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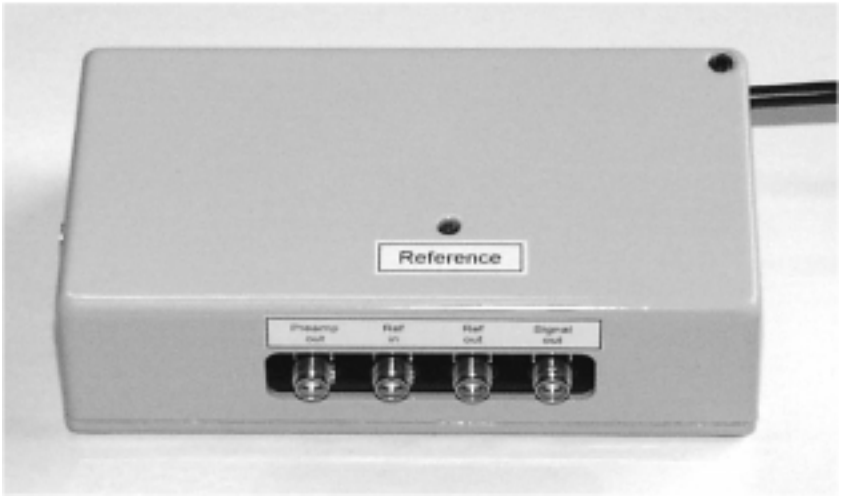
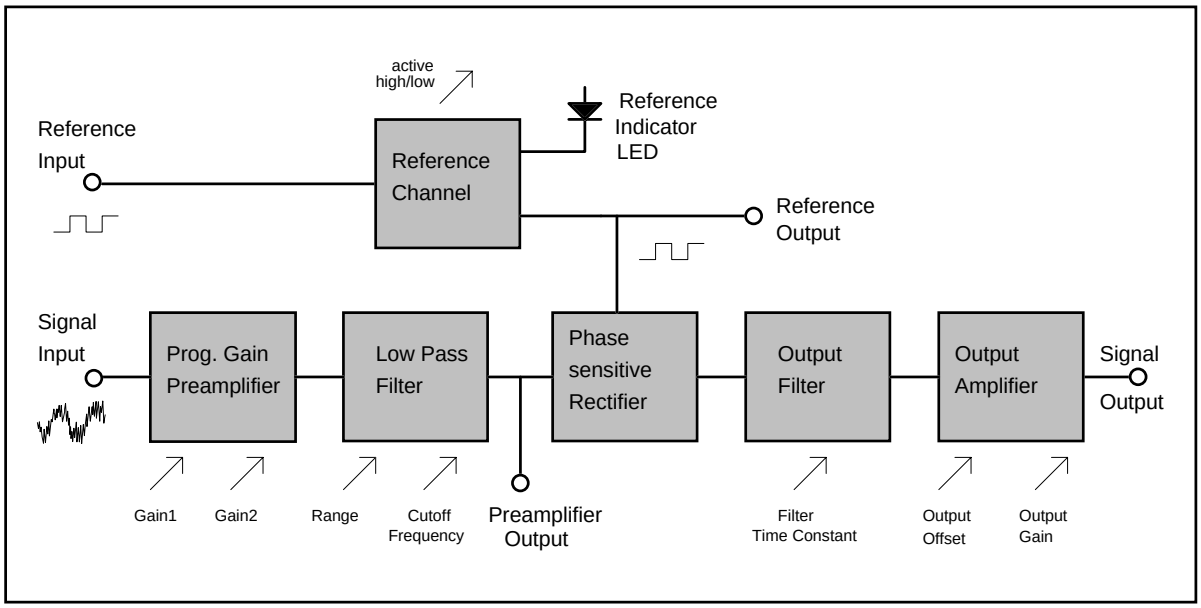
Lock-in Amplifier Module LIM-100

- **Wide frequency range: 100 Hz to >1 MHz**
- **Wide Gain Range: 200 to 200 000**
- **Low noise: 4.5 nV/√Hz**
- **Voltage Range: ± 5 V to ± 12 V**
- **Small Size: Module for Front End Applications**



Functional Description

The LIM-100 is a complete single phase lock-in-amplifier module for the frequency range from 100 Hz to 1 MHz. It contains a low noise preamplifier with an adjustable low pass filter, a TTL controlled phase sensitive rectifier, an adjustable output filter and an output amplifier with adjustable gain. A block diagram of the LIM-100 is shown in the figure below.



The preamplifier has a selectable gain of 100, 1000 or 10 000. A subsequent low pass filter is provided to suppress noise components above the interesting frequency range. Controlled by the reference signal, the phase sensitive rectifier periodically inverts the amplified input signal. For input signals components having the same frequency as the reference signal, the result is a DC signal which depends on the input signal amplitude and the phase difference between the input signal and the reference signal. Signals with other frequencies are converted into AC signals, which are suppressed in the subsequent output filter. Thus the system works as a filter / rectifier combination with a centre frequency determined by the reference signal and a bandwidth set by the output filter.
The overall gain of the LIM-100 is the product of preamplifier gain and output gain and can be as high as 200 000. To avoid overload by wideband noise, the low pass filter can be set from 1.5 kHz to 150 kHz and from 150 kHz to 15 MHz by a switch and a potentiometer. The amplified and filtered signal is available at a monitor output connector.
The reference channel accepts TTL or CMOS levels. A LED is provided to indicate whether a reference signal is present. The reference signal can be inverted by the 'active low/high' switch. This switch can be used to reverse the polarity of the output signal. The internal reference signal is available at the 'Reference Output' connector.
The output filter time constant is adjusted by a potentiometer from 30 ms to 1 s (other values available on request).
The output amplifier provides an additional signal gain from 2 to 20 (adjustable by a potentiometer). An offset adjustment is provided to compensate offsets due to amplifier offset and switching transients at high reference frequencies.

Specification

Signal Channel

Input Impedance	1MΩ / 30 pF*
Preamplifier Gain (Switch Selectable)	100 / 1000 / 10000*
Preamplifier Bandwidth	Gain = 100: 5 MHz Gain = 1000: 1.5 MHz Gain = 10000: 1.1 MHz
Low Cut-off Frequency	50 Hz*
Input Voltage Noise (Source Impedance 50Ω)	100 Hz: 9 nV / √Hz 1kHz: 6 nV / √Hz 10kHz: 4,5 nV / √Hz
Input Current Noise (100 Hz)	2 fA / √Hz
Low Pass Filter (2 Ranges Switch Selectable)	1.5 kHz to 150 kHz and 150 kHz to 5 MHz (continuously adjustable)
Output Filter Time Constant	10 ms to 1 s*
Output Amplifier Gain	2 to 20 (continuously adjustable)
Preamplifier-Out Monitor Signal	Vee + 2V to Vcc -2V, from 1 kOhm
Output Signal (1 kΩ Load)	Vee + 2V to Vcc - 2V, max. 20 mA
Output Signal (50 Ω Load, Vcc = -Vee = 12V)	± 2 V

Reference Channel

Input Impedance	100 kΩ, pull up or pull down*
Polarity (Switch Selectable)	H or L active
Threshold	TTL / CMOS
Phase Stability	< 2ns
Reference Indicator	LED
Reference Monitor Output	CMOS

Power Supply

Vcc	+5 V to +12 V
Vee	-5 V to - 12 V

Mechanical Data

Connectors	SMA
Dimensions	111 x 60 x 31 mm

* Other Values on Request - please specify

Operating Instructions

Controls

The potentiometers for the low pass filter of the preamplifier, the output amplifier gain and offset and the output filter are accessible through holes in the case. To set the switches for the preamplifier gain, the low pass filter range and the reference polarity the case of the LIM-100 must be opened. The location of the switches and potentiometers on the LIM-100 board is shown in the figure below.

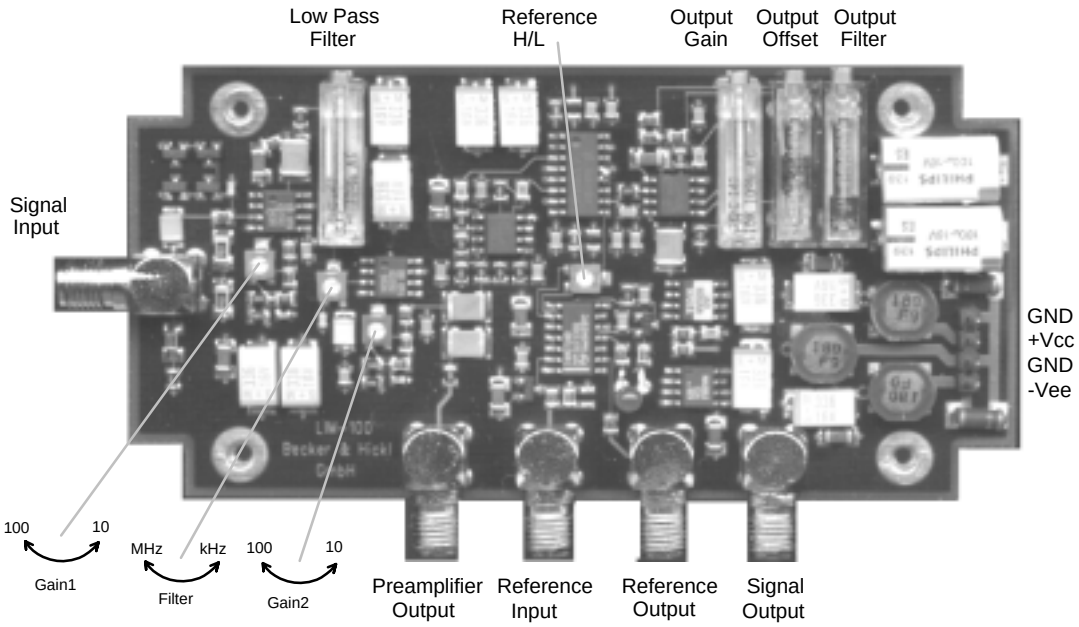


Figure 1: LIM Controls

Inputs

To operate the LIM-100, the input signal is connected to the 'Signal Input' and the reference signal to the 'Reference Input'. The internal connection of the signal input and the reference input is shown in the figure below.

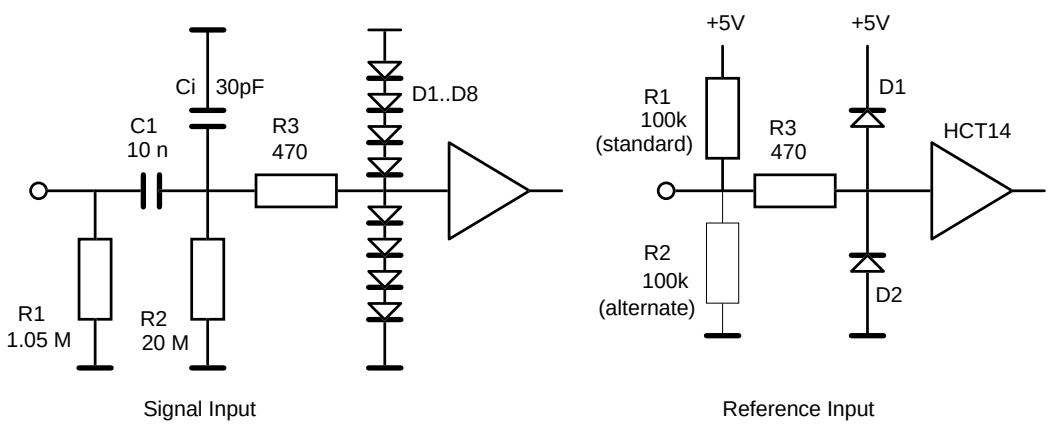


Fig. 2: Input Configuration

The signal input is shown in the left part of figure 2. C1 prevents DC signals from the amplifier input. The input impedance of the circuit is 1 MΩ parallel with 30 pF. When connecting the LIM-100 to high impedance signal sources, the high input resistance in conjunction with the input capacitance Ci (and the cable capacitance) forms a low pass filter. To avoid high frequency cut-off in these cases, an additional termination resistor is recommended. The input capacitance can, however, be utilized to reduce the crest factor of extremely fast signals (e.g. from photomultipliers).
The reference input is shown on the right of figure 2. The input accepts TTL or CMOS levels. In the standard configuration, it has a 100 kΩ pull up resistor (R1). To derive a reference signal from mechanical chopper devices, a simple fork or reflex optocoupler can be used with its output connected to the reference input. An alternate configuration uses R2 instead of R1 thus pulling down the unconnected input to the 'Low' state.
To avoid damage due to overvoltage, both inputs are protected by safety diodes. The diodes withstand a current of 1 A for 1 us. Due to the 470 Ω series resistors the inputs withstand transients up to several 100 V.

Outputs

To check gain and bandwidth of the preamplifier or the phase relationship between input and reference signal, a preamplifier and a reference output are provided. Furthermore, the reference output can be used to cascade several LIM modules by connecting one reference output to the next reference input. The reference input to output delay is approximately 15 ns. The phase shift associated with this delay is negligible in most cases.
The signal output of the LIM-100 has 50 Ω output impedance and can deliver up to 40 mA output current. If the module output is connected to a 50 Ω load, the maximum output voltage therefore is 2 V and the gain is reduced by a factor of 2.

Operating Recommendations

As long as the noise in the input signal is comparable to the signal amplitude, all you have to do is to set the desired gain and output time constant.
However, to get maximum performance from the LIM-100 with signals lost in noise or signals with a high crest factor, the following recommendations should be observed.
The worst case is a weak signal lost in a noise spectrum which is similar to the spectrum of the signal. In this case the preamplifier gain should be set to a value which just avoids saturation by the highest noise peaks. To provide maximum dynamic range, the LIM-100 should be operated with ± 12 V supplies. The preamplifier output signal should be checked by an oscilloscope and adjusted to approximately ± 5 V. To achieve the desired output voltage, the output gain has to be increased or only a fraction of the maximum output level used. With the maximum output gain of 20 and an output level of ± 5 V the 'dynamic reserve' is 20. If an output voltage of ±1 V is used the dynamic reserve is increased to 100.
Fortunately, the noise spectrum usually is much wider than the signal spectrum. In this case the noise above the signal (reference) frequency can be cut off by the low pass filter of the preamplifier. This yields an additional gain in the dynamic reserve equal to the square root of the ratio of the noise bandwidth to the signal frequency. A special case of this kind are signals from photomultipliers that consist of short, random pulses due to the detection of single photons. The spectrum of the PMT signal 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.

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 LIM-100 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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