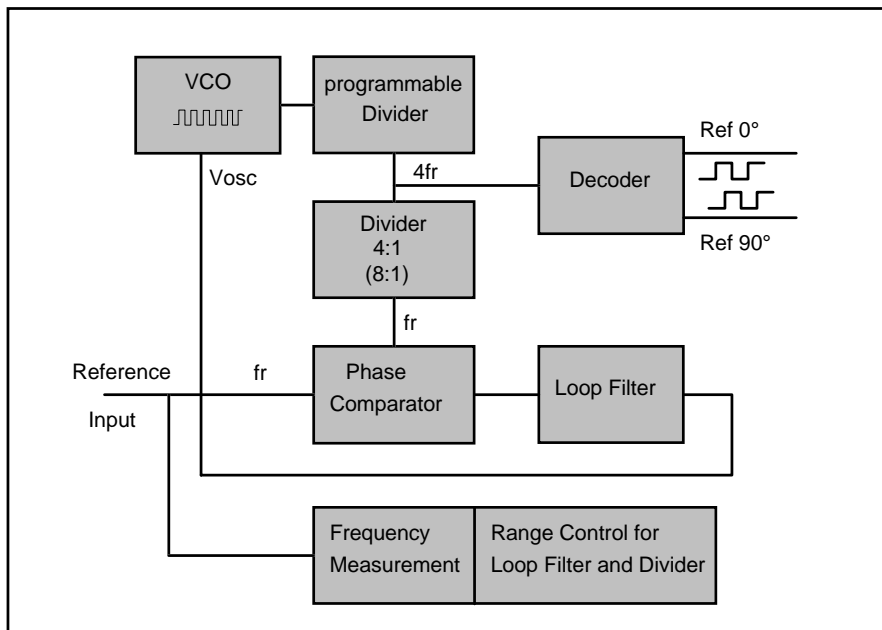
The disadvantage of the simple circuit shown in the figure above is that there is no possibility to distinguish between amplitude and phase changes. It can be used successfully if there is a stable relation between the phase of the input signal and the reference signal and the phase difference between both signals can easily be adjusted to zero. A typical application is the measurement of a light intensity in conjunction with a mechanical light chopper.

Dual Phase Lock-in Amplifier

The LIA-150 can be operated in the above described 'Single Phase' mode. However, to overcome the mentioned restrictions, it is designed primarily to work in the 'Dual Phase' mode. The principle is shown in the next figure. The basic idea of the 'dual phase' principle is to measure the input signal with two phase sensitive rectifiers which are controlled by 'orthogonal' reference signals, i.e. reference signals which have a phase difference of 90 degrees. As a result, two rectified signals are available which represent the input signal components at the two orthogonal reference phases. From these components both the amplitude and the phase of the input signal can be calculated.



Unfortunately, the generation of the two orthogonal reference signals is not a simple task. To generate these signals, a phase-locked loop (PLL) is used which creates a frequency four times greater than the input frequency. From the periods of this higher frequency the orthogonal rectifier pulse trains are derived. The principle of the PLL is shown in the next figure.



A voltage controlled oscillator (VCO) generates a frequency proportional to the control voltage V_{osc} . This frequency is divided by a programmable factor to yield a frequency $4f_r$ which is 4 times the frequency f_r of the reference input signal. This frequency is divided by a factor of four. In the phase comparator the resulting signal is compared with the reference input signal. The phase compare result is fed through the loop filter and controls the VCO. Thus the VCO frequency changes until the phase difference between both inputs of the phase comparator is zero. When the control loop has settled, the output of the programmable divider delivers a frequency of $4f_r$ which has a defined phase relation to the reference input signal. The $4f_r$ signal is used to generate the orthogonal rectifier control signals.

An interesting modification of the circuit is achieved, if the 4:1 divider is replaced by a 8:1 divider. In this case rectifier control signals are generated at twice the frequency of the reference input signal. Thus, the second harmonic of the input signal is measured.

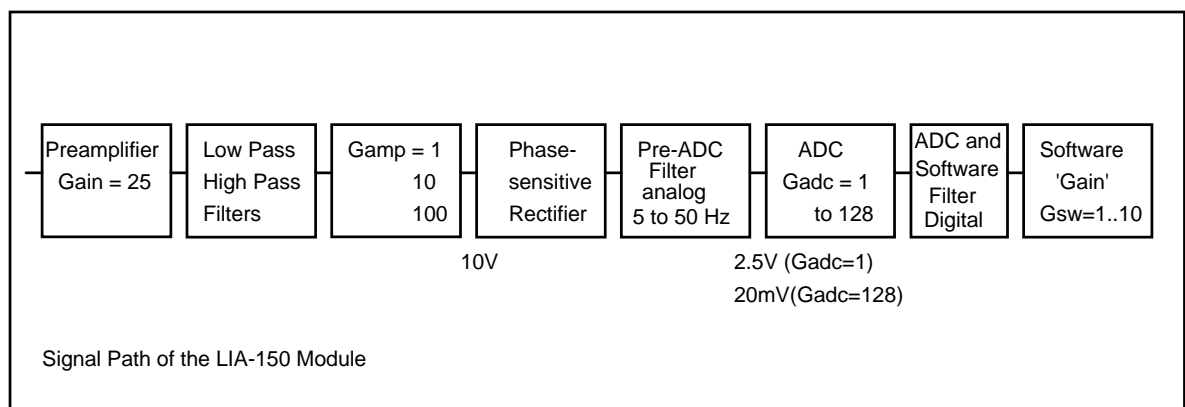
The circuit has to work in a wide frequency range (10Hz to 1MHz). This is too much to be covered by the VCO control voltage range alone. Therefore the programmable divider is used to hold the VCO frequency in the correct range. When the divider ratio is changed also the time constant of the loop filter must be changed to maintain stability of the control loop. To provide a fast divider and filter control, the frequency f_r of the reference input signal is measured. The divider and the filter are set according to the result of this measurement.

Dynamic Range Considerations

The dynamic range of a signal processing device is usually defined as the ratio of the greatest signal which is processed with an acceptable amount of distortion to the noise level or other background signals. Because both the distortion at high signal values and the noise at low signal values may depend on the system parameters or even on the shape of the signal itself, the dynamic range usually is not a fixed value. The situation is still more complicated for a device like a lock-in amplifier which achieves a considerable reduction of the noise background. Furthermore, the input signal itself may contain an amount of noise much greater than the signal. The upper limit for the input voltage thus is determined by the sum of the signal and the noise - a situation which considerably reduces the useful dynamic range of the device.

To characterise the properties of a lock-in amplifier the 'Dynamic Reserve' is used. The Dynamic Reserve is the factor by which the peaks of the signal together with the noise can exceed the average signal value without introducing distortions into the result.

The figure below shows the signal path of the LIA-150.



The input amplifier has a gain of 25. In the subsequent high pass and low pass filters noise components outside the interesting frequency range of the signal are removed. The filtered signal is amplified by a factor of 1, 10 or 100. The resulting signal is fed to the phase sensitive rectifier. At this point the useful amplitude range is $\pm 10V$. The rectified signal is filtered by a low pass filter (Filter 1) with a cutoff frequency from 5 Hz to 50 Hz (depending on the overall output filter setting). This filter removes most of the wide band noise, which is normally the dominating noise component. The rectified and filtered signal is converted in the ADC, which has a selectable gain between 1 and 128. The converted data is filtered again in a

digital filter. At the end of the signal chain, the software multiplies the data with a 'software gain' factor to adjust the overall gain to the selected input voltage range.

With respect to the dynamic reserve, three noise components must be taken into consideration.

Wide band noise is suppressed very effectively in the 'Pre-ADC' Filter in front of the ADC. Therefore, for the wide band noise only the ± 10 V amplitude window at the rectifier input is essential. As long as the noise peaks do not exceed this window, no distortion will appear.

Low frequency noise is converted by the rectifier into a noise spectrum around the reference frequency. If the reference frequency is much higher than the cutoff frequency of the pre-ADC Filter, this noise is suppressed in the pre-ADC filter as well as the wideband noise.

The narrow band noise in the range of less than ± 5 Hz to ± 50 Hz around the reference frequency is not suppressed in pre-ADC filter. It appears at the input of the ADC and must fit into the ADC input voltage range which is 20 mV to ± 2.5 V depending on the ADC gain selected.

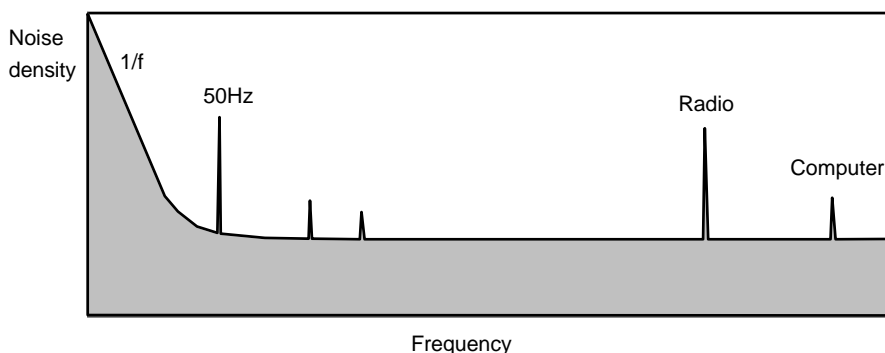
To optimise the performance of the LIA-150 depending of the noise spectrum of the signal the gain distribution in the signal chain can be changed. For each input voltage range three dynamic reserve settings are available: low, medium and high. For the 'low' settings the system gain is achieved mainly in the analog part, for the 'high' settings by the software gain factor.

To minimise errors due to internal noise and drift and to obtain a maximum ADC resolution we recommend to use the lowest acceptable dynamic reserve setting. To decide whether the dynamic reserve is sufficient, the signal at the rectifier input is monitored by a window comparator. Furthermore, the software monitors the ADC output values. A warning is displayed, if the signal exceeds the allowed amplitude range.

Input Amplifier Bandwidth

The amplifier path of the LIA-150 contains a low pass filter and a high pass filter. Both filters are used to remove noise components outside the interesting signal frequency range. Proper filtering can thus considerably improve the effective dynamic reserve of the measurement.

A noise spectrum of a typical measurement signal is shown in the figure below.



At low frequencies the '1/f' noise dominates. The 1/f noise appears in all amplifiers or detectors. Its reasons are manifold - slow exchange of trapped carriers in semiconductor oxide layers, thermal effects, vibrations or mechanical stress. At higher frequencies the noise is

mainly constant, but at discrete frequencies noise peaks appear - the line frequency and its harmonics, radio transmitters and the noise of other devices as computers, power supplies or pulsed lasers. As long as the reference frequency is well apart from ranges with a high noise density, the noise will be filtered out of the signal. The noise is, however, present in the amplifier path and increases the requirements to the dynamic reserve. Thus some simple recommendations can be given:

Restrict the bandwidth by the low and high pass filters as far as possible. Use - if possible - a high reference frequency to keep out of the $1/f$ noise range. Don't use reference frequencies near the line frequency and its harmonics and near other noise sources in your environment.

A special case are signals from photomultipliers. These signals consist of short, random pulses due to the detection of single photons. The spectrum of the PMT output current is constant up to 100 MHz or more, whereas the signal frequency can be in the kHz range. The processing of such signals does not cause any problems if proper filtering is used.

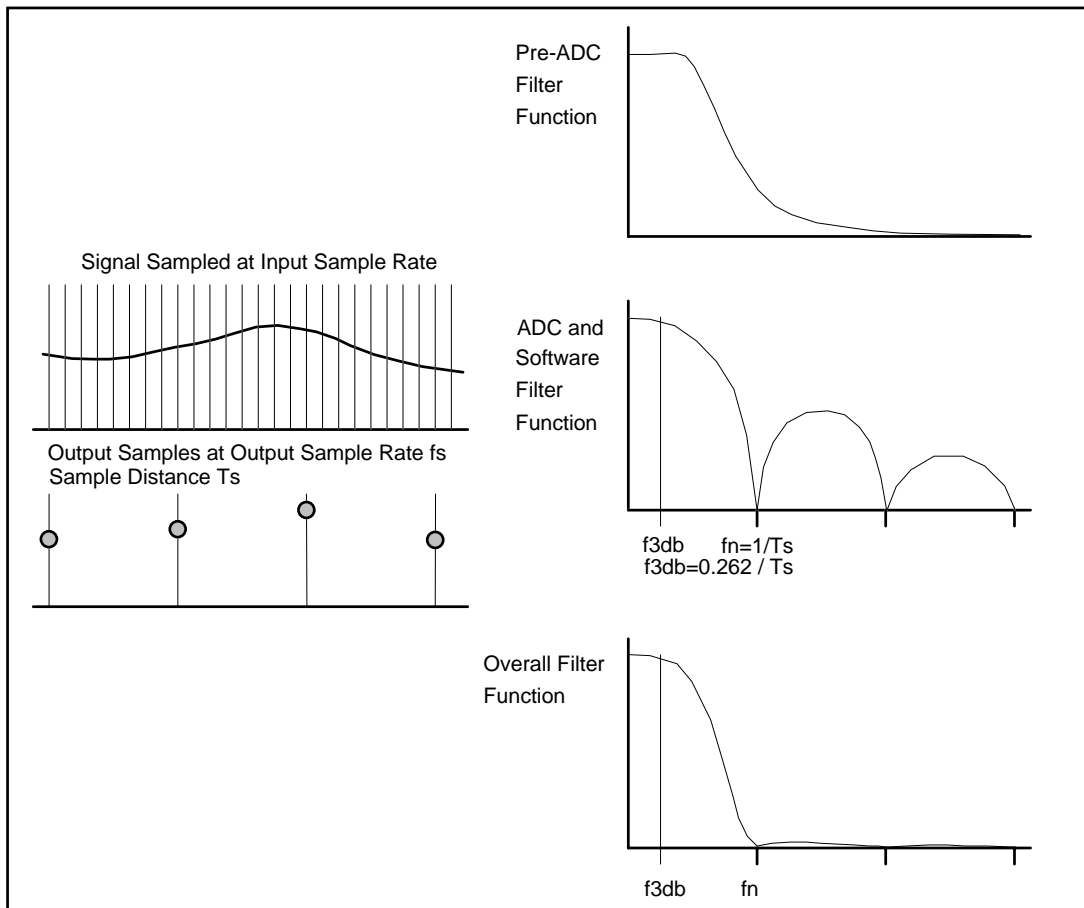
Output Filter

Output filtering in the LIA-150 is carried out in three steps. The components of the output filter characteristic are explained in the figure below.

The first step is done in an analog filter (Pre-ADC Filter) between the rectifier output and the ADC input. Due to the analog filter structure, the filter function is not very steep, but the attenuation at high frequencies is high. Therefore, the pre-ADC filter rejects most of the wide band noise from the ADC input.

The next step of filtering occurs in the ADC. The ADC samples its input voltage at an input sample rate of 19.5 kHz or more. To achieve the desired resolution a high number of input samples are averaged to yield one output sample. Thus, the ADC works as a filter with a cut-off frequency which is related to the ADC output sample rate. The filter response has a notch at $f_n = f_s$, where f_s is the ADC output sample rate. The 3 dB frequency of the filter is $f_{3dB} = 0.262 f_s$. Due to this close connection of ADC output rate and filter response both values cannot be chosen independently. The lowest filter frequency that can be achieved by the ADC is $f_n = 10 \text{ Hz}$ or $f_{3dB} = 2.62 \text{ Hz}$. To extend the filter response to lower frequencies an additional software filter is used. The software filter calculates a sliding average over a selectable number of ADC samples. The filter characteristic is the same as for the ADC, but it provides more flexibility for choosing output rate and filter frequency.

The overall output filter characteristic is the product of the pre-ADC and the ADC and software filter characteristic. Both filter functions are controlled in a way that the pre-ADC filter does not change the 3-dB frequency of the ADC filter, but suppresses the periodical bumps in the ADC filter characteristic. The result is a steep, but smooth filter with a good dynamic reserve for almost all practical relevant signal and noise spectra.



Input Signal Conditioning

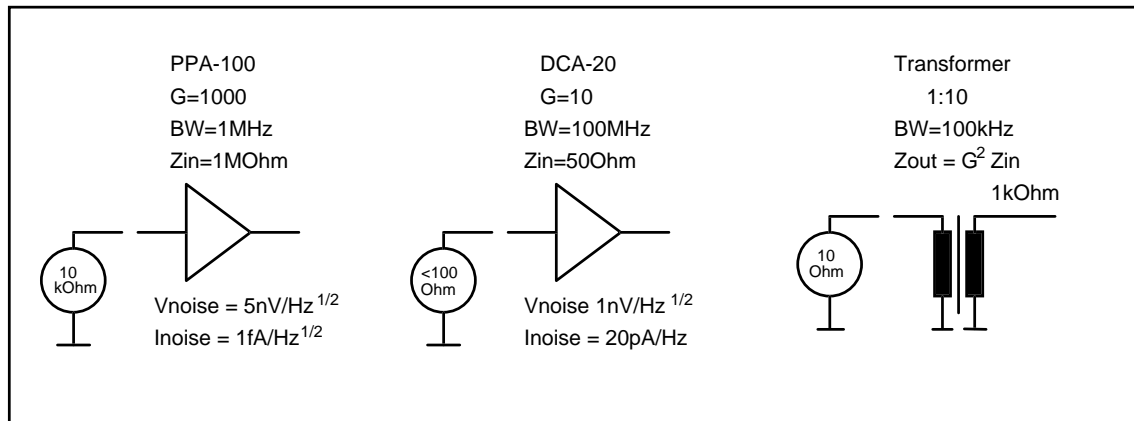
The input impedance of the LIA-150 can be approximated by $1\text{ M}\Omega$ parallel with 30 pF . Thus, low impedance signal sources (sensors with internal amplifiers, resistive strain gauges, inductive transducers) can be connected directly to the LIA-150 input without appreciable loss of signal amplitude or contribution of noise. High impedance sources (e.g. photodiodes) can be connected directly if the signal frequency is below the cutoff frequency set by the detector, cable and LIA input capacity together with the $1\text{ M}\Omega$ input resistor. To achieve optimum performance, the following considerations should be taken into account.

Low Impedance Sources

As long as the source impedance does not exceed a few $\text{k}\Omega$ the signal can be connected directly to the LIA-150 input. However, most low impedance transducers produce very low level signals. If the signal amplitude is a problem a preamplifier must be used. This amplifier should provide enough gain and introduce as little noise as possible. The input noise of an amplifier can be described by a noise voltage which adds to the input signal and a noise current which produces an additional noise voltage when it flows through the source impedance.

Some typical amplifiers with their typical noise values are shown in the figure below. Which amplifier is the best depends on the source impedance. For a source impedance below $100\ \Omega$ and signal frequencies above 10 kHz high frequency amplifiers often present a better noise

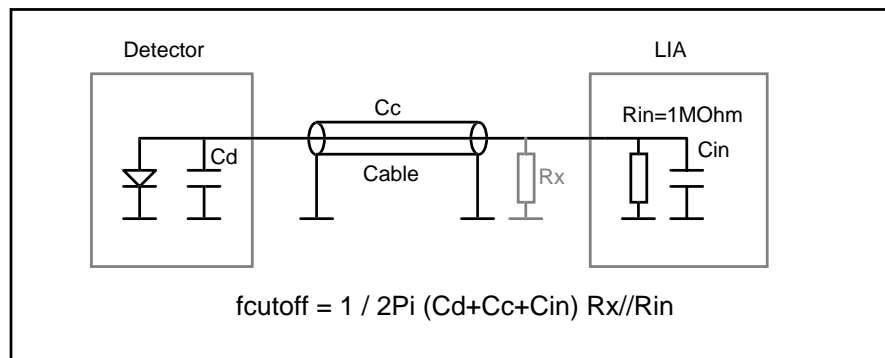
performance than typical low noise amplifiers for the kHz to 1 MHz range. For a very low source impedance a simple transformer can be the best choice.



High Impedance Sources

Voltage Amplifier

Many detectors (e.g. photodiodes) are mainly current sources. The DC source impedance can be in the order of $1\text{G}\Omega$ and more. If such a detector is connected directly to the LIA input (or any other ordinary amplifier) the bandwidth is limited by the sum of the detector capacitance C_d , cable capacitance C_c and the LIA input capacitance C_{in} together with the input resistance of $1\text{M}\Omega$. The situation is shown in the figure below.

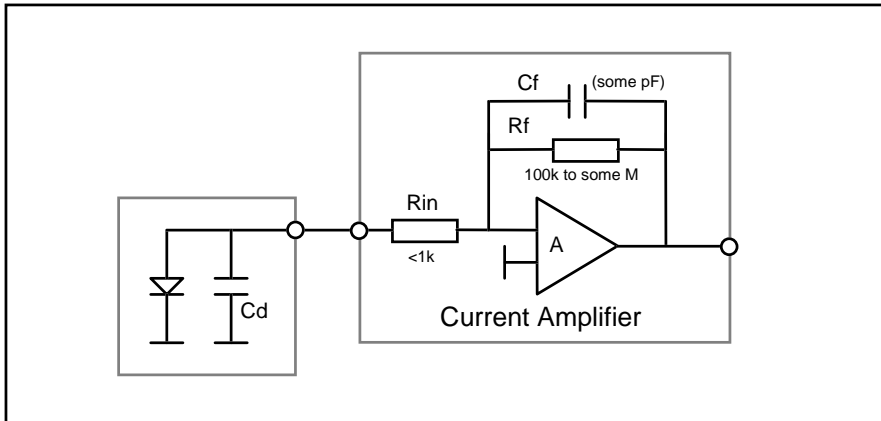


If the bandwidth is not sufficient an additional load resistor, R_x , can be connected parallel to the detector output or the LIA input. This is an acceptable solution for signal amplitudes well above the noise level of the parallel connection of R_{in} and R_x .

Current Amplifier

Another solution is the 'Current' or 'Transimpedance' amplifier. The principle is shown in the figure below.

The amplifier converts a current at the input into a voltage at the output. The 'transimpedance' gain (in V/A) is equal to R_f . C_f and R_{in} are required to maintain stability for different source impedances. The input impedance is R_{in} , normally less than $1\text{k}\Omega$. The small input impedance is particularly important for unbiased photodiode detectors which are intrinsically nonlinear unless the signal voltage is kept below some mV .

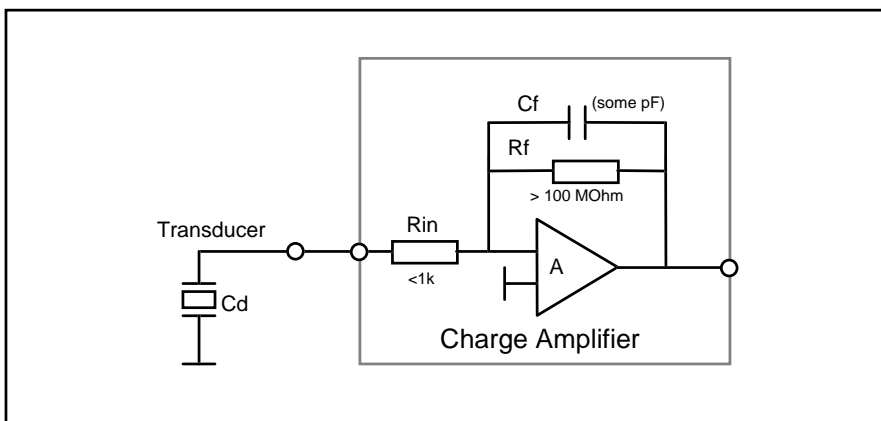


The bandwidth of the arrangement is $BW = 1 / 2\pi R_f C_f$. To achieve this value, the gain-bandwidth product of the operational amplifier A must be greater than $GBW = BW C_d / C_f$. Therefore, it is difficult to achieve a high bandwidth with a high detector capacitance C_d .

Usually - if C_d is not too high - the noise of the arrangement is dominated by the current noise of R_f , i.e. the input referred noise decreases with increasing R_f . Therefore, R_f should be not smaller than necessary to reach the required bandwidth. For high values of C_d the voltage noise of the operational amplifier (and R_{in}) becomes noticeable because it is amplified with C_d / C_f . Therefore, C_d should be kept as small as possible and the amplifier should be located close to the detector to avoid additional cable capacitance.

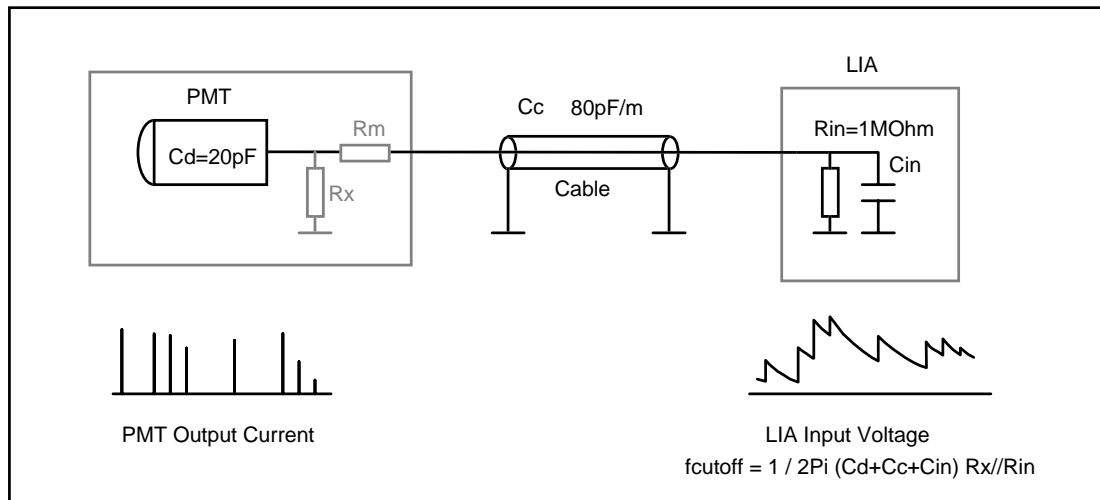
Charge Amplifier

Piezoelectric transducers convert the input signal into a proportional charge output signal. To convert the charge signal to a voltage signal, a charge amplifier is used. The structure of a charge amplifier is the same as for the current amplifier (see figure below). R_f is very high, so that the input charge is transferred into a voltage signal across C_f and consequently into a voltage at the amplifier output. Due to the high R_f , the noise behaviour of a charge amplifier is excellent. The bandwidth decreases with increasing C_d . As for the current amplifier, the amplifier voltage noise is amplified with C_d/C_f . Therefore, it is recommended to use a transducer with the lowest possible C_d (provided it delivers the same charge).



Photomultipliers

Photomultipliers (PMTs) are a special case of high impedance sources. Due to the high gain of a PMT, the output current consists of short pulses caused by the detection of single photons. The pulse duration is a few ns, and the peak current can be up to some mA. Because the average current can be very small the direct processing of the fast PMT signal causes dynamic range problems. The problem can be overcome by simply connecting the PMT to the LIA input and using a proper load resistor as shown for the voltage amplifier with a high impedance source. The effect on the signal is shown in the figure below.



The parallel resistor R_x should be chosen for a cutoff frequency of a few times the reference frequency. R_m reduces ringing in the unmatched cable and is equal to the cable impedance. It is required for long cables only. R_x and R_m should be placed directly at the PMT socket.

Do not attempt to increase the sensitivity or to reduce the noise of PMT measurements by additional preamplifiers. The gain of a PMT is so high that a single photon is seen by the LIA input. Thus, the noise is determined essentially by the statistics of the photon detection. Additional amplifiers cannot improve this situation, they can only reduce the dynamic range.

Caution: Do not connect photomultipliers to the LIA input when the high voltage of the PMT is switched on. When the PMT output is open the signal cable is charged to a voltage of several hundreds of volts. When connected to the LIA, the cable discharges into the LIA input. Although the LIA input is overvoltage protected, it may be damaged by such a maltreatment.

Installation of the LIA-150

Requirements to the Computer

The LIA-150 module and the LIA-150 software run on 386, 486 or Pentium PCs. For old 386 or 486-SX machines a coprocessor is required. To provide sufficient speed for efficient working, we recommend to use a machine with 200 MHz or more. There must be a free ISA slot to insert the LIA-150 module. The LIA software runs under Windows 3.1 / 3.11, Windows 95 / 98 or Windows NT. The computer should have at least 8 Mb memory. The LIA software requires approximately 2 MB hard disk space.

Installation of the LIA-150 Software

The installation of the LIA-150 software is simple. Select the appropriate set of installation disks (one is for WINDOWS 3.1 and WINDOWS 95 or 98, the other for WINDOWS 95/98 and WINDOWS NT). Start WINDOWS and put the installation disk into drive A or B. Call the file manager or explorer and start setup.exe from the disk drive.

The LIA software is based on 'LabWindows/CVI' of National Instruments. Therefore the so-called 'CVI Run-Time Engine' is required to run the LIA software. The 'Run-Time Engine' contains the library functions of LabWindows CVI and is loaded together with the PMM software. The installation routine suggests a special directory to install the Run-Time Engine. If the required version of the Run-Time Engine already installed for another application, it is detected by the installation program and shared with the existing LabWindows CVI applications.

The LIA-150 software is able to control up to four LIA modules at the same time. To operate more than one module, the module addresses must be different, and the address values must be declared in the LIA150.INI file (see 'Changing the Module Address'). If you purchase several LIAs for operation in one PC we deliver the modules and the LIA150.INI file in a ready-to-use configuration.

Hardware-Installation

Upgrading PCs with measurement modules sometimes causes problems such as system crashes, malfunctions of special hardware or software components or other mysterious effects. To our experience such problems normally arise from interrupt and memory conflicts between different components. Therefore, the LIA-150 module has been designed without using interrupts and direct memory access and the installation usually does not cause any problems.

To install the device, switch off your computer and put the LIA-150 module into a free slot. To avoid damage due to electrostatic discharge we recommend to touch the module at the metallic back shield first. Then touch a metallic part of the computer with the other hand. After that insert the module into a free slot of the computer.

Keep the LIA-150 as far as possible apart from loose cables or other computer modules to avoid noise pick up. When the module is installed switch on, start Windows and start the LIA software. The software performs a hardware test of the module. If there is no error message you can expect that the installation has been successful.

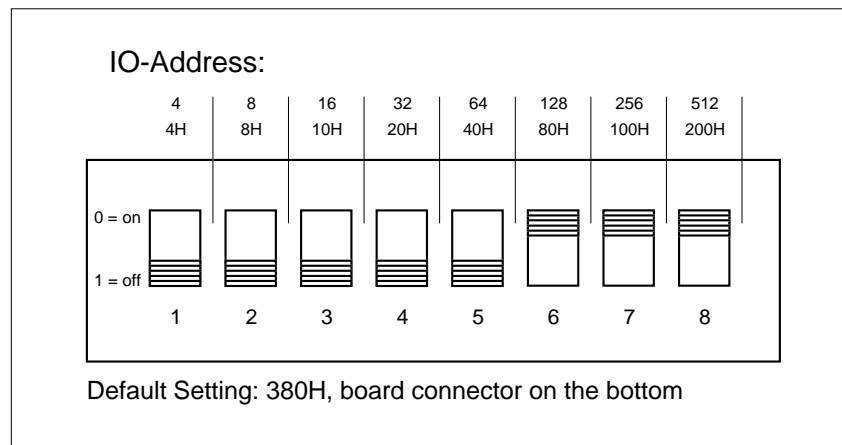
Changes of the module address of a single LIA-150 (see section below) are not normally required. For the operation of more than one LIA module in one computer the module

addresses must be different, and the address values must be declared in the LIA150.INI file (see 'Changing the Module Address'). If you purchase several LIAs for operation in one PC we deliver the modules and the LIA150.INI file in a ready-to-use configuration.

Should there be any malfunction after installing the LIA-150 either the capacity of the power supply is exceeded or - which is more probable - another module in the PC has the same I/O address as the LIA-150. In this case, please change the module address as described in 'Changing the Module Address'.

Changing the Module Address

The LIA-150 module is controlled by a block of four subsequent IO addresses. The start address of this block is the 'Module Base Address'. The module base address is set by a DIP switch on the LIA board (see figure below). The address value is switched on if the switch is in 'on' (up) position.



The software (standard software or library functions) reads the addresses of the LIA module from the configuration file LIA150.INI. Therefore, the DIP switch setting and the addresses in LIA150.INI must be the same. The LIA150.INI file can be edited with any ASCII editor (e.g. Norton Commander). It contains a first part which is common for all modules, and a module specific part. The common part is specified by the headline

```
[lia_base],
```

the module specific parts by the headlines

```
[lia_module0]
[lia_module1]
[lia_module2]
[lia_module3]
```

To activate a particular module, the correct address value must be specified in the module specific part, and the module must be activated by setting 'active=1'. If a module is not present 'active=0' should be set to avoid error messages from the hardware test during the software startup. In the table below an example is given for four LIA modules:

```
[lia_module0]
```

```
baseadr= 0x380      ;base I/O address (0 ... 0x3FC,default 0x380)
active= 1           ;module active
```

```
[lia_module1]
```

```
baseadr= 0x280      ;base I/O address (0 ... 0x3FC,default 0x280)
```

```

active= 1           ;module active

[lia_module2]
baseadr= 0x2A0     ;base I/O address (0 ... 0x3FC,default 0x2A0)
active= 1           ;module active

[lia_module3]
baseadr= 0x2C0     ;base I/O address (0 ... 0x3FC,default 0x2C8)
active= 1           ;module active

```

If you purchase several LIAs for operation in one PC we deliver the modules and the LIA150.INI file in a ready-to-use configuration.

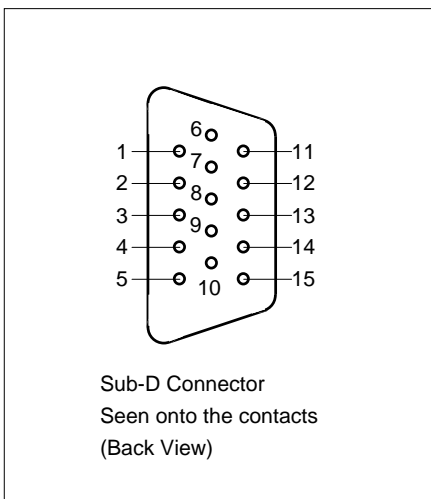
Using the LIA-150 Software without the LIA Hardware

You can use the LIA-150 software also without the LIA module. The software will display a warning that the module is not present. If you accept this warning the software will start in a special mode with the measurement being simulated. You can load, display and store data and do everything except a real measurement.

When a LIA module is present, the software can be forced into the simulation mode by typing 'hardware=0' instead of 'hardware=1' in the LIA150.INI file under 'lia_base'. A second possibility is to add the command line parameter '-s' in the command line.

Sub-D Connector: Sweep Trigger Input and Supply Voltages

For the 'Sweep Trigger' input and for the power supply of external amplifiers a 15 pin sub-d connector is provided at the PMS-300 board. The signals at this connector are described below.



Pin	Function
1	+ 5 V, max. 100 mA via 1.0 Ω
2	Not connected
3	DACOUT1 (8 bit DAC, not used by the standard software)
4	DACOUT2 (8 bit DAC, not used by the standard software)
5	GND
6	- 5 V, max. 100 mA via 1.0 Ω
7	Reserve, do not connect
8	Reserve, do not connect
9	Sweep Trigger Input (TTL)
10	+12V, max. 500 mA
11	Do not connect, -12V in other B&H devices
12	Reserve, do not connect
13	Reserve, do not connect
14	Reserve, do not connect
15	GND

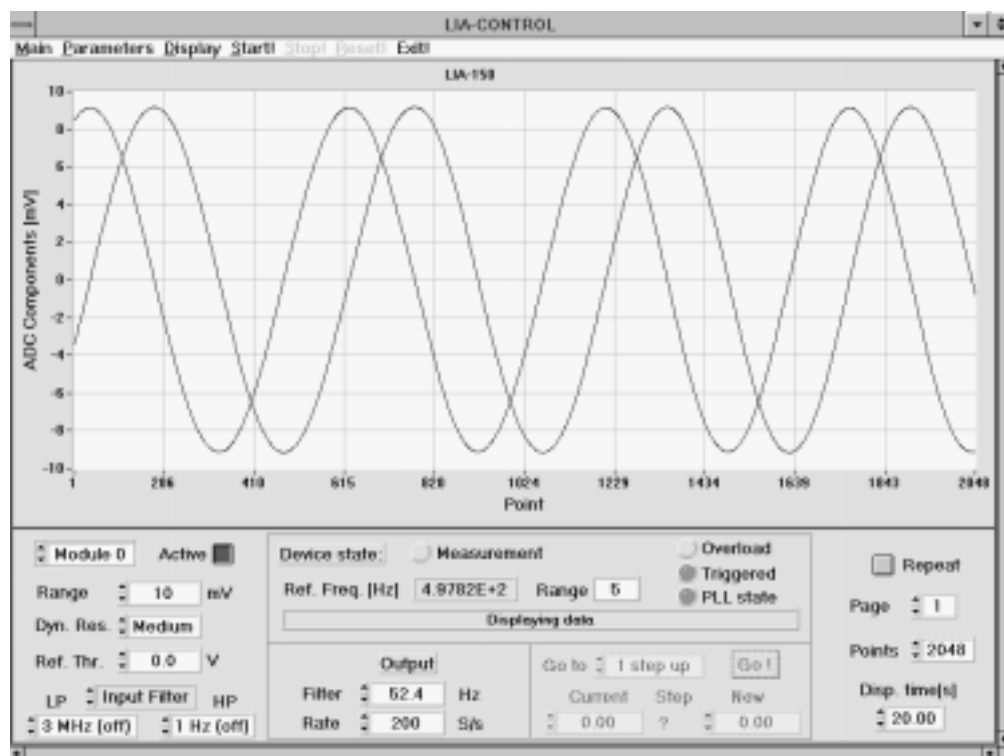
The LIA-150 Software

Two software versions are delivered with the LIA-150 module - one for Windows 3.1 and Windows 95/98, the other for Windows 95/98 and Windows NT. The LIA-150 software runs on 386, 486 or Pentium PCs. Although not absolutely required, we recommend a speed of 133 MHz or more for convenient working. The computer should have 8 Mb of memory or more. For the older 386 or 486-SX systems a mathematical coprocessor is required.

The LIA-150 software incorporates the setting of the measurement parameters, the control of the measurement, the loading and saving of measurement data and parameters, the display of the results as curves or bars and the application of mathematical operations to the result curves. Furthermore, the software is able to control a stepping motor in conjunction with our stepping motor controller card STP-240.

User Interface

After starting the LIA-150 software the main window appears. This incorporates a curve window for measurement data display, information about the present state of the module, facilities to set the measurement parameters and a menu bar to call functions as load/save, print, display with cursor movement and mathematical functions, setting of display parameters and start/stop of a measurement.



Menu Bar

The menu bar includes the following items:

Main Parameters Display Start Stop Reset Exit

Under these items the following functions are available:

Main:	Load, Save, Print
Parameters:	System Parameters, Display Parameters, Trace Parameters, Module Adjust Parameters
Display:	Curve display with cursor and zoom functions, mathematical operations
Start:	Start of the measurement
Stop:	Stop of a measurement
Reset:	Reset of a stopped measurement
Exit:	Exit from the LIA-150 software

Curve Window

In the curve window the measurement results are displayed. The display mode depends on the parameter 'points' and on the current setting of the 'Trace Parameters' and the 'Display Parameters'. At Points = 1 the results are displayed in a bar graph mode. At points > 1 the results are displayed as curves with the selected number of points.

Device State

'Device State' informs about the current state of the measurement system.

Module-Parameters

Most of the measurement control parameters are accessible directly in the main window. However, due to lack of space, some of the less important parameters had to be placed in the system parameter menu. The following parameters are available in the main window:

Range

'Range' is the full scale input voltage range. Possible values are 0.5 mV, 0.2 mV ... to 100 mV in 5-2-10 steps. Ranges smaller than 0.5 mV and intermediate full scale settings can be achieved by using the 'Limit High' and 'Limit Low' parameters in the 'Display Parameters' menu.

Dynamic Reserve

Possible values: Low, medium, high. The parameter controls the gain distribution in the signal path thus setting the amplitude reserve for fast signal or noise peaks. When changing from one input voltage range to another, the software - if possible - chooses a dynamic reserve configuration which is equivalent to the previous one.

Ref. Threshold

This parameter controls the trigger threshold for the reference input. It can be set from -2.5V to +2.5V. The resolution is 8 bit. 'Reference Threshold' should be set to be well within the reference input waveform (e.g. 1.5V for TTL signals). Triggering is indicated by the 'Triggered' light.

Input Filter: Low Pass

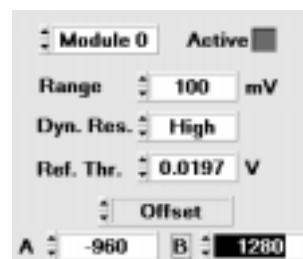
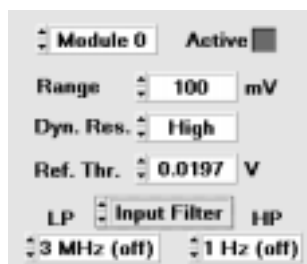
The settings refer to the low pass filter in the amplifier path. The Filter can be set to 100Hz, 1kHz, 10kHz, 100kHz, 1MHz and 'off' (approximately 3MHz). The input filter parameters are arranged in the same place with the 'offset' parameter. To toggle between 'Filter' and 'Offset' click on the 'Input Filter' or 'Offset' field (see figure below).

Input Filter: High Pass

The settings refer to the high pass filter in the amplifier path. It can be set to 'off' (approximately 1Hz), 10Hz, 100Hz or 1kHz. The filter parameters are arranged in the same place with the 'offset' parameter. To toggle between 'Filter' and 'Offset' click on the 'Input Filter' or 'Offset' field (see figure below).

Offset

Although the baseline offset of the LIA-150 is very small and usually not visible a correction is possible by the 'Offset' parameter. 'Offset' is given in ADC units and ranges from - 1 000 000 to + 1 000 000. The Offset parameters are arranged in the same place with the 'Input Filter' parameters. To toggle between 'Filter' and 'Offset' click on the 'Input Filter' or 'Offset' field (see figure below).



Output Filter

This parameter refers to the filter which processes the rectified signal. The filter frequency can be selected from 52.4 Hz to 5.24 mHz. The Output Filter setting is connected to the Output Rate setting. For each Output Filter setting several Output Rate values are available (see 'Output Rate').

Output Rate

The Output Sample Rate is connected to the Output Filter frequency. For each Output Filter setting a set of several Output Sample Rates is available (see also 'Output Filter'). The values range from 200 Hz (at Output Filter = 52.4 Hz) to 0.02 Hz (at Output Filter = 5.24 mHz).

Repeat

If the 'Repeat' push-button is pressed the measurement of the curve (with the selected number of points) is repeated and older curves are overwritten. If the Repeat push-button is not pressed, the measurement is stopped when the last curve point has been reached.

Page

The measurement data memory is divided into four pages. In each page space is provided for one measurement (signal components or amplitude and phase) with the selected number of curve points. By switching to a different page the data of several measurements can be held in the memory. Current measurement data is stored always in the selected page.

Points / Curve

Points / Curve can be set from 1 to 4096. If Points/Curve = 1 is used, the results are shown in a bar graph display. For points/curve > 1 curves are displayed.

Display Time

The measurement results are displayed automatically at the end of the measurement, i.e. when the last point of the result curves has been reached. Intermediate results can be displayed

either by switching on the 'Display after each Point' button in the 'Display Parameters' or in constant intervals defined by the parameter 'Display Time'. 'Display Time' can be set from 0.5 s to 1000 s. 'Display Time' = 0 disables the intermediate display action.

Displaying intermediate results takes some time in which the software is not able to read new samples from the LIA-150. Therefore this function should be used only at low Output Rates, for adjusting purposes or if the measurement is slowed down by long step motor actions.

Stepping Motor Control

If a stepping motor controller STP-240 is present in the system the software activates the stepping motor panel (see figure below). From this panel the motor can be controlled directly by the operator. (For automatic stepping during the measurement see 'System Parameters'.)



The stepping motor controller is configured by a configuration file. In this file the electrical and mechanical parameters of the driving system are defined. It contains the stepping frequency, start and stop ramps, duration of overvoltage pulses, end positions, the unit of the driven axis (e.g. nm for a wavelength drive) and the number of motor steps per unit. The default name of this file is STP.CFG, and a default STP.CFG file is installed together with the LIA software. Other file names can be used to switch between different configurations. The actual file name is set in the 'System Parameters'. Should there be an error message that the STP configuration file cannot be opened, please check the path to the file in the 'System Parameters'.

Device State

'Device State' informs about the current state of the measurement system. An indicator shows whether a measurement is running. The current reference frequency (from the selected source, either external or internal), the trigger condition at the reference input, the current frequency range of the PLL and its state (locked or unlocked) are displayed.

To perform a reasonable measurement, the reference input must be in the 'triggered' state (make sure that an appropriate reference signal is present and the reference threshold is adjusted correctly) and the PLL must be in the 'locked' state. For low reference frequencies, it can take some seconds until the PLL locks.

The situation in the signal path is shown by the 'Overload' indicator. If the 'Overload' indicator turns on, serious distortions may be introduced to the results. In this case either a greater input voltage range or a higher dynamic range setting should be used. However, if the input signal is noisy and the overload warning flashes occasionally at an extreme noise peak, there is no need to change the settings. Some overhead dynamic range is provided even when the 'overload' just turns on, thus no noticeable error will occur in this case.

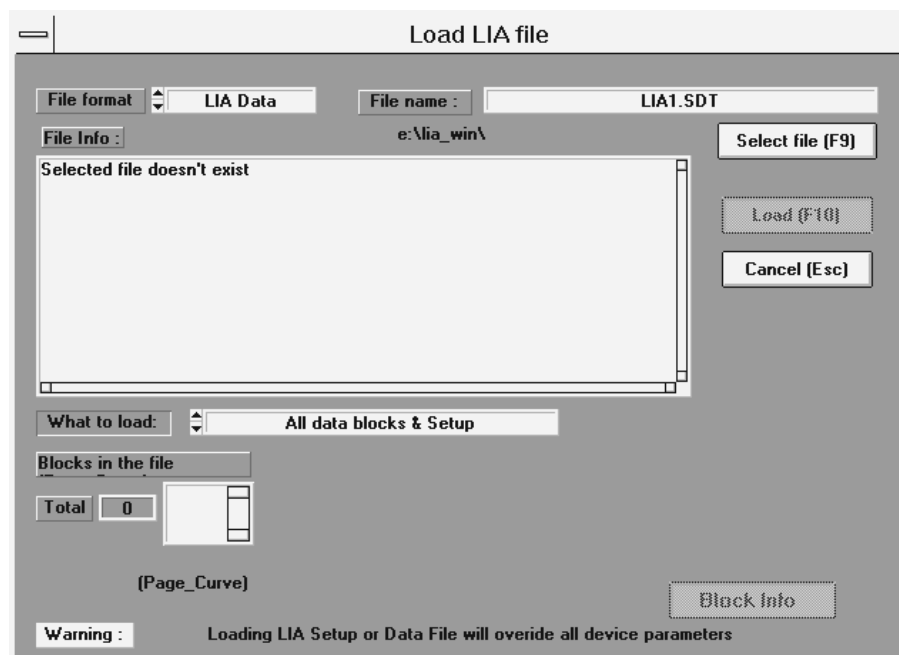
Functions in the Menu Bar

Main: Load, Save, Print

Under 'Main' the functions for loading and saving data and the print functions are available.

Load

The 'Load' menu is shown in the figure below.



In the 'Load' menu the following functions are available:

File Format

You can choose between 'LIA Data' and 'LIA Setup'. The selection refers to different file types. With 'LIA Data' files are loaded that contain measurement data and system parameters as well. Thus the complete state is restored as it was in the moment of saving.

If you choose 'LIA Setup', files are loaded that contain the system parameters only. The actual measurement data is not influenced. Files for 'LIA Data' have the extension '.sdt', files for 'LIA Setup' the extension '.set'.

File Name / Select File

The name of the data file to be loaded can be either typed in the 'File Name' field or selected from a list. To select the file from the list, 'Select File' opens a dialog box that displays the available files. These are '.sdt' files or '.set' files depending on the selected file format. Furthermore, in the 'Select File' box you can change to different directories or drives.

File Info

After selecting the file an information text is displayed that has been typed in when the data was saved.

Load (F10), Cancel (ESC)

Loading of the selected file is started by 'Load' or F10. 'Cancel' rejects the loading and closes the 'Load' menu.

Loading selected curves

To load selected curves out of a larger .sdt file you may select curve and page numbers from a list that shows the curves and page numbers available in the file. The function is used to compare the results of different measurements. Several options are available to control the source and destination of the data to be loaded:

Set all to file numbers: The data is stored to the same curves and pages as it was present in the moment when it was saved.

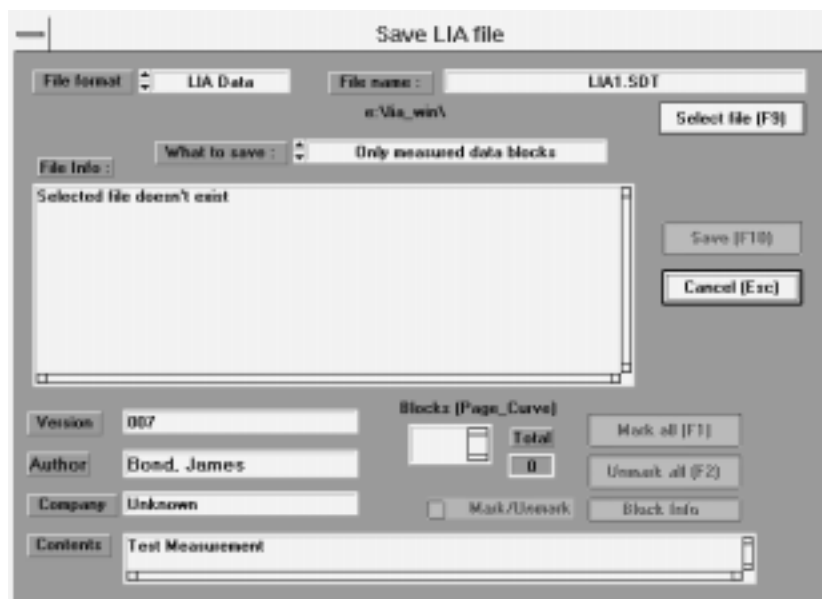
Clear all: The list of source and destination curve/page numbers is cleared.

Fit to free blocks: The data from the file is stored into free curves/pages

In any case the list of source and destination curve/page numbers can be edited to shift data into the desired location. With 'Block Info' information about the selected data block can be displayed.

Save

The figure below shows the menu for saving measurement and setup data.



In the 'Save' menu the following functions are available:

File Format

You can chose between 'LIA Data' and 'LIA Setup'. The selection refers to different file types. With 'LIA Data' files are created which contain measurement data and system parameters as well. Thus the complete state is restored when the file is loaded. If you chose 'LIA Setup' files are created that contain the system parameters only. When loading such files the actual measurement data is not influenced.

Files created by 'LIA Data' have the extension '.sdt', files created by 'LIA Setup' have the extension '.set'.

File Name

The name of the data file to which the data will be saved can be either typed into the 'File Name' field or selected from a list. To select the file from the list, 'Select File' opens a dialog box that displays the available files. These are '.sdt' files or '.set' files depending on the selected file format. Furthermore, in the 'Select File' box you can change to different directories or drives.

File Info

After selecting the file an information text may be typed into the 'File info window'. If you have selected an existing file you may edit the existing file information. When you load the file later on, this text is displayed. This will help to identify the correct file before loading.

Save (F10), Cancel (ESC)

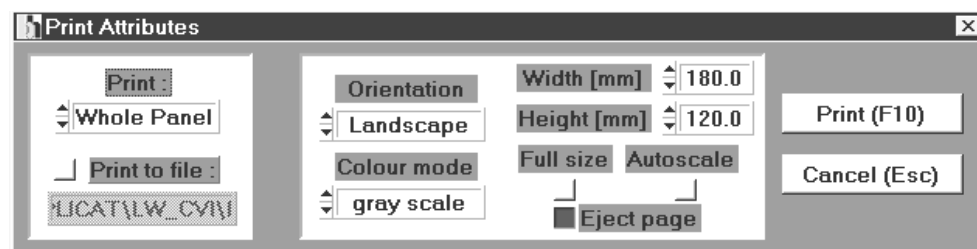
Saving of the selected file is started by 'Load'. 'Cancel' rejects the saving and closes the 'Load' menu.

Saving selected curves

Under 'What to Save' you can select between several options. You can save 'All used Data Blocks', 'Measured Data Blocks' or 'Selected Data Blocks'. In the latter case curve and page numbers can be selected from a list while information about the particular data blocks is available under 'Block Info'.

Print

The 'Print' function prints the actual screen pattern on the printer. You can print either the whole panel or the visible part only. 'Portrait' or 'Landscape' selects the orientation on the sheet. The dimensions are set by 'Autoscale', 'Full Size' or 'Size X' and 'Size Y'.



If you want to create a file of a screen pattern you can use the 'Print to File' option. However, a more convenient possibility to save a screen pattern is the 'print screen' key. When this key is pressed, Windows stores the screen pattern to the clipboard from where it can be loaded into any other program.

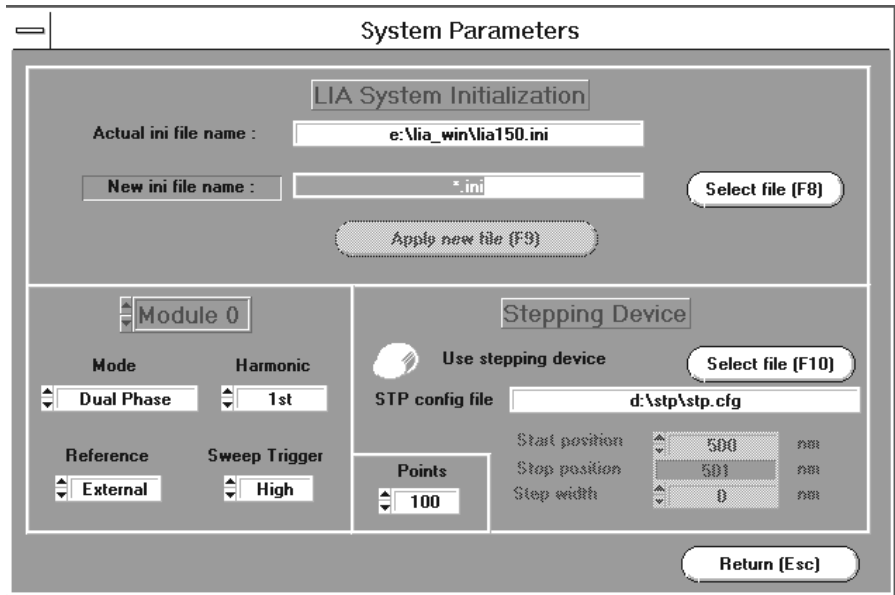
Parameters

Under 'Parameters' the System Parameters, Display Parameters, Trace Parameters and Adjust Parameters are accessible. The display parameters are used to configure the curve window and to select the scales, the trace parameters contain the colours and the memory location

('Page') of the measured or displayed curves, and the adjust parameters are used to store adjust data and manufacturing information of the module.

System Parameters

The system parameters window is shown in the figure below. Along with some module parameters which did not find place in the main menu it contains information about the system configuration including the optional step motor controller.



Configuration file names

In the System Parameters the configuration files for the LIA module and for the (optional) step motor controller are defined. The default names of these files are LIA322.INI and STP.CFG (See also Section 'Installation'). LIA.INI contains information about the LIA module and its address. STP.CFG contains the address of the (optional) step motor controller card STP-240 and its configuration (speed, overvoltage pulse duration, full step / half step mode etc.). Both files are delivered with the LIA-150 and STP-240 modules and need not be changed for standard applications. For special applications the System Parameters provide an easy possibility to switch between different system configurations.

Step motor drive

If a step motor controller STP-240 is present in the system, it is activated by the switch 'Use Stepping Device'. The start point, end point and step width can be specified inside the range defined in the configuration file (default file name STP.CFG). This file also defines the unit of the driven axis (default is nm for a monochromator drive).

Mode

Dual Phase: The signal is processed by two rectifiers which are controlled by orthogonal reference signals. The results are displayed in form of the two orthogonal signal components or as amplitude and phase.

Single Phase: Both rectifiers are controlled directly by the reference input signal (The PLL is not used in this case). The results of both rectifiers are added and displayed as a single curve.

Reference

The parameter controls the source of the reference signal. 'External' means that the reference signal comes from the reference input connector. This is the standard setting. When set to 'internal', the source of the reference signal is the measurement signal itself. In this case the reference signal is taken from the output of the last amplifier stage, i.e. from the input of the rectifiers. This setting, of course, works well only with signals which have a good signal-to-noise ratio. Furthermore, the phase measurement in the dual phase mode does not yield a meaningful result. The 'internal' setting is recommended for rough amplitude measurements only.

Harmonic

Possible settings are '1st' and '2nd'. When set to '1st' the measurement signal is rectified at reference frequency. With '2nd' the rectifiers are controlled with the frequency-doubled reference signal. Therefore, the result of the measurement shows the signal components of the second harmonic of the signal. The '2nd' setting is available in the dual phase mode only.

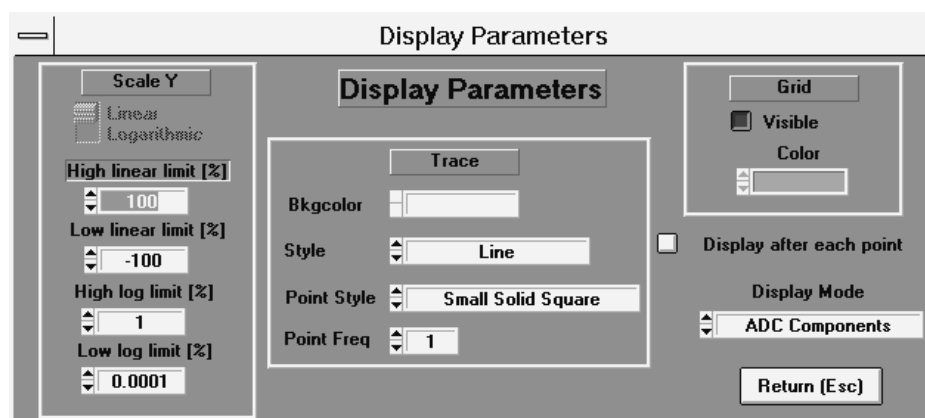
For exact analysis of the results it should be mentioned that in any case the input signal is rectified (i.e. mixed) with a square wave. Therefore, the results contain also higher harmonics of the input signal than the selected 1st or 2nd harmonic.

Sweep Trigger

This parameter applies for Point/curve > 1 only when the subsequent samples from the ADC (or from the software filter) are displayed as curves. For 'Sweep Trigger = none' the recording starts immediately after pressing the 'Start' button. For Trigger = 'low' or 'high' the device waits for a sweep trigger condition (Low or High) at the sweep trigger input (SUB-D Connector, pin 9).

Display Parameters

The display parameters control - together with the trace parameters - the style and the colours of the curve display. The display parameters window is shown in the figure below.



Scale Y

Under 'Scale Y' you can switch between a linear or logarithmic display of the curves or select a display window smaller than the selected input voltage range. Therefore, 'Scale Y' can be used to achieve an input sensitivity much higher than provided by the most sensitive input voltage range.

Linear / Logarithmic: Linear or logarithmic Y-scale
 High Linear Limit: Upper limit of the display range for linear scale
 Low Linear Limit: Lower limit of the display range for linear scale
 High Log Limit: Upper limit of the display range for logarithmic scale
 Low Log Limit: Lower limit of the display range for logarithmic scale

All limit values are given in % of the overall range.

Trace

Bkgcolor: Background colour of the curve window. For Curve colours please refer to 'Trace Parameters'
 Style: Display style of the curves. The styles 'Line', 'Points Only' and 'Connected Points' are available.
 Point Style: Display style of the curve points
 Point Freq: At values >1 each n-th point is displayed only. 'Point Freq' has no influence if 'Line' is selected.

Grid

Visible: Toggles the grid on and off.
 Color: Sets the grid colour.

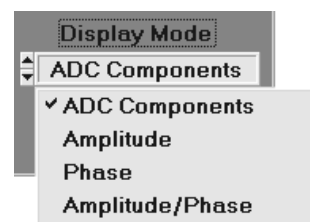
Display after each Point

The measurement results are displayed automatically at the end of the measurement, i.e. when the last point of the result curves has been reached. Intermediate results can be displayed either by setting the 'Display Time' parameter to the desired time interval or by switching on the 'Display after each Point' button. Displaying intermediate results takes some time in which the software is not able to read new samples from the LIA-150. Therefore the 'Display after each Point' function should be used only at low Output Rates, for adjusting purposed or if the measurement is slowed down by long step motor actions.

Display Mode

'Display Mode' defines the representation of the measurement results.

ADC Components: The signals of the two rectifier/ADC channels, i.e. the orthogonal signal components are displayed
 Amplitude: The signal amplitude, i.e. the quadratic sum of both orthogonal signal components is displayed
 Phase: The phase of the signal is displayed
 Amplitude/Phase: Amplitude and phase are displayed



Trace Parameters

Up to eight individual curves can be displayed in the curve window. The curves on the screen are referred to as 'traces'. In the trace parameter menu you can define which information the traces should contain and in which colour they are displayed. The displayed curves can be measured curves, calculated data or data which have been loaded from a file.

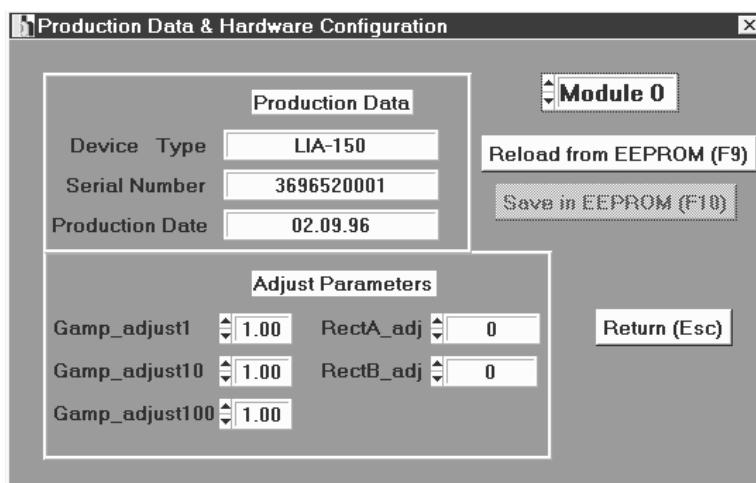


With 'active' a particular trace can be switched on or off. We recommend to switch off traces that are not needed. This will increase the speed of the display. 'Color' sets the colour of the trace.

'Page' is a partition of the memory which provides space for a complete measurement with the maximum number of curve points. Four different pages are available so that four complete measurement results can be held in the memory. By selecting 'Page' and 'Curve' the trace definition allows to display curves from different pages (i.e. different measurements) at the same time.

Adjust Parameters

Adjust values and production information are stored in an EEPROM on the LIA-150 module. The adjust values are accessible via the adjust parameters menu. To change the adjust parameters a certain knowledge about the LIA-150 hardware is required. Wrong inputs may seriously deadjust the module. Therefore you can change the adjust parameters, but not save them to the EEPROM. The changed adjust values are used by the device, but they will be replaced by the original values after reloading from the EEPROM or after restarting the LIA software.



Production Data

This area contains manufacturing information about the particular module. The information is used by the software to recognise different module versions. Please do not change these parameters.

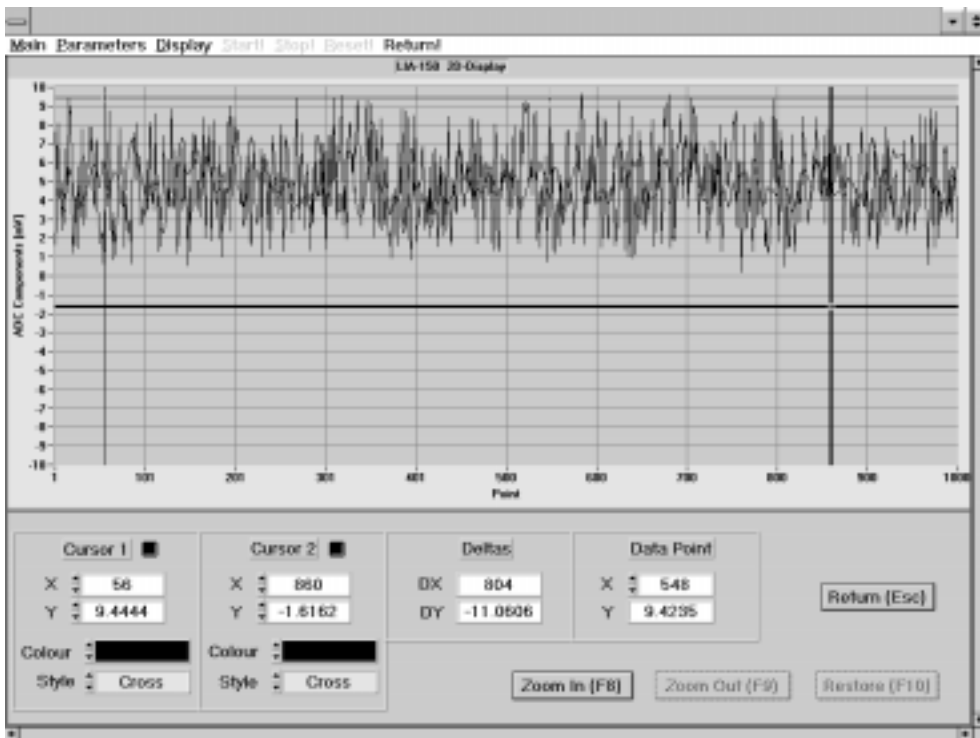
Adjust Parameters

The adjust parameter area contains gain adjust values for different preamplifier gains and offset values for the phase sensitive rectifier.

Display

Curve Display

'Curve Display' incorporates functions for inspection and evaluation of the measured data. Under 'Curve Display' the traces defined in the 'Trace Parameters' are displayed.



Two cursor lines are available to select curve points and to display the data values numerically. The scale can be changed in both axis by zooming the area inside the cursor lines.

The display style (linear/logarithmic, window limits, curve style, background and grid colours) is set in the display parameters.

When the 'Curve Display' is active, Data operations can be accomplished via the 'Display' menu and selection of 'Data Processing'. Furthermore, 'Display Parameters', the 'Trace Parameters' and the 'Print' function can be accessed directly.

Cursors

The two cursors are used to select and measure curve points and to set the range for zooming the displayed data.

With 'Style' you can select whether a cursor is a horizontal line, a vertical line or a cross of a vertical and a horizontal line. For each cursor the X-Position (vertical cursor), the Y-Position (horizontal cursor) or both (crossed line cursor) are displayed. Under 'Deltas' the differences between the cursor values are displayed. The colours of the cursors are set by 'Colors'.

The cursors can be moved with the mouse or with the keyboard. If the keyboard is used, the cursor is selected with 'page up' and 'page down' and shifted with the cursor keys. By pressing the cursor keys together with the 'shift' key a fine stepping is achieved.

Data Point

In addition to the cursors, the 'Data Point' may be used to measure data values. The data point is a small cross that can be shifted across the screen by the mouse. When the mouse key is released, the data point drops to the next true data location of the next trace. At the same time X and Y values are displayed.

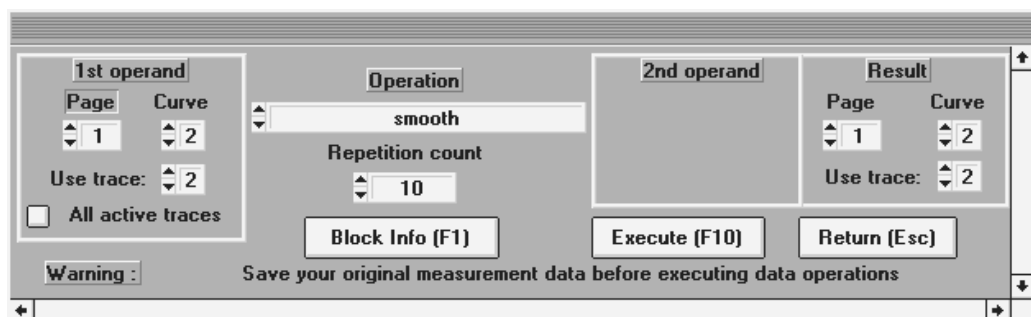
Zoom Function

'Zoom in' magnifies the area between the two cursors to the whole screen width. If the cursors are vertical lines the magnification occurs in X-direction. If the cursors are horizontal the scale is magnified in Y-direction. For crossed line cursors zooming is done in both directions stretching the rectangle between the cursor to the full screen.

'Zoom Out' restores the state before the last zooming action. This includes the zoom state as well as the other display parameters as 'linear' or 'logarithmic'. 'Restore' will restore the state as it had been when entering the 'Zoom' function.

Data Processing

When the 'Curve Display' is active, the Data Processing operations can be accessed via the 'Display' menu and selection of 'Data Processing'. In this case in the lower part of the screen the data processing window appears (see figure below). In this window the source of the operands, the operation and the destination of the result can be selected. All operations refer to the range inside the cursors.



1st operand

In this place the curve number of the first operand has to be specified. This can be done either by 'Curve' and 'Page' or by selecting one of the active traces via 'use trace'. If an active trace is selected, 'Curve' and 'Page' is set according to the values in the trace parameters. 'Curve' and

'Page' are displayed in the colour of the selected trace. With 'all active traces' the selected operation is applied to all active traces at once.

Operation

'Operation' selects the operation to be applied to the operands. To keep the result inside the data range of the measurement memory the result is multiplied by the 'Scaling Factor'. This factor can be set to any floating point number.

2nd operand

In this place the curve number of the second operand has to be specified. This can be done either by 'Curve' and 'Page' or by selecting one of the active traces via 'use trace'. If an active trace is selected, 'Curve' and 'Page' is set according to the values in the trace parameters. 'Curve' and 'Page' are displayed in the colour of the selected trace.

Result

In this place the curve number of the result has to be specified. This can be done either by 'Curve' and 'Page' or by selecting one of the active traces via 'use trace'. If an active trace is selected, 'Curve' and 'Page' is set according to the values in the trace parameters. 'Curve' and 'Page' are displayed in the colour of the selected trace.

Start / Stop / Reset

'Start' starts the measurement. At any time, the measurement can be stopped by pressing the 'Stop' button. When the measurement is stopped it can be restarted from the current state by pressing 'start' again. To start a new measurement from the 'stop' state, the 'reset' button must be pressed before starting again.

The measurement procedure depends on the setting of 'Points' and 'Repeat'. For Points = 1 only one ADC sample is taken for both channels and the results are shown as bars in the display. The measurement repeats automatically if 'repeat' is set.

For Points > 1 the ADC readout is repeated for the given number of points and the results are shown as curves. The whole procedure is repeated if 'Repeat' is set. The old curve is overwritten by the new one.

Exit

The LIA-150 software is left by 'Exit'. When the program is left, the system parameters are saved in a file 'auto.set'. This file is loaded automatically at the next program start. Thus the system will come up in the same state as it has been left. If you do not want to save the current settings you can reject saving by switching off the 'save data on exit' knob.

Data File Format

General

The data files consist of

- a **File Header** which contains structural data used to find the other parts of the file
- the **File Information** which was typed in when the file was saved
- the **System Setup Data** for hardware and software
- the **Data Blocks** containing one curve each

File Header

The LIA data files start with a file header which contains information about the location and the length of the other parts of the file. The header file variables are shown in the table below.

short	revision	software revision number
long	info offset	offset of the info part which contains general information (Title, date, time, contents etc.)
short	info length	length of the info part
long	setup_offs	offset of the setup data (system parameters, display parameters, trace parameters etc.)
short	setup_length	length of the setup data
long	data_block_offset	offset of the first data block (one data block contains one curve)
short	no_of_data_blocks	number of data blocks
long	reserved1	
short	reserved2	

File Information

This part contains the general information which has been typed in when the data was saved. The info part is stored in ASCII. An example is given below.

```
*IDENTIFICATION
ID           : _LIA Setup & Data File_
Title        : startup
Version      : 007
Revision     : 1
Date         : 10-10-1997
Time         : 12:29:01
Author       : Bond, James
Company      : Unknown
Contents     : Dye sample from Dr. No
*END
```

System Setup Data

The System Setup Data block contains all the system parameters, display parameters, trace parameters etc. It is used to set the LIA system (up to four modules and software) into the same state as it was in the moment when the data file was saved. The values are stored together with an identifier of the particular parameter. If a parameter is missing in the System Setup Data, a default value is used instead. A typical System Setup Data part is shown below.

```

*SETUP
SYS PARA BEGIN:
#PR [PR_INIFIL,S,D:\LIA\LIA150.INI]
#PR [PR_PCOL,I,1]
#PR [PR_PWHAT,I,0]
#PR [PR_PF,B,0]
#PR [PR_PFNAM,S,IMAGE.PRT]
#PR [PR_PORIE,I,1]
#PR [PR_PEJECT,B,1]
#PR [PR_PWIDTH,F,180]
#PR [PR_PHEIGH,F,120]
#PR [PR_PFULL,B,0]
#PR [PR_PAUTO,B,0]
#PR [PR_SAVE_T,I,1]
#PR [PR_REPEAT,B,1]
#PR [PR_PAGE,I,1]
#PR [PR_POINTS,I,256]
#PR [PR_DTIME,F,1]
#PR [PR_USESTP,B,0]
#PR [PR_STP_FN,S,D:\STP\STP.CFG]
#PR [PR_WL_STA,F,500]
#PR [PR_WL_STO,F,500.70001]
#PR [PR_WL_STE,F,0.1]
#DI [DI_SCALE,G,0]

#DI [DI_MAX,F,100]
#DI [DI_MIN,F,-100]
#DI [DI_LMAX,F,100]
#DI [DI_LMIN,F,9.9999997e-05]
#DI [DI_GRID,B,1]
#DI [DI_GCOL_F,G,8]
#DI [DI_GCOL_B,G,0]
#DI [DI_TRSTYL,G,0]
#DI [DI_TRNO,G,2]
#DI [DI_PSTYLE,X,9]
#DI [DI_PFREQ,G,1]
#DI [DI_2DC1,B,1]
#DI [DI_2DC2,B,1]
#DI [DI_2DC1C,I,1]
#DI [DI_2DC2C,I,5]
#DI [DI_2DC1S,I,0]
#DI [DI_2DC2S,I,0]
#DI [DI_DAES,B,0]
#DI [DI_MODE,X,0]
#DI [DI_SIZE,I,1]
#MP0 [MP_BASE,G,896]
#MP0 [MP_ACTIVE,B,1]
#MP0 [MP_RANGE,G,7]
#MP0 [MP_LFILT,G,0]

#MP0 [MP_HFILT,G,0]
#MP0 [MP_DYN_RE,G,2]
#MP0 [MP_PHASE,B,0]
#MP0 [MP_REF_SO,B,1]
#MP0 [MP_REF_TH,F,-0.01968504]
#MP0 [MP_HARM,G,1]
#MP0 [MP_O_FILT,F,13.1]
#MP0 [MP_O_RATE,F,100]
#MP0 [MP_TRIG,G,0]
#MP0 [MP_OFF_A,L,0]
#MP0 [MP_OFF_B,L,0]
SYS PARA END:
TRACE PARA BEGIN:
#TR #0 [1,15,1,1]
#TR #1 [1,12,2,1]
#TR #2 [0,7,1,2]
#TR #3 [0,4,2,2]
#TR #4 [0,5,5,1]
#TR #5 [0,6,6,1]
#TR #6 [0,10,7,1]
#TR #7 [0,8,8,1]
TRACE PARA END:
*END

```

Data Blocks

Each Data Block contains the data of one curve. The number and the location of the data blocks is contained in the file header at the beginning of the data file. Each data block starts with the block header followed by the data set.

Each data block can (but need not) be measured with different hardware parameters. Therefore, for each block a data block header is provided, which specifies the corresponding measurement parameters. Furthermore the header contains the header length, a block number, the offset of the data block from the beginning of the file, the offset to the next data block and the specific block information in the structure 'BlockInfo'.

The structure of the data block header is shown below.

short	hdr_length	length of the header in bytes
short	block_no	number of the block in the file, from 0 to no_of_data_blocks-1
long	data_offs	offset of the data block from the beginning of the file
unsigned short	data_length	length of the data block in bytes
long	next_block_offs	offset of the data block header of the next data block from the beginning of the file
long	reserved1	
BlockInfo	info	structure with specific information about the subsequent data block

The 'BlockInfo' structure of the block header contains specific information about the subsequent data block. The 'BlockInfo' structure has the following format:

char	type	0: unused 1: measured data 2: measured data from file 3: calculated data 4: simulated data
unsigned short	points	number of data points in the block
char	time[9]	time of creation
char	date[11]	date of creation
char	mod_ser_no[16]	serial number of the module
unsigned short	range	input signal range 0 (default) .. 7 - 100, 50, 20, 10, 5, 2, 1, 0.5 mV
unsigned short	lfilter	low pass input filter 0 .. 5 (default) - 100Hz, 1, 10, 100kHz, 1, 3MHz(off)
unsigned short	hfilter	high pass input filter 0(default) .. 3 - 1Hz(off), 10Hz, 100Hz, 1kHz
unsigned short	dyn_reserve	dynamic reserve 0-low (default),1-medium ,2-high
unsigned short	phase_mode	phase mode 0-dual phase (default),1- single phase
unsigned short	ref_source	reference signal source : 0 - external (default) , 1 - internal (from input signal)
float	ref_threshold	reference signal threshold [V] (-2.5V .. +2.5V , default 1.0 V)
float	ref_freq	reference frequency [Hz]
long	offset	channel offset (-10000 .. +10000)
char	reserved1	
short	reserved2	

The information in the 'BlockInfo' structure is used for the 'Block Info' function in the 'Load', 'Save' and 'Trace Parameter' menus.

The data of the block specified by the block header is stored as shown below. It follows directly after the data block header. The data is interpreted as 32-bit float values of subsequent points of the curve.

float	curvepoint[0]
float	curvepoint[1]
.	.
.	.
.	.
float	curvepoint[No of Points - 1]

Technical Support

We are pleased to support you in all problems concerning the measurement of fast electrical or optical signals. This includes the installation of the LIA-150 module, its application to your measurement problem, the technical environment and physical problems related to short time measurement techniques. Simply call us!

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