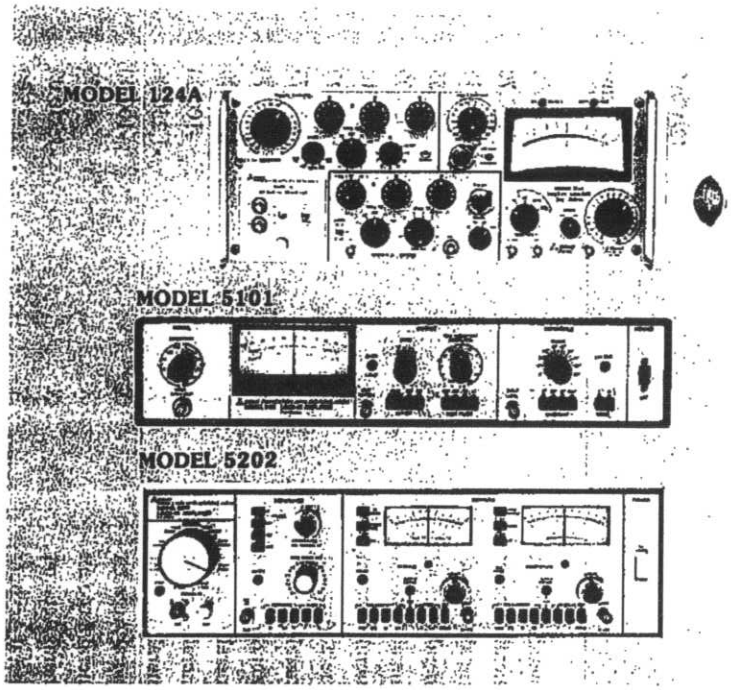
# Lock-In Amplifiers

*Lock-in amplifiers, first commercially introduced by* ***EG&G PARC*** *in 1962, are specialized ac voltmeters which accurately measure low-level signal amplitudes in the presence of high-level noise. By comparing an input signal with a reference and ignoring all components not synchronized with it, nanovolt-range signals can be measured in the presence of noise that is as much as 150 dB greater in amplitude.*




## Model 124A Precision Lock-In Amplifier

The most versatile lock-in available, the Model 124A features 1000X full scale dynamic reserve (noise overload capability) in flat mode and up to 200,000X in bandpass mode, a wide selection of low noise plug-in preamplifiers, 5 switch-selectable signal channel filtering modes, variable Q, 3 reference channel operating modes, signal monitor output, ten-turn phase control, 2 Hz-210 kHz frequency range, 21 switch-selectable calibrated voltages, 13 switch-selectable time constants (6 and 12 dB/octave rolloff rates), and overload/output stability tradeoff controls. Options include selective external reference mode (for noisy reference signals), remote programming of sensitivity, phase meter, mixer monitor, digital readout, and extended low frequency operation (0.2 Hz).

To ac-offset signals at the input of Models 124A and 126 lock-in amplifiers, users may employ EG&G PARC's Model 123 AC Zero Offset which provides a square wave of variable amplitude and phase at the operating reference frequency.

## Model 126 Lock-In Amplifier

For flexibility with economy, the Model 126 incorporates many Model 124A features. It provides a wideband signal channel yielding a flat response from 0.2 Hz to 210 kHz, 6 dB/octave low- and high-frequency rolloffs, and a unique built-in linear integration mode that can produce the original curve from derivative spectra.

The Model 126 uses the same plug-in preamplifiers as the Model 124A. Other features and characteristics include three reference channel modes, ten-turn phase control up to 370° with 0.1° repeatability, a dc output expand control, up to 1 μV full scale sensitivity, and as little as 15 ppm/K output drift (depending on output expand setting).

## Model 128A Lock-In Amplifier

The Model 128A is a low-cost instrument exhibiting excellent performance. Features include tuned signal channel and reference oscillator options, 0.5 Hz to 100 kHz operating frequency range, automatic reference tracking, a built-in low-noise differential preamp, 1 μV full-scale sensitivity, 100 dB common mode rejection and calibrated ten-turn phase shift and zero suppress controls with 0.1% repeatability.

## Model 186A Synchro-Het® Lock-In Amplifier

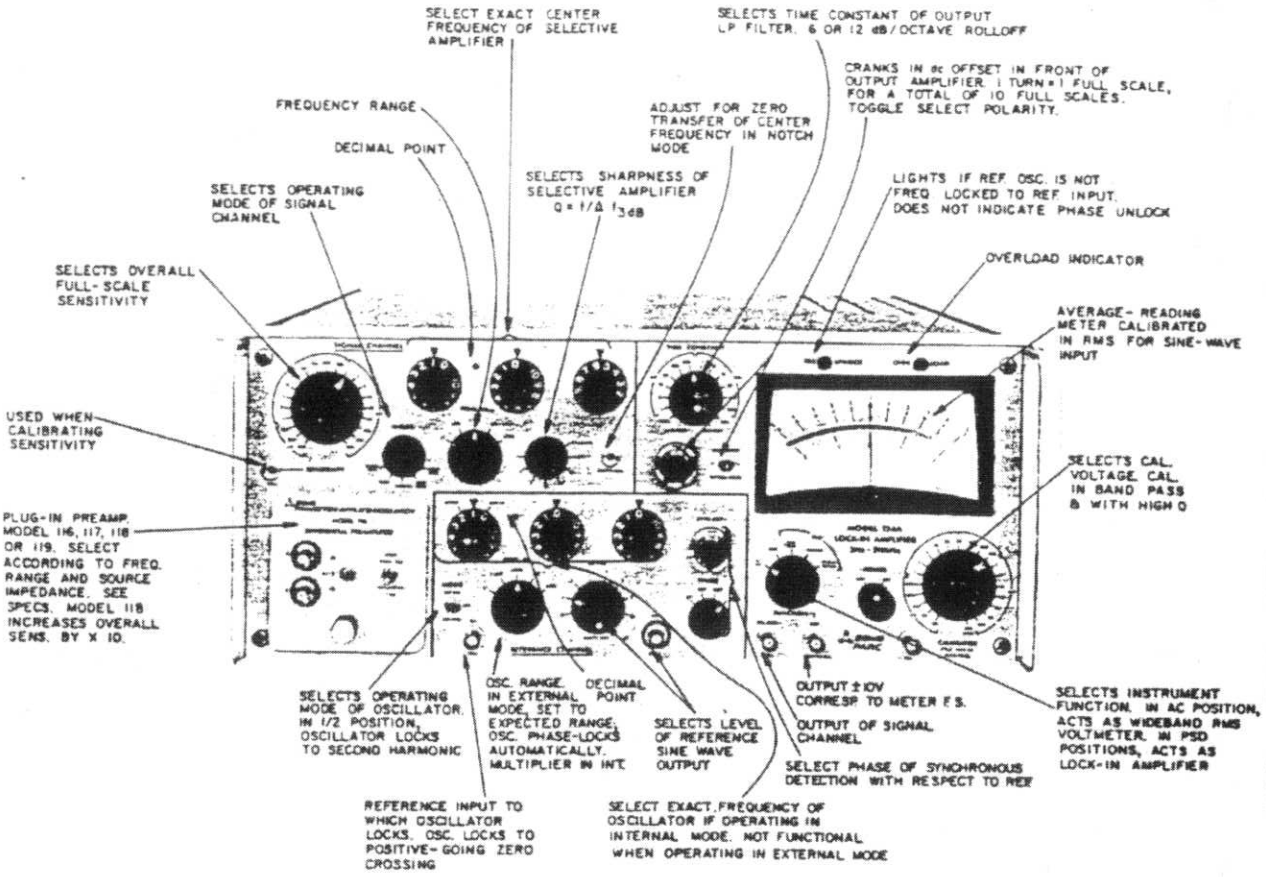
Using a patented synchronous heterodyning process, the Model 186A, in addition to operational ease, offers 0.03-30 s time constant range for fast signal response, 10 ppm/K output stability; 5 Hz to 100 kHz operating range without band switching or card changing, 100 nV full scale sensitivity, automatic signal/reference tracking, single-ended or differential input, 300,000X full scale dynamic reserve, calibrated zero suppression up to ±1000% of full scale, 370° calibrated phase adjustment with 0.1° repeatability, computer control capability, and frequency-independent dynamic reserve/output drift switching. An internal oscillator, low frequency operation and increased time constants are separate options.

## Model 5101 Lock-In Amplifier

This lock-in, incorporating many of the most desirable features of EG&G PARC's more sophisticated instruments, is a versatile and precise signal processor that is used effectively in industrial quality control, scientific research, and as a teaching tool in colleges and universities where it is used to demonstrate phase-sensitive detection. In addition to its low cost and operational simplicity, the Model 5101 features a built-in 5 Hz-100 kHz operating frequency range without band switching or card changing, automatic reference tracking, 1 μV full scale sensitivity, a built-in 2f mode, and tuned signal channel or internal oscillator options for even greater flexibility.

## Model 5202 Lock-In Amplifier

Until the introduction of the Model 5202 High Frequency Lock-In Amplifier, the signal recovery capability of synchronous detection was restricted to below 1 MHz. Operating frequency ranges can now comfortably extend



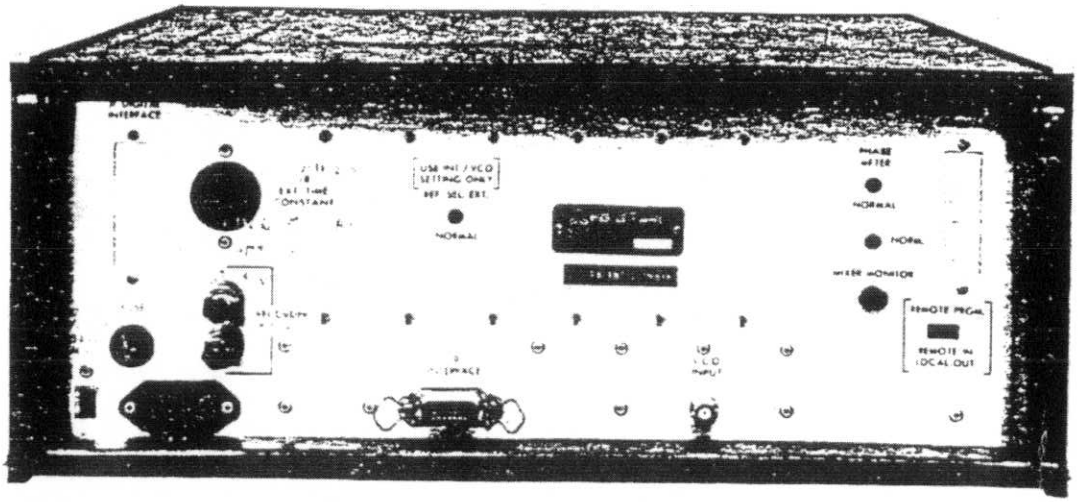



Figure I-1. MODEL 124A LOCK-IN AMPLIFIER

(1) Remove the top cover. Then turn on the power and allow a fifteen minute warmup.

(2) Set the Model 124A controls as follows.

Input Selector (Preamplifier): A
Sensitivity: 50 mV
Signal Mode: FLAT
Reference Frequency controls: NORM, 4.00, X100
Reference Mode: INT
Reference Level switch: .1 V
Reference Level vernier: fully clockwise
Phase dial: 9.00 (90°)
Phase switch: 270°
Time Constant: 300 ms (6 dB)
Zero Offset dial: 0.00 (fully counterclockwise)
Zero Offset switch: OFF (center position)
Function switch: ACVM
NORM/PHASE switch (rear panel): PHASE

(3) Connect a cable from the Reference Channel OUT connector to the Preamplifier "A" Input.

(4) Connect the oscilloscope, dc coupled, to pin 9 of the Phase board. NOTE: This board is mounted against the Signal Amplifier board shield.

(5) The signal observed at the oscilloscope should be a 400 Hz square wave. After verifying that the signal is as indicated, rotate the front-panel Reference Level vernier counterclockwise as required to make the square wave noisy.

(6) Adjust the A2 DC control (located on the Phase board) for best symmetry in the observed square wave. When best symmetry is obtained, try further reducing the Reference Output amplitude and repeat the symmetry adjustment. Repeat these two steps until no further improvement in the setting of the symmetry adjustment can be made.

(7) Before proceeding, check at pin 5 of the Phase board for a sinewave output with an amplitude of approximately 20-to-60 mV pk-pk. Then set the rear-panel NORM/PHASE switch to NORM, and adjust the Reference Level Vernier for 1 V pk-pk at the oscilloscope.

(8) Connect the oscilloscope to J3-9 (Mixer board). Then set the Sensitivity switch to 5 mV and adjust the Reference vernier for 1 V pk-pk amplitude in the observed signal.

(9) Set the Sensitivity switch to 50 mV.

(10) Adjust the A1 GAIN trim-potentiometer (located on the Phase board) for 0.1 V pk-pk amplitude in the observed signal.

(11) Set the NORM/PHASE switch back to PHASE. Then set the Model 124A Function switch to LOW DRIFT.

(12) Observing the oscilloscope, adjust the front-panel Reference Level vernier until the amplitude of the monitored sinewave is just high enough to cause both negative and positive clipping.

(13) Adjust the CLIPPING SYMMETRY trim-potentiometer, located on the Phase board, for symmetrical clipping of the observed signal. Then remove the oscilloscope.

(14) Connect the DVM (digital voltmeter) to the front-panel Function OUT connector. Then adjust the A2 AMPLITUDE trim-potentiometer (located on the Phase board) for a DVM indication of 9.00 V.

(15) Carefully set the front-panel Phase dial for peak DVM indication. Then readjust the A2 AMPLITUDE trim-potentiometer for the desired 9.00 V reading.

This completes the Phase board alignment.

## 4.4 MODEL 116, 117, OR 119 PREAMPLIFIER ALIGNMENT

To align the preamplifier, it will be necessary to use a Model 183 Remote Preamplifier Adapter with extender cable.

### 4.4A PRELIMINARY STEPS

(1) Plug the Model 183 Remote Preamplifier Adapter into the Model 124A. Then interconnect the Model 183 and the Preamplifier with the Extender Cable.

(2) Remove the two screws at the rear of the preamplifier that secure the cover. Then slide the cover back onto the cable to get it out of the way.

(3) Set the Preamplifier Input Selector to "A–B". In the case of a Model 116 or a Model 119, set the Mode selector to DIRECT.

(4) Set the Model 124A controls as follows.

Sensitivity: 500 $\mu$V
Mode: FLAT
Signal Channel Frequency
  dials: setting immaterial
  multiplier switch: setting immaterial
Q Selector: setting immaterial
Reference Channel Frequency
  dials: 4.00, NORMAL
  multiplier switch: X100
Mode: INT/VCO
Phase switch: 0°
Phase dial: 90.0°
Reference Level: 1.0 V rms
Function: NORMAL
Calibrator Output Level: setting immaterial
Power: ON

### 4.4B PROCEDURE

(1) BIAS ADJUST (R101)

(a) Connect the DVM to that end of R130 which is in common with R127 and R133.

(b) Adjust R101 (BIAS ADJUST) for a voltage indication of −5.1 V.

(2) DC ZERO (R119)

(a) Transfer the DVM to either end of R132.

(b) Adjust R119 (DC ZERO) for a voltage indication of 0.00 V.

(3) COMMON-MODE REJECTION (R136)

(a) Connect the M124A Reference Channel output to *both* the A and B inputs of the preamplifier. NOTE: If an overload indication occurs, ignore it.

(b) Monitor the signal at R132 with an ac voltmeter or sensitive oscilloscope. Then adjust R136 (COMMON-MODE REJECTION) for a null in the ac voltmeter indication.

(4) HIGH-FREQUENCY COMMON-MODE REJECTION (C109)

(a) Change the setting of the Reference Frequency controls to 10.00, NORMAL, x10k. The frequency of the applied signal will now be 100 kHz. Set the M124A Reference output level to 0.5 V.

(b) While continuing to monitor the signal at R132 with the ac voltmeter (or oscilloscope), adjust C109 for a null in the ac signal level.

(5) DC ZERO CHECK

(a) Disconnect the calibrator output from the preamplifier inputs. Also, remove the ac voltmeter from R132 and connect the DVM to this point instead.

(b) The indicated voltage should be 0 V ±50 mV. If it is not, touch up the setting of R119 as required to obtain an indicated voltage of 0.00 V.

This completes the preamplifier alignment. The preamplifier cover can now be returned to its normal position.

## 4.5 MODEL 118 PREAMPLIFIER ALIGNMENT

To align the preamplifier, it will be necessary to use a Model 183 Remote Preamplifier Adapter with extender cable.

### 4.5A PRELIMINARY STEPS

Perform steps 1 through 4 inclusive of the procedure outlined in Subsection 4.4A.

### 4.5B PROCEDURE

(1) DC ZERO (R105 and R133)

(a) Connect the DVM to R125.

(b) Adjust R105 (DC ZERO) for an indicated voltage of 0.0 V.

(c) Alternate the voltmeter between resistors R125 and R144, and adjust R133 (DC ZERO) until the voltage at both points is the same.

(d) Readjust R105 (DC ZERO) for 0.0 V at R125.

(2) COMMON-MODE REJECTION (R130) AND RC BAL (R103)

(a) Set the Sensitivity to 1 mV. Then connect the M124A Reference output to *both* the A and B preamplifier inputs. Reduce the frequency to 40 Hz.

(b) Monitor the signal at R125 with the ac voltmeter. Then alternately adjust R130 (CMR ADJ.) and R103 (RC BAL) for a null in the measured signal level. Continue until no further improvement in the null can be obtained.

This completes the preamplifier alignment.

# APPENDIX C

## PREAMPLIFIER OVERLOAD DETECTION

One difference between the Model 124A and the earlier Model 124 is that the preamplifier overload sensing is done at a different point. In the Model 124, this sensing was done at the Selective Amplifier circuit board. In the Model 124A, the sensing is done at the preamplifier. As a consequence of this change, all plug-in preamplifiers supplied with the Model 124A differ from those supplied with the Model 124. The new-type preamplifiers can be identified by a small "x" located in the upper left-hand corner of the label at the rear of these instruments.

Proper preamplifier overload sensing is obtained if a new-type preamplifier is operated in conjunction with either a Model 124 or a Model 124A. Preamplifier output overload sensing is lost, however, if an old-type preamplifier is operated with a Model 124A. On two counts, this is not as serious as it may at first seem. First of all, the selective amplifier overloads first on most sensitivity ranges. The only ones where preamplifier overload can take place first are those for which the selective amplifier gain is X1 (least sensitive ranges; see Table V-1). Second, it is a simple matter to convert an old-type preamplifier to a new-type preamplifier. On the Models 116, 117, 118, 119, and 185, one need only connect two diodes (IN4009) to the blue-ribbon connector at the rear of the instrument. The diodes are connected inside the preamplifier as follows. One diode is connected from pin 11 (anode) to pin 14 (cathode). The other is connected from pin 10 (cathode) to pin 14 (anode). Nothing more is required.

In the case of the Model 184, the situation is a bit more complicated because an attenuator must be installed as well. The attenuator is formed by connecting a 4.02 kilohm resistor in series with a 2 kilohm resistor (both resistors 1%). The free end of the 4.02 kilohm resistor is connected to the junction of R216 and R217. The free end of the 2 kilohm resistor is connected to ground #1 (this is the ground bus to which the various bypass capacitors, C205, C210, C208, are returned). The diodes are connected to connector pins 10 and 11, the same as for the other preamplifiers. However, instead of returning the free ends of the diodes to pin 14, they are connected instead to the junction of the two attenuator resistors.