

# Lock-In-Amplifier Module



<p>Features</p>	<ul style="list-style-type: none"> <li>• <b>BNC connectors for input and output signals</b></li> <li>• <b>Rugged aluminum housing</b></li> <li>• <b>Single phase detection with X output</b></li> <li>• <b>Working frequency 50 Hz ... 120 kHz, digital phase shifter 0 ... 360°</b></li> <li>• <b>Parameter control by local switches and opto-isolated digital inputs</b></li> <li>• <b>Optional reference oscillator module available</b></li> </ul>
<p>Applications</p>	<ul style="list-style-type: none"> <li>• <b>Spectroscopy</b></li> <li>• <b>Luminescence, fluorescence, phosphorescence measurements</b></li> <li>• <b>Light scattering measurements</b></li> <li>• <b>Opto-electronical quality control</b></li> </ul>
<p>Block Diagram</p>	<p>The block diagram illustrates the internal architecture of the Lock-In-Amplifier Module. It is divided into several functional blocks:</p> <ul style="list-style-type: none"> <li><b>Input Section:</b> Includes a <b>VOLTAGE INPUT</b>, a <b>VOLTAGE OUTPUT</b>, and a <b>CURRENT INPUT</b> which is processed by a <b>Transimpedance Amplifier</b> with a gain of <math>-100\text{ kV/A}</math>.</li> <li><b>Reference Section:</b> A <b>REFERENCE INPUT</b> is processed by a <b>Reference Comparator</b> and a <b>Digital Phase-Shifter</b> (providing a phase shift <math>\Delta\phi = 0 \dots 360^\circ</math>).</li> <li><b>Signal Processing Section:</b> The main signal path consists of a <b>Progr. Gain AC-Amplifier</b>, followed by a <b>Lowpass-Filter</b> (<math>f_{LP} = 100\text{ Hz} \dots 1\text{ MHz} / 6\text{ dB}</math>), a <b>Highpass-Filter</b> (<math>f_{HP} = 2\text{ Hz} \dots 10\text{ kHz} / 6\text{ dB}</math>), and a <b>PSD</b> (Phase Sensitive Detector) block. The PSD output is filtered by another <b>Lowpass-Filter</b> (<math>t = 0.3\text{ ms} \dots 1\text{ s}</math>, <math>6/12\text{ dB/Oct.}</math>).</li> <li><b>Control Section:</b> <b>CONTROL INPUTS</b> are processed by an <b>Optocoupler Isolate Unit</b> and <b>Manual Switches</b>, both feeding into a <b>Parameter Control Unit</b>.</li> <li><b>Output Section:</b> The filtered signal is processed by a <b>Progr. Gain DC-Amplifier</b> to produce the <b>X-OUTPUT</b> (<math>R \cdot \cos(\phi)</math>). A <b>MONITOR-OUTPUT</b> is also available. The <b>X-OFFSET INPUT</b> is used for phase offset adjustment.</li> <li><b>Status Section:</b> Includes an <b>Overload Detector</b> and an <b>Unlocked Detector</b>, which provide status signals to the <b>STATUS-OUTPUT</b>.</li> </ul> <p>BS01-1032-12</p>

## Lock-In-Amplifier Module

Specifications	Test Conditions	$V_s = \pm 15\text{ V}$ , $T_A = 25\text{ }^\circ\text{C}$			
Voltage Input	Voltage input characteristic	true differential instrumentation amplifier			
	Voltage input range	3 $\mu\text{V}$ ... 1V in 1-3-10 steps (for full scale output)			
	Voltage input coupling	AC			
	Voltage input impedance	1 M $\Omega$ // 4 pF			
	Voltage input noise	12 nV/ $\sqrt{\text{Hz}}$			
	Voltage input CMRR	110 dB @ 1 kHz, 100 dB @ 10 kHz			
	Voltage input gain drift	100 ppm/K			
Current Input	Current input characteristic	transimpedance amplifier, -100 kV/A (inverting)			
	Current input range	30 pA ... 10 $\mu\text{A}$ in 1-3-10 steps (for full scale output)			
	Current input noise	0.4 pA/ $\sqrt{\text{Hz}}$			
	Current input source-capacit.	10 pF – 500 pF (recommended)			
	Current input gain error vs. Source capacitance	$C_s$	$f < 20\text{ kHz}$	$f = 50\text{ kHz}$	$f = 100\text{ kHz}$
		10 pF	< 1 %	1 %	4 %
		100 pF	< 1 %	1 %	3 %
	500 pF	< 1 %	4 %	3 %	
Signal Filter (without optional Bandpass-Module)	Signal filter lowpass (-3 dB BW)	1 MHz, 100 kHz, 10 kHz, 1 kHz, 100 Hz; 6 dB/oct. selectable per jumper			
	Signal filter highpass (-3 dB BW)	2 Hz, 10 Hz, 100 Hz, 1 kHz, 10 kHz; 6 dB/oct. selectable per jumper			
	Signal filter cutoff accuracy	$\pm 20\%$			
	Max. dynamic reserve	80 dB			
Signal Monitor Output	Signal monitor output gain	1 ... 3333 (depends on gain setting)			
	Signal monitor output voltage	$\pm 8\text{ V}$ max.			
	Signal monitor output impedance	100 $\Omega$			
	Signal monitor output current	$\pm 10\text{ mA}$ max.			
Note	When using current input with low input ranges, the monitor output may be disabled by opening the soldering jumper at the board (near JP1) to prevent from recoupling.				
Demodulator	Demodulator dynamic reserve	15 dB @ ultra stable setting 35 dB @ low drift setting 55 dB @ high dynamic setting			
	Reference Input	Reference input voltage range	$\pm 100\text{ mV}$ ... $\pm 5\text{ V}$ @ bip. mode (0 V comparator threshold) -5 V / +10 V @ TTL mode (+2 V comparator threshold)		
	Reference input impedance	1 M $\Omega$		Reference acquisition time	
		max. 2 s @ fast setting		max. 4 s @ slow setting	
Phase Shifter	Phase shifter type	digital, working frequency 50 Hz ... 120 kHz			
	Phase shifter range	0 ... + 360 $^\circ$			
	Phase shifter resolution	1.4 $^\circ$ @ $f < 60\text{ kHz}$ , 2.8 $^\circ$ @ $f > 60\text{ kHz}$			
	Phase shifter drift	<100 ppm/K			
	Phase shifter accuracy	<0.3 $^\circ$			
Time Constants	Time constant range	300 $\mu\text{s}$ ... 1 s in 1-3-10 steps			
	Time const. filter characteristic	6 dB/oct. or 12 dB/oct. switchable			

## Lock-In-Amplifier Module

Specifications (continued) Output	<p>Output channels X = in phase</p> <p>Output voltage range <math>\pm 10</math> V (@ 2 k<math>\Omega</math> load)</p> <p>Output current <math>\pm 5</math> mA max.</p> <p>Output impedance 50 <math>\Omega</math></p> <p>Output DC-stability 5 ppm/K @ ultra stable setting 50 ppm/K @ low drift setting 500 ppm/K @ high dynamic setting</p> <p>Output basic accuracy 2 % @ sinusoidal input signal</p> <p>Output voltage offset range <math>\pm 100</math> % full scale by <math>\pm 10</math> V control voltage</p> <p>Output voltage offset control- Output load impedance &gt;2 k<math>\Omega</math></p>																																			
Status Indicator LED	<p>Functions amplifier overload status reference PLL unlocked status</p>																																			
Digital Control	<p>Control input voltage low: <math>-0.8</math> V ... <math>+0.8</math> V, high: <math>+1.8</math> V ... <math>+12</math> V</p> <p>Control input current 0 mA @ 0V, 1.5 mA @ +5 V, 4.5 mA @ +12V typ.</p> <p>Digital status output voltage Active: <math>+4.5</math> V typ., Non Active: 0 V typ.</p> <p>Digital status output current 10 mA max.</p>																																			
Power Supply	<p>Supply voltage <math>\pm 15</math> Vdc ... <math>\pm 18</math> Vdc</p> <p>Supply current <math>-60</math> mA, <math>+120</math> mA</p>																																			
Case	<p>Material Aluminum anodized</p> <p>Dimension 64,4 x 105,0 x 223,0 mm (without BNC connectors)</p> <p>Weight 1000 g (2.2 lb)</p>																																			
Temperature Range	<p>Storage temperature <math>-40</math> ... <math>+100</math> <math>^{\circ}\text{C}</math></p> <p>Operating temperature 0 ... <math>+60</math> <math>^{\circ}\text{C}</math></p>																																			
Absolute Maximum Ratings	<p>Signal input AC voltage 50 V<sub>pp</sub></p> <p>Reference input voltage <math>\pm 15</math> V</p> <p>Control input voltage <math>-5</math> V, <math>+30</math> V</p> <p>Power supply voltage <math>\pm 22</math> V</p>																																			
Switch Settings	<table border="1"> <thead> <tr> <th>4 dip switch - presettings</th> <th>switch OFF</th> <th>ON</th> </tr> </thead> <tbody> <tr> <td>S1</td> <td>low drift &amp; high dynamic</td> <td>ultra stable &amp; low drift</td> </tr> <tr> <td>S2</td> <td>1-f mode</td> <td>2-f mode</td> </tr> <tr> <td>S3</td> <td>fast PLL-locking</td> <td>slow PLL-locking</td> </tr> <tr> <td>S4</td> <td>reference-input-threshold = 0 V</td> <td>reference-input-threshold = +2 V</td> </tr> </tbody> </table> <table border="1"> <thead> <tr> <th>Sensitivity setting, output DC-gain modes</th> <th colspan="3">3 output DC-gain modes are selectable:</th> </tr> <tr> <th>mode</th> <th>DC-gain</th> <th>dyn. reserve</th> <th>DC-stability</th> </tr> </thead> <tbody> <tr> <td>ultra stable</td> <td>10</td> <td>low</td> <td>high</td> </tr> <tr> <td>low drift</td> <td>100</td> <td>medium</td> <td>medium</td> </tr> <tr> <td>high dynamic</td> <td>1000</td> <td>high</td> <td>low</td> </tr> </tbody> </table> <p>If only low dynamic reserve is required, select the higher DC-stability settings. Use dip switch S1 to preselect either the two upper or the two lower DC-gain modes, then select best mode by sensitivity switch settings 0–7 or 8–F.</p>	4 dip switch - presettings	switch OFF	ON	S1	low drift & high dynamic	ultra stable & low drift	S2	1-f mode	2-f mode	S3	fast PLL-locking	slow PLL-locking	S4	reference-input-threshold = 0 V	reference-input-threshold = +2 V	Sensitivity setting, output DC-gain modes	3 output DC-gain modes are selectable:			mode	DC-gain	dyn. reserve	DC-stability	ultra stable	10	low	high	low drift	100	medium	medium	high dynamic	1000	high	low
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## Lock-In-Amplifier Module

Switch Settings (continued)

S1 = ON: sensitivity setting for full scale (= 10 V output)

ultra stable mode			low drift mode		
setting	voltage	current	setting	voltage	current
0	1 V	10 $\mu$ A	8	100 mV	1 $\mu$ A
1	300 mV	3 $\mu$ A	9	30 mV	300 nA
2	100 mV	1 $\mu$ A	A	10 mV	100 nA
3	30 mV	300 nA	B	3 mV	30 nA
4	10 mV	100 nA	C	1 mV	10 nA
5	3 mV	30 nA	D	300 $\mu$ V	3 nA
6	1 mV	10 nA	E	100 $\mu$ V	1 nA
7	300 $\mu$ V	3 nA	F	30 $\mu$ V	300 pA

S1 = OFF: sensitivity setting for full scale (= 10 V output)

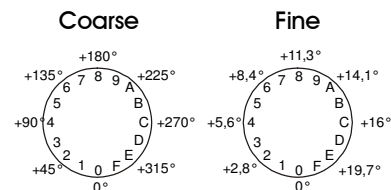
low drift mode			high dynamic mode		
setting	voltage	current	setting	voltage	current
0	100 mV	1 $\mu$ A	8	10 mV	100 nA
1	30 mV	300 nA	9	3 mV	30 nA
2	10 mV	100 nA	A	1 mV	10 nA
3	3 mV	30 nA	B	300 $\mu$ V	3 nA
4	1 mV	10 nA	C	100 $\mu$ V	1 nA
5	300 $\mu$ V	3 nA	D	30 $\mu$ V	300 pA
6	100 $\mu$ V	1 nA	E	10 $\mu$ V	100 pA
7	30 $\mu$ V	300 pA	F	3 $\mu$ V	30 pA

Time constant setting

6 dB/oct.	12 dB/oct.	time constant
0	8	300 $\mu$ s
1	9	1 ms
2	A	3 ms
3	B	10 ms
4	C	30 ms
5	D	100 ms
6	E	300 ms
7	F	1 s

Phase shift setting

Phase shift is adjusted by 2 phase switches with 8 Bit resolution. Values 0 ... 255 (Hex 00 ... FF) correspond to phase shift setting 0 ... +360  $^{\circ}$ . One step with switch marked "Coarse" changes phase shift by 22.5  $^{\circ}$ . The "Fine"-switch changes phase shift by 1.4  $^{\circ}$  - steps:



If frequency range  $f > 70$  kHz or 2-f mode is selected, the resolution of digital phase control changes to 2.8  $^{\circ}$  and the phase shift range doubles to 0 ... +720  $^{\circ}$ .

# Lock-In-Amplifier Module

Internal Jumper Settings (jumpers are accessible when top of case is removed)

Input signal filter setting

Set cut-off frequency of input lowpass filter with JP1 + JP2 (always same position) and highpass filter with JP3:

JP3	highpass	lowpass	
	-3 dB cut-off	JP1, JP2	-3 dB cut-off
3 - 4	2 Hz	1 - 2	100 Hz
1 - 3	10 Hz	3 - 4	1 kHz
2 - 4	100 Hz	5 - 6	10 kHz
3 - 5	1 kHz	7 - 8	100 kHz
4 - 6	10 kHz	none	1 MHz *

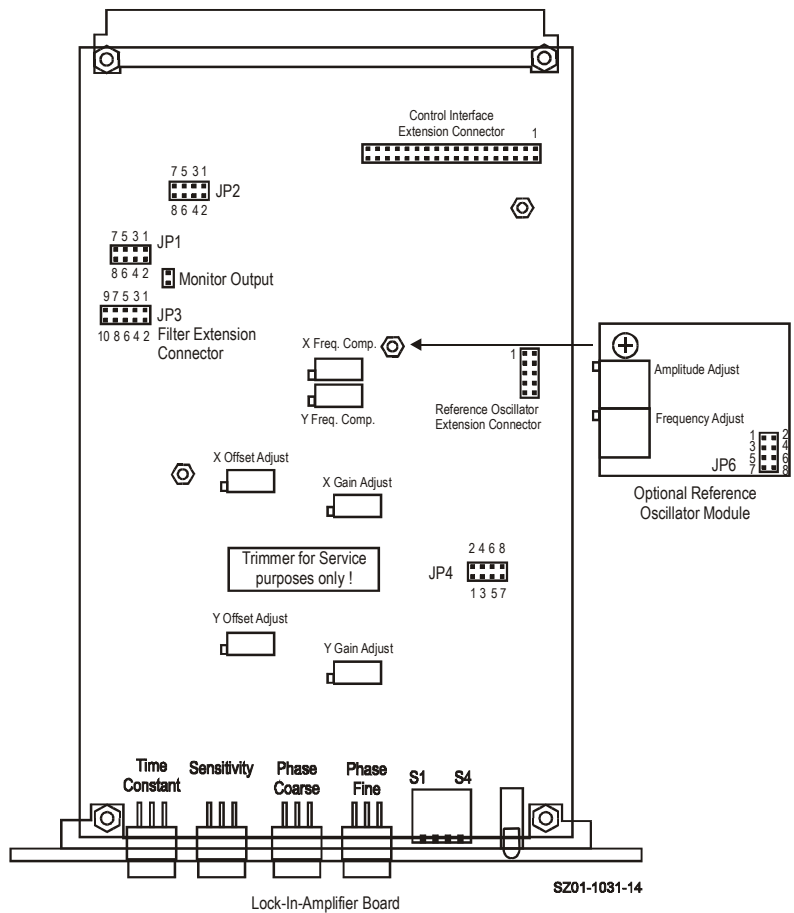
\* (At sensitivity settings 6,7 & E,F max. 200 kHz)

Frequency range selection

JP4	frequency range
1 - 2	f < 60 kHz
3 - 4 & 5 - 6	f > 60 kHz
7, 8	test pins, do not use

(if 2-f mode is used, position is always 1-2)

Internal Jumper Position Diagram (look at top of board when case is opened)




## Lock-In-Amplifier Module

Internal Connector  
(of build-in Lock-In Board)

Connector type	Euro-card DIN 41612 connector, 64 pin male, (a+c)
Input	<p>Pin C2: voltage input, non-inverting, DC-coupled</p> <p>Pin C3: voltage input, non-inverting, AC-coupled</p> <p>Pin C4: voltage input, inverting, AC-coupled</p> <p>Pin C5: voltage input, inverting, DC-coupled</p> <p>Pin C7: current input</p> <p>Pin C6: current amplifier voltage output</p> <p>Pin A2- A6: input GND</p>
Monitor output	<p>Pin C9: monitor output</p> <p>Pin A9: monitor GND</p>
Output	<p>Pin C14: X-signal output</p> <p>Pin C15: output GND</p>
Offset input	<p>Pin A10: X-offset input</p> <p>Pin A13: offset GND</p>
Status output	<p>Pin C10: unlocked status output</p> <p>Pin C11: overload status output</p> <p>Pin C17: status output GND (=power supply GND)</p>
Power supply	<p>Pin A16+C16: power supply – 15V</p> <p>Pin A18+C18: power supply + 15V</p> <p>Pin A17+C17: power supply GND</p>
Remote control inputs (opto-isolated)	<p>Pin C19: time constant (TC0)</p> <p>Pin A19: time constant (TC1)</p> <p>Pin C20: time constant (TC2)</p> <p>Pin A20: time constant slope (TCSL)</p> <p>Pin A22: sensitivity (SEN0)</p> <p>Pin C21: sensitivity (SEN1)</p> <p>Pin A21: sensitivity (SEN2)</p> <p>Pin C22: dynamic mode (DYN0)</p> <p>Pin A28: phase shift (PH0)</p> <p>Pin C28: phase shift (PH1)</p> <p>Pin A27: phase shift (PH2)</p> <p>Pin C27: phase shift (PH3)</p> <p>Pin A26: phase shift (PH4)</p> <p>Pin C26: phase shift (PH5)</p> <p>Pin A25: phase shift (PH6)</p> <p>Pin C25: phase shift (PH7)</p> <p>Pin C24: disable local switch control</p> <p>Pin A23+A24: remote control GND (common optocoupler cathode)</p>
Reference input	<p>Pin A32: reference input</p> <p>Pin A31: reference input ground</p>
Reference output (Connected only if optional oscillator module is installed)	<p>Pin A30: reference output</p> <p>Pin A17: refer. output GND (=power supply GND)</p> <p>Pin A29: reference synchronization input</p>
Standard control interface (Connected only if optional control interface module (future product) is installed)	<p>Pin C29: interface 0</p> <p>Pin C30: interface 1</p> <p>Pin C31: interface 2</p> <p>Pin C32: interface 3</p>

## Lock-In-Amplifier Module

External Connectors  
(at backside, Standard Configuration)

Signal input	Factory set to BNC, isolated (single ended)
X-output	BNC
Reference input	BNC
Power supply	Lemo® series 1S, 3-pin fixed socket (mating plug type: FFA.1S.303.CLAC52) Pin 1: +15V Pin 2: -15V Pin 3: GND
	
Control port	Sub-D 25-pin, female, qual. class 2 Pin 1: +12V (stabilized power supply output) Pin 2: -12V (stabilized power supply output) Pin 3: AGND (analog ground) Pin 4: +5V (stabilized power supply output) Pin 5: X-output Pin 6: overload status output Pin 7: unlocked status output Pin 8: disable local switch control input Pin 9: DGND (ground f. digital control pin 8 - 25) Pin 10: dynamic mode (DYN0) Pin 11: sensitivity (SEN0) Pin 12: sensitivity (SEN1) Pin 13: sensitivity (SEN2) Pin 14: time constant slope (TCSL) Pin 15: time constant (TC0) Pin 16: time constant (TC1) Pin 17: time constant (TC2) Pin 18: phase shift (PH0) Pin 19: phase shift (PH1) Pin 20: phase shift (PH2) Pin 21: phase shift (PH3) Pin 22: phase shift (PH4) Pin 23: phase shift (PH5) Pin 24: phase shift (PH6) Pin 25: phase shift (PH7)

Connector Wiring Options

General

The BNC-contractor configuration can be easily changed by setting electrical jumpers at the internal I/O-adapter card. Disconnect the power supply and open the case by loosening the two upper screws at the case front and rear side. Please pay attention to the ground connection at the backplane. Now open the case by lifting the top. The jumper options and functions are described in the following table.

## Lock-In-Amplifier Module

Connector Wiring Options,  
Jumpers on internal  
Adapter Board

Input connectors (JP1)	input wiring	jumper installed
	IN A = voltage input (single ended, AC)	" +V-IN → IN A" " GND → IN A/SHLD" " -V-IN → IN A/SHLD"
	IN A = voltage input (differential, AC)	" +V-IN → IN A" " -V-IN → IN A/SHLD"
	IN A / IN B = voltage input (2 BNC differential, AC) (OUT A cannot be used)	" +V-IN → IN A" " GND → IN A/SHLD" " -V-IN → IN B"
	IN A = current input (single ended)	" C-IN → IN A" " GND → IN A/SHLD" " -V-IN → C-OUT" " +V-IN → GND"
Output connectors (JP2)	output wiring	jumper installed
	OUT A = X-output	" X → OUT A" (JP1) "USE OUT A/NO IN B"
	OUT B = X-output	" X → OUT B"
	OUT A = Y-output	" Y → OUT A" (JP1) "USE OUT A/NO IN B"
	OUT B = Y-output	" Y → OUT B"
	OUT C = Y-output	" Y → OUT C"
	OUT A = R-output	" R → OUT A" (JP1) "USE OUT A/NO IN B"
	OUT B = R-output	" R → OUT B"
	OUT C = R-output	" R → OUT C"
	OUT B = monitor output	" MON → OUT B"
	OUT C = monitor output	" MON → OUT C"
	OUT B = unlocked output	" UNL → OUT B"
	OUT C = unlocked output	" UNL → OUT C"
	OUT B = Overload output	" OVL → OUT B"
	OUT C = overload output	" OVL → OUT C"
	OUT C = reference output	" REF-OUT → OUT C"
Reference connector (JP3)	reference wiring	jumper installed
	REF = reference input	" REF-IN → REF" (2 jumper)
	REF = reference output (reference output connected to ref. input)	" REF-OUT → REF-IN" (2 jp.) " REF-IN → REF" (2 jumper)
(Reference output only if optional oscillator module is installed)	REF = refer. sync. input (use OUT C as reference output)	" REF-SYNC → REF" (2 jp.)



## Lock-In-Amplifier Module

Remote Control Operation

General

Remote control input bits are opto-isolated and connected by logical OR to local switch setting. The 4 hexadecimal switches are 4 Bit-coded as shown in the following table:

switch code	MSB		LSB	
	Bit 3	Bit 2	Bit 1	Bit 0
0	Low	Low	Low	Low
1	Low	Low	Low	High
2	Low	Low	High	Low
3	Low	Low	High	High
4	Low	High	Low	Low
5	Low	High	Low	High
6	Low	High	High	Low
7	Low	High	High	High
8	High	Low	Low	Low
9	High	Low	Low	High
A	High	Low	High	Low
B	High	Low	High	High
C	High	High	Low	Low
D	High	High	Low	High
E	High	High	High	Low
F	High	High	High	High

For remote control a switch setting, set the local switch to "0" and select the wanted setting via the 4-bit-code at the corresponding digital inputs.

Sensitivity switch - corresponding inputs

Bit	corresponding control port input	
Bit 0	SEN0	(Pin A22)
Bit 1	SEN1	(Pin C21)
Bit 2	SEN2	(Pin A21)
Bit 3	DYNO	(Pin C22)

Time constant switch - corresponding inputs

Bit	corresponding control port input	
Bit 0	TC0	(Pin C19)
Bit 1	TC1	(Pin A19)
Bit 2	TC2	(Pin C20)
Bit 3	TCSL	(Pin A20)

Phase switch coarse - corresponding inputs

Bit	corresponding control port input	
Bit 0	PH4	(Pin A26)
Bit 1	PH5	(Pin C26)
Bit 2	PH6	(Pin A25)
Bit 3	PH7	(Pin C25)

Phase switch fine - corresponding inputs

Bit	corresponding control port input	
Bit 0	PH0	(Pin A28)
Bit 1	PH1	(Pin C28)
Bit 2	PH2	(Pin A27)
Bit 3	PH3	(Pin C27)

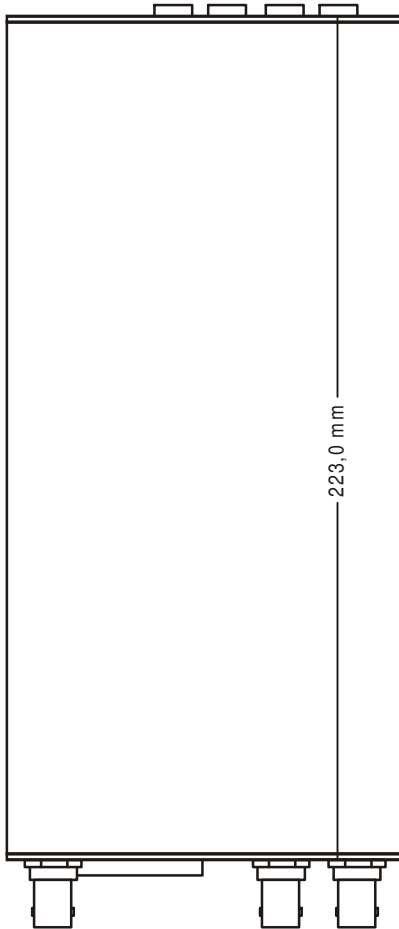
Remote control example

For example, to select a switch setting code "6", you have to connect a "high"- level signal to the corresponding control input pins Bit 1 & Bit 2. Mixed operation, e.g. local phase settings and remote controlled sensitivity setting, is also possible.

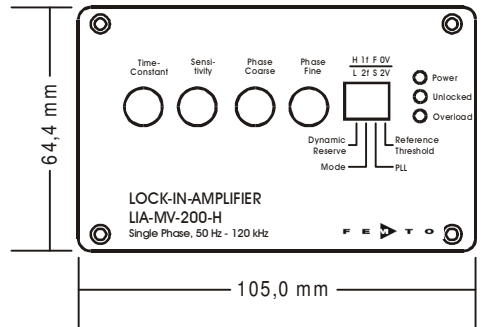
Lock-In-Amplifier Module

Dimensions

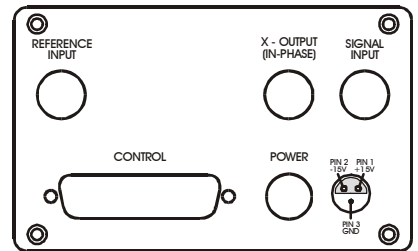
Top View



Front View



Back View



Case Material:  
Al, natural anodised

DZ01-1072-10

Optional Extensions

Reference oscillator module

Model No.: SOM-1

- frequency range 5 Hz ... 130 kHz, user adjustable
- output voltage 0 ... 2 V<sub>RMS</sub>, user adjustable
- 100 ppm/K amplitude accuracy

Factory set

1 kHz, 1 V<sub>RMS</sub>

FEMTO Messtechnik GmbH  
Klosterstr. 64  
10179 Berlin · Germany  
Phone: +49 30 280 4711-0  
Fax: +49 30 280 4711-11  
Email: info@femto.de  
www.femto.de

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