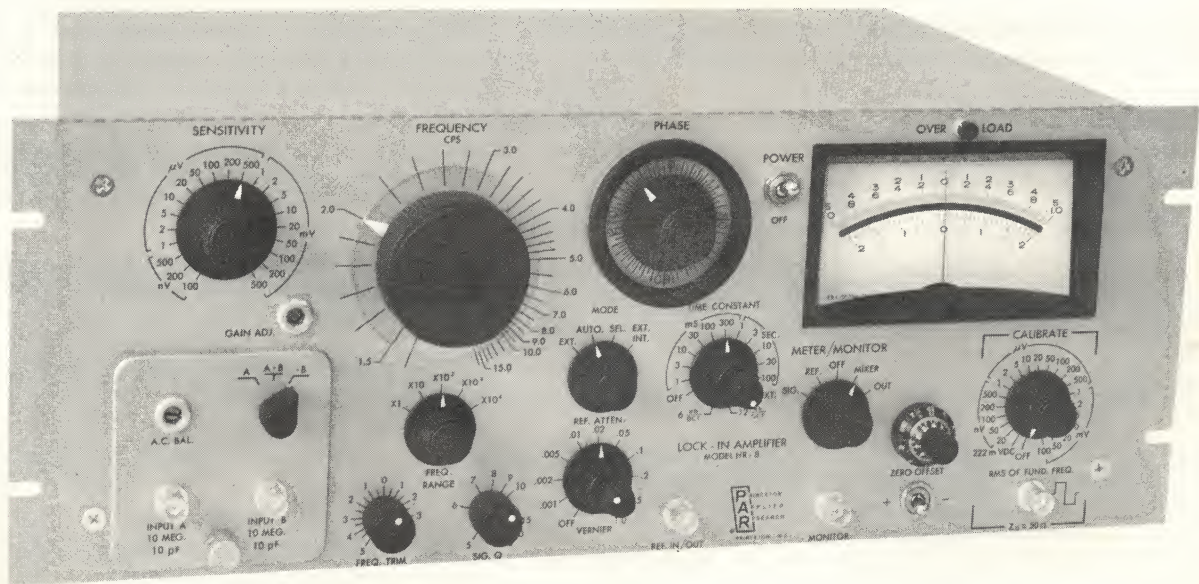


**PRECISION
 LOCK-IN AMPLIFIER
 MODEL HR-8**

**PRECISION PHASE SENSITIVE DETECTION SYSTEM
 FEATURING**

- CONTINUOUS TUNING—1.5 CPS TO 150 KC
- 0.0025 CPS EQUIVALENT NOISE BANDWIDTH
- HIGH SENSITIVITY
- 1% GAIN CALIBRATION
- CALIBRATED PHASE SHIFTER
- HIGH STABILITY



The PAR Model HR-8 Lock-In Amplifier is a new instrument designed to provide the ultimate operational characteristics in phase sensitive detection systems for the recovery of extremely weak signal intensities in the presence of noise. These instruments essentially operate as extremely narrowband detectors, the center frequency of which is locked to a particular frequency at which the signal information has been made to appear. As a result, **complete** freedom from drift between the detector center frequency and the characteristic signal frequency is obtained regardless of how narrow the bandwidth is made. Consequently, this unit is capable of enhancing signal-to-noise ratio in a wide variety of situations.

For those experiments which require Lock-In Amplifiers which are at the current state-of-the-art in signal detection capability and versatility, the Model HR-8 features a built-in low-noise preamplifier (capable of remote operation), calibrated 360° phase control, and a high degree of sensitivity, stability, linearity and overall accuracy. The above features, coupled with the internal oscillator, allows the Model HR-8 to serve as a general purpose laboratory instrument when not being used for its primary function.

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SPECIFICATIONS - PRECISION LOCK-IN AMPLIFIER MODEL HR-8

FREQUENCY RANGE: Continuously tunable from 1.5 cps to 150 KC in 5 ranges. Calibration accuracy within $\pm 5\%$.

SENSITIVITY: Twenty-one full scale ranges extending from 100 nanovolts to 500 millivolts (in 1, 2, 5, 10 increments). One hundred nanovolts rms of input signal coherent with reference signal will drive output meter to full scale.

NOISE REJECTION: A signal 56 db below ambient white noise in a 1KC bandwidth centered about signal frequency may be recovered with a signal-to-noise ratio of 1.

INTERNAL NOISE: At 1KC, noise figure shall be less than 3db for resistive sources between 10K and 5 megohms. (Noise figure for 200 K ohm resistive sources shall be less than 1db.)

EQUIVALENT NOISE BANDWIDTH: 0.0025 cps minimum (100 seconds maximum internal RC integrating time).

FILTER TIME CONSTANTS: 0, 1, 3, 10, 30, 100, 300 milliseconds; 1, 3, 10, 30, 100 seconds and EXT. position which allows capacitance to be added to rear connector to obtain any desired time constant. 6 or 12db/octave roll-off selectable by front panel switch.

ZERO SUPPRESS: Calibrated control permits off-setting zero by $\pm 1000\%$ of full scale on any range.

LINEARITY: $\pm 0.1\%$ of full scale.

SIGNAL CHANNEL CHARACTERISTICS: Differential or single-ended input impedance of 10 megohms shunted by 20 picofarads (either input to ground). Active notch filter in a negative feedback loop with nominal Q of 10. Q adjustable (with NO gain change) from 5-25 by means of calibrated dial.

REFERENCE CHANNEL CHARACTERISTICS: The reference signal, by which the signal to be measured is demodulated, is obtained by four modes of operation.

INTERNAL: Internal oscillator drives demodulator and presents a 0-1 VRMS (continuously variable) signal at "REF. IN/OUT" connector.

EXTERNAL: Phase control not operable. Requires externally generated signal of 1V peak-to-peak minimum level which crosses its mean value only twice each cycle with equal time between crossings.

SELECTIVE EXTERNAL: Externally generated reference signal filtered by tuned amplifier with a Q of 10, phase shifted and applied directly to demodulator. Minimum of 50 mv rms signal required.

AUTOMATIC: Any waveform from 0.5 to 300 V peak-to-peak crossing its mean value only twice each cycle.

PHASE ADJUSTMENT: Calibrated 360° phase shifter. Accuracy of phase setting indication within $\pm 5^\circ$.

DC OUTPUT STABILITY: 0.1% of full scale per 24 hours.

OUTPUT (located on rear): Single-ended with respect to ground. Panel meter ($\frac{1}{2}\%$ meter scale with either center or optional left-hand zero) full scale corresponds to ± 10 volts at output terminal. Adjustment allows output source impedance to be varied from 5K-20K ohms which permits driving either $\pm \frac{1}{2}$ ma recorders with internal resistance less than 10K or ± 1 ma recorders with internal resistance less than 3K as well as servo-type recorders.

MONITOR: A five position switch allows the panel meter and monitor output terminals to be switched to SIGNAL, REFERENCE, OFF, MIXER (OUTPUT), OUTPUT.

INTERNAL CALIBRATOR: Provides 21 square wave output levels extending from 20 nanovolts to 100 millivolts, accurate to within 1%.

POWER REQUIREMENTS: 105-125 volts or 210-250 volts; 50-60 cps; 25 watts.

SIZE: 19" W x 7" H x 15 $\frac{3}{4}$ " D. Weighs approximately 40 lbs.

ACCESSORIES: Model BZ-1 Mechanical Light Chopper with built-in reference signal capable of providing reference signal for Model HR-8 operating in SEL. EXT. mode. Interchangeable preamplifiers for the purpose of optimizing noise performance over a wide range of input source impedances. For additional information, please contact Princeton Applied Research Corp. directly or your local PAR representative.

PRICE: \$1850.00 excluding plug-in preamplifier. Type A High Impedance Differential Preamp or Type B Low Impedance Transformer Input Preamp available at \$250 each.

WARRANTY: One year.

Specifications and prices subject to change without notice.

NEW PRICES EFFECTIVE 9/15/65
HR-8: \$1950. EITHER PREAMP: \$300.

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MODEL HR-8 PREAMPLIFIER SPECIFICATIONS

GENERAL: The Model HR-8 Lock-In Amplifier requires a preamplifier which can either be plugged directly into the Model HR-8 main frame or operated remotely (with the purchase of the adapter kit described below.) In either case, the preamplifier is powered from and controlled by the Model HR-8. The following specifications refer to the performance of the individual preamplifier when used with the Model HR-8.

TYPE A PREAMPLIFIER

The Type A is a high input impedance low noise preamplifier for the Model HR-8 used to obtain optimum signal-to-noise ratios for source impedances above $3K\Omega$.

SENSITIVITY: 21 ranges, from 100 nanovolts rms full scale to 500 millivolts rms full scale, in a 1-2-5 sequence.

FREQUENCY RANGE: 1.5cps to 150Kc.

INPUT IMPEDANCE: 10 megohms shunted by 20 pf (either input to ground.) Differential or single-ended input.

NOISE: High sensitivity settings (100 nv to 500 uv), noise figure for either (single-ended) input shall be better than 0.5 db for a 100K source at 1Kc. For low sensitivity settings (1mv to 500mv), the internally generated noise shall result in a meter deflection of 1% (rms) of full scale with a time constant setting of 1 sec (6db/oct.)

TYPE B PREAMPLIFIER

The Type B Preamplifier is a transformer input preamplifier. The standard Type B is supplied with a 100:1 voltage transformation ratio (other ratios also available) to obtain optimum signal-to-noise ratios for source impedances as low as several ohms. The following specifications refer to the standard 100:1 ratio connection.

SENSITIVITY: Twenty-one ranges, from 1 nanovolt rms full scale to 5 millivolts rms full scale in a 1-2-5 sequence.

FREQUENCY RANGE:* Depends on source impedance. With a 10Ω source the frequency range will be approximately 10 cps to 10Kc. Lower source impedances will extend the low frequency response somewhat.

INPUT: Differential or single-ended. The transformer primary is brought to a pair of input connector terminals which are isolated from chassis ground.

INPUT IMPEDANCE: The input impedance is complex but at the lower frequencies is simply the transformer inductance of approximately .25 Henry.

NOISE: The noise figure at 1Kc with a 10Ω source shall be better than 3db.

*Type B1 Preamplifier available which operates in the frequency range of 5Kc to 150Kc with a 10Ω source. Noise figure at 50Kc with a 10Ω source shall be better than 3db.

REMOTE PREAMPLIFIER KIT

The Remote Preamplifier Kit allows the preamplifiers described above to be used at a distance from the main frame of the Model HR-8. The standard length of the cable supplied is 10 feet, but longer cables can be furnished on special request.

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MODEL HR-8 PREAMPLIFIER SPECIFICATIONS

TYPE C PREAMPLIFIER

The completely transistorized Type C Preamplifier is used with the Model HR-8 to obtain optimum signal-to-noise ratios with source impedances in the range of 100 ohms to 30K ohms.

SENSITIVITY: Twenty-one ranges from 10 nanovolts to 50 millivolts rms full scale in a 1-2-5 sequence.

FREQUENCY RANGE: 1.5 cps to 150 Kc.

INPUT: Switch selectable, differential or single-ended.

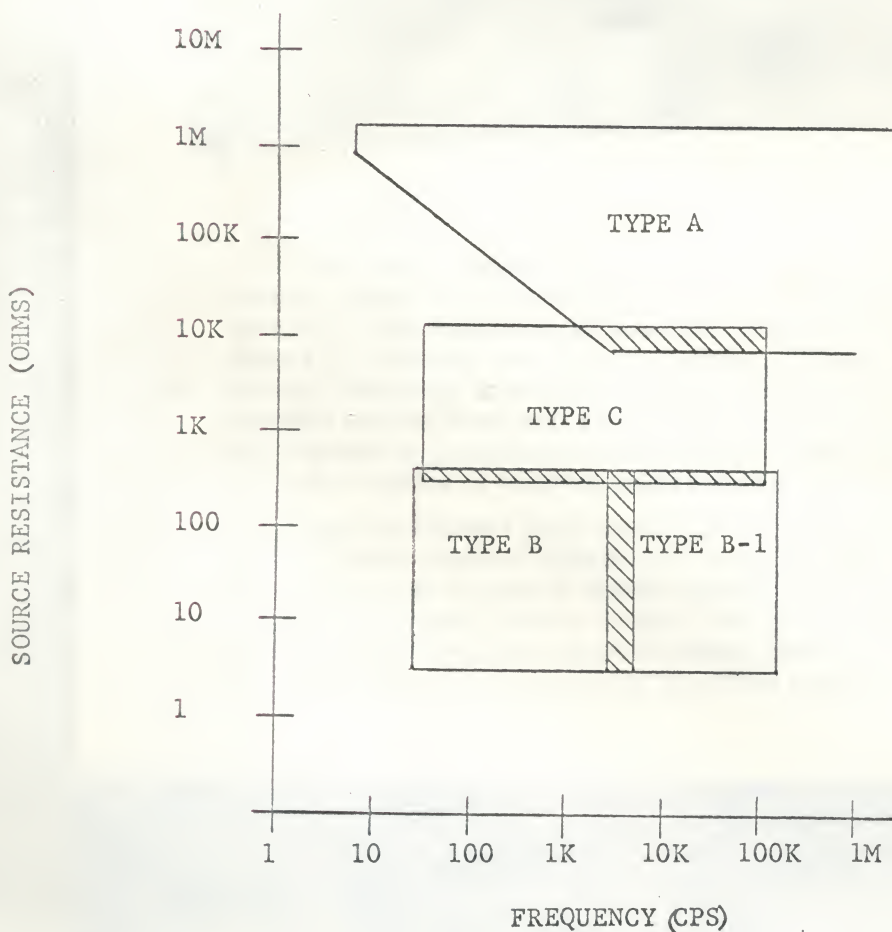
INPUT IMPEDANCE: 50K ohms each input to ground. At higher sensitivity settings an additional 50K ohms is inserted between the inputs.

NOISE: The noise figure at 1 Kc with a source impedance of 3K ohms is less than 2 db. The equivalent short circuit noise resistance at 1 Kc is less than 500 ohms (2.9×10^{-9} volts \times cps $^{-\frac{1}{2}}$).

MODEL HR-8 PREAMPLIFIER SELECTION

In general, the complete noise figure contours should be examined before selecting a preamplifier. The sketch below indicates the 3 db noise figure loci for all Model HR-8 Preamplifiers and may serve as a guide in the ultimate selection.

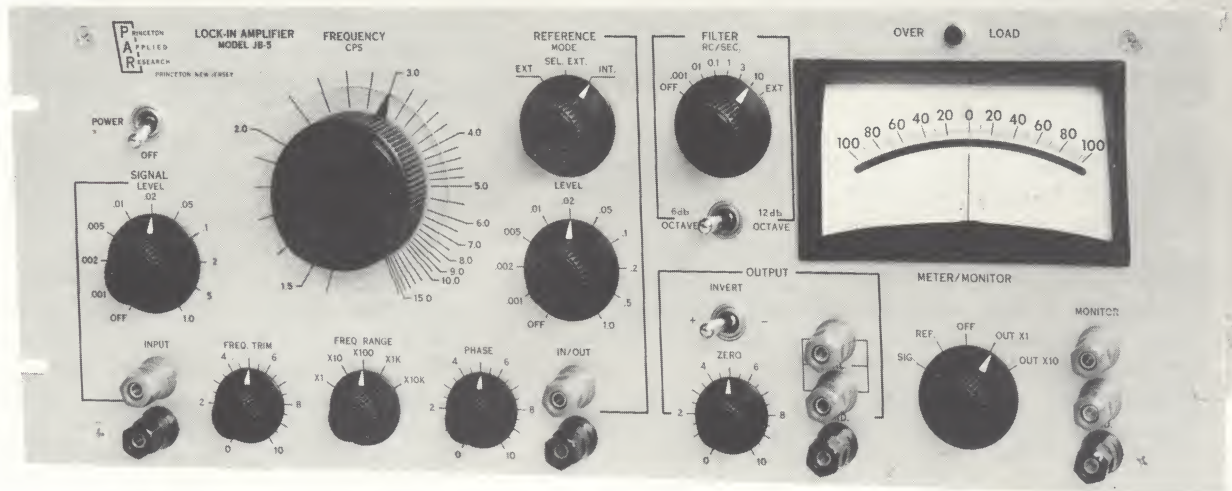
LOCI OF 3DB NOISE FIGURES
FOR MODEL HR-8 PREAMPS



LOCK-IN AMPLIFIERS

MODELS JB-4 AND JB-5

MODEL JB-5



PHASE SENSITIVE DETECTION SYSTEMS

CONTINUOUSLY TUNABLE

1.5 cps TO 150 kc

PAR Lock-In Amplifiers are completely transistorized signal processing instruments designed to employ the theoretically optimum technique for the measurement of extremely weak signal intensities in the presence of noise. They are truly universal narrow band coherent detectors and include: high Q continuously tunable selective amplifiers, phase sensitive detector, d.c. amplifier, selective d.c. filtering, continuous phase control, signal modulating oscillator, meter monitor and recorder drive circuits.

These instruments essentially operate as extremely narrow band detectors, the center frequency of which is locked to a particular frequency at which the signal information has been made to appear. As a result, **complete** freedom from drift between the detector center frequency and the characteristic signal frequency is obtained, regardless of how narrow the bandwidth is made. Consequently, these systems are applicable to most situations where narrow band operation will enhance signal-to-noise ratio. PAR Lock-In Amplifiers have been used successfully in various experimental applications such as: radio astronomy, nuclear and electron resonance experiments, carrier lifetime studies in semiconductors, experiments in special and general relativity, optical pumping, infrared studies, laser investigations, electro-physiological signal processing, radiometers, WWV comparators, plasma studies, vibrating sample magnetometers, electronic polarizing microscopes, electroencephalographic studies, mass spectrometers, and in many other small signal recovery problems.

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SPECIFICATIONS ★ LOCK-IN AMPLIFIERS MODELS JB-4 AND JB-5

	MODEL JB-4	MODEL JB-5
FREQUENCY RANGE: (Calibration Accuracy $\pm 5\%$)	15 cps to 15KC continuously tunable in three ranges.	1.5 cps to 150 KC continuously tunable in five ranges.
PRICE:	\$990.00 Export prices approximately 5% higher (except Canada)	\$1350.00

GENERAL SPECIFICATIONS APPLICABLE TO BOTH MODELS

GAIN: (rms AC in to push-pull DC out) Greater than 9,000. One-half millivolt rms input signal coherent with reference signal will drive output meter to full scale.

NOISE REJECTION: A signal 46 db below ambient white noise in a 1 KC bandwidth centered about signal frequency may be recovered with a signal to noise ratio of 1.

EQUIVALENT INPUT NOISE: Equivalent input noise with the input terminals shorted in a 1/40 of a cycle bandwidth is approximately 1/2 microvolts rms. To detect lower level signals of the order of microvolts, use PAR Model CR-4 Pre-Amplifier.

EQUIVALENT BANDWIDTH: 0.024 cps minimum (10 seconds maximum internal RC integrating time). 6 or 12 db per octave roll-off selectable by front panel switch.

TIME CONSTANTS: 0, 0.001, 0.01, 0.1, 1, 3, 10 secs, and EXT. Single or double section RC filtering. In the EXT. position appropriate points internal to the instrument are brought out to a rear connector where capacitance may be added to obtain any desired electronic integrating time constant.

HARMONIC REJECTION: Second harmonic down by a factor of 1000 or 60 db. Third harmonic down by a factor of 200 or 46 db.

OVERLOAD INDICATOR: Light indicates overload condition at critical circuit points.

OUTPUT: Will drive most galvanometric or servo recorders. Also direct reading panel meter.

LINEARITY: Better than $\pm 1\%$ of full scale.

ZERO DRIFT: $\pm 1/2\%$ of full scale per hour maximum.

POWER REQUIREMENTS: 105-125 volts or 215-245 volts; 50-60 cps. 10 watts.

SIGNAL CHANNEL CHARACTERISTICS:

INPUT IMPEDANCE: Approximately 50 k.

INPUT LEVEL CONTROL: Input signal may be attenuated up to a factor of 1000 in steps of 1.0, 5, .2, .1, .05, .02, .01, .005, .002, .001; accuracy $\pm 5\%$.

FREQUENCY SELECTIVE AMPLIFIER: Selectivity characteristic of tuned amplifier in signal channel is that of parallel resonant circuit with a Q of approximately 25. (Not twin-T type)

REFERENCE CHANNEL CHARACTERISTICS: The reference signal, by which the signal to be measured is demodulated, is obtained by three modes of operation; INTERNAL, EXTERNAL and SELECTIVE EXTERNAL.

SELECTIVE EXTERNAL MODE: Externally generated reference signal filtered by tuned amplifier having characteristics of parallel resonant circuit with a Q of approximately 25, phase shifted and applied directly to demodulator. Minimum of 100 millivolts peak to peak reference signal required.

EXTERNAL MODE: Externally generated reference signal phase shifted and applied directly to demodulator. 5 volts peak to peak reference signal required.

INTERNAL MODE: Self-contained oscillator drives demodulator (through phase shifter) directly. Output frequency appears as sine wave at "REFERENCE IN/OUT" terminals. Maximum output approximately 5 volts peak to peak at 3 m.a. maximum.

PHASE ADJUSTMENT: Provides minimum of 180° of continuous phase change at any frequency. Also 180° INVERT switch.

OUTPUT:

LEVEL: Maximum D.C. output

- into high impedance load ± 5 volts.
- into pen recorder of less than 2 k resistance ± 1 milliamp or $\pm 1/2$ milliamp (switch selectable)

COMMON MODE QUIESCENT VALUE: -8 volts D.C.

MONITOR: A five position switch allows the panel meter and monitor output terminals to be switched to SIGNAL, REFERENCE, OFF and two output points in the instrument, OUTX1 and OUTX10 for level monitoring, setting up, zeroing, etc. The meter indicates the peak to peak A.C. voltage when it is switched to REFERENCE and SIGNAL positions.

WEIGHT: Approximately 15 lbs.

SIZE: 19" W x 7" H x 11" D.

FINISH: Iridited aluminum case, light grey front panel.

ACCESSORIES: PAR Model CR-4 Pre-Amplifier. For additional information, send for Bulletin #114.

WARRANTY: 1 year.

Specifications and prices subject to change without notice.

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TWO-PHASE LOCK-IN AMPLIFIER MODEL JB-6



TWO-PHASE LOCK-IN AMPLIFIER SIMULTANEOUSLY RECOVERS IN-PHASE AND QUADRATURE COMPONENTS OF SIGNAL INFORMATION FROM NOISE.

PAR Lock-In Amplifiers are completely transistorized signal processing instruments designed to employ the theoretically optimum technique for the measurement of extremely weak signal intensities in the presence of noise. They are truly universal narrowband coherent detectors and include: high Q continuously tunable selective amplifiers, phase sensitive detector, d.c. amplifier, selective d.c. filtering, continuous phase control, signal modulating oscillator, meter monitor and recorder drive circuits.

These instruments essentially operate as extremely narrowband detectors, the center frequency of which is locked to a particular frequency at which the signal information has been made to appear. As a result, complete freedom from drift between the detector center frequency and the characteristic signal frequency is obtained, regardless of how narrow the bandwidth is made. Consequently, these systems are applicable to most situations where narrowband operation will enhance signal-to-noise ratio.

Wherever the signal information can be made to appear as both an in-phase and quadrature component, the PAR Model JB-6 Lock-In Amplifier permits simultaneous measurement and recording of both. Outputs for each channel are completely independent, containing separate filter selectors, roll-off selectors, meter displays, zeroing adjustments, 180° invert switches and recorder full scale adjustments. Convenient front panel adjustments of inter-channel orthogonality and gain over the complete operating frequency range are also provided.

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SPECIFICATIONS • LOCK-IN AMPLIFIER MODEL JB-6

FREQUENCY RANGE: 1.5 CPS to 150 KC continuously tunable in five ranges.

GAIN: (rms AC in to push-pull DC out) Greater than 9,000 for each channel. One-half millivolt rms input signal coherent with reference signal will drive IN-PHASE meter to full scale. One-half millivolt rms input signal in quadrature phase relationship to the reference signal will drive QUADRATURE meter to full scale. "In-phase mixer gain" (I GAIN) control provides a convenient adjustment for making the gain of the two channels identical.

NOISE REJECTION: Maximum internal time constant permits the recovery of either component of a signal 46db below ambient white noise in a 1KC bandwidth centered about signal frequency with a signal-to-noise ratio of one.

EQUIVALENT INPUT NOISE: Equivalent input noise with the input terminals shorted in a 1/40 of a cycle bandwidth is approximately 1/2 microvolts rms. To detect lower level signals of the order of microvolts, use PAR Model CR-4 Pre-Amplifier.

EQUIVALENT BANDWIDTH: 0.025 CPS minimum (10 seconds maximum internal RC integrating time). 6 or 12 db per octave roll-off selectable by front panel switch for each channel.

TIME CONSTANTS: 0, 0.001, 0.01, 0.1, 1, 3, 10 secs, and EXT. Single or double section RC filtering. In the EXT. position appropriate points internal to the instrument are brought out to a rear connector where capacitance may be added to obtain any desired electronic integrating time constant. Independent controls and "EXT CAP" connectors are provided for each channel.

HARMONIC REJECTION: Second harmonic down by a factor of 1000 or 60 db. Third harmonic down by a factor of 200 or 46 db.

OVERLOAD INDICATOR: Light indicates overload condition at critical circuit points.

LINEARITY: Better than $\pm 1\%$ of full scale for each channel.

ZERO DRIFT: $\pm 1/2\%$ of full scale per hour maximum for each channel.

POWER REQUIREMENTS: 105-125 volts or 215-245 volts; 50-60 cps. 10 watts.

SIGNAL CHANNEL CHARACTERISTICS:

INPUT IMPEDANCE: Approximately 50 k.

INPUT LEVEL CONTROL: Input signal may be attenuated up to a factor of 1000 in steps of 1.0, .5, .2, .1, .5, .02, .01, .005, .002, .001; accuracy $\pm 5\%$.

FREQUENCY SELECTIVE AMPLIFIER: Selectivity characteristic of tuned amplifier in signal channel is that of parallel resonant circuit with a Q of approximately 25. (Not twin-T type.)

REFERENCE CHANNEL CHARACTERISTICS: The reference signal, by which the signal to be measured is demodulated, is obtained by three modes of operation; INTERNAL, EXTERNAL, and SELECTIVE EXTERNAL. The ORTHOG position provides an internal calibration signal for adjustments of orthogonality between channels.

SELECTIVE EXTERNAL MODE: Externally generated reference signal filtered by tuned amplifier having characteristics of parallel resonant circuit with a Q of approximately 25, phase shifted and applied directly to demodulator. Minimum of 100 millivolts peak-to-peak reference signal required.

EXTERNAL MODE: Externally generated reference signal phase shifted and applied directly to demodulator. 5 volts peak-to-peak reference signal required.

INTERNAL MODE: Self-contained oscillator drives demodulator (through phase shifter) directly. Output frequency appears as sine wave at "REFERENCE IN/OUT" terminals. Maximum output approximately 5 volts peak-to-peak at 3 ma maximum.

ORTHO: Provides internal calibration signal for adjustments of orthogonality between channels to within $\pm 1^\circ$ from 3 CPS to 30 CPS and $\pm 5^\circ$ from 1.5 CPS to 150 KC.

PHASE ADJUSTMENT: Provides minimum of 180° of continuous phase change at any frequency. Also 180° INVERT switch.

OUTPUT: Will drive most galvanometric or servo recorders. Also direct reading panel meters. Independent outputs for each channel available simultaneously at the rear of instrument.

LEVEL: Maximum DC output for each channel

a) into high impedance load ± 5 volts.

b) into pen recorder of less than 2 k resistance ± 1 milliamp or $\pm 1/2$ milliamp (switch selectable)

COMMON MODE QUIESCENT VALUE: -6 volts DC.

MONITOR: A four position switch allows the panel MONITOR METER and MONITOR output terminals to be switched to SIGNAL, REFERENCE, QUADRATURE output and IN-PHASE output for level monitoring, setting-up and zeroing. The MONITOR METER indicates peak-to-peak AC voltage when it is switched to the REFERENCE and SIGNAL positions.

WEIGHT: Approximately 15 lbs.

SIZE: 19" W x 7" H x 13" D.

FINISH: Iridited aluminum case, light grey front panel.

PRICE: \$1,750. Export price approximately 5% higher (except Canada).

WARRANTY: 1 year.

Specifications and prices subject to change without notice.

ACCESSORIES: PAR Models CR-4 and CR-4A Pre-Amplifiers and PAR Models BZ-1 Mechanical Light Chopper. For additional information on applicable accessories or on PAR's complete line of Lock-In Amplifiers, please write directly to the factory or to your local PAR representative.

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