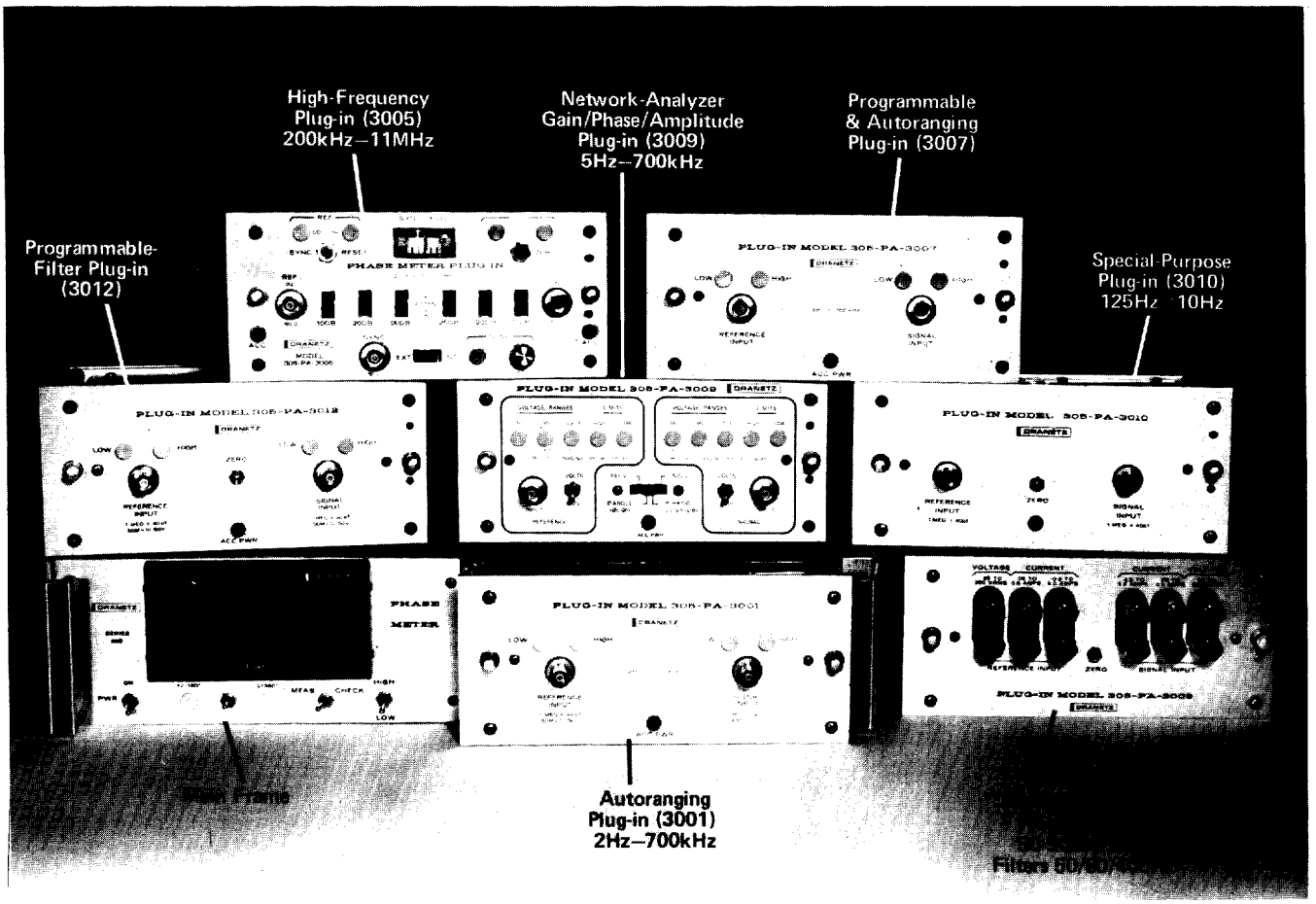


SERIES 305 PHASE & GAIN/PHASE INSTRUMENTATION

State-of-the-Art Performance. . . Unprecedented Modular Flexibility

Many of the applications discussed earlier demand superior performance from the phase (or gain/phase) meter. In order to appreciate the constraints imposed on those applications by phasemeter characteristics, and to appreciate what can be achieved by the use of the most advanced phase instrumentation, it is necessary to describe, in detail, the features and specifications of such equipment.

The Dranetz 305 Series is unquestionably the best example of advanced phase instrumentation, for a number of reasons:

- It provides the highest accuracy, stability, and linearity currently available in phase measurement . . .indeed, it is listed in U.S. (D.O.D.) standards laboratories publications as an acceptable transfer standard of phase. It also has been assigned Federal Stock Numbers.
- It provides this performance over the widest frequency ranges, the widest signal-amplitude ranges, and in the widest range of output and control formats currently available.
- It provides all of these superior characteristics without sacrificing either convenience or simplicity. All functions are available in "no-hands" autoranging and/or digitally programmable modes, with a wide choice of readouts, input configurations, and accessories.
- It provides flexibility without excessive cost, by offering a wide range of mainframe/plug-in combinations, each optimized for a particular class of applications. Thus, the user need never buy more than his needs, and yet may extend his measurement capability economically, as required.

In many ways, the Dranetz Series 305 is unique among phasemeter designs. Many of the circuits employed are exclusive, proprietary Dranetz developments, and some are protected by basic patents*, issued or pending. Therefore, such features as noise rejection at critical zero-crossings, automatically self-adjusting integration time constants, and optimum harmonic rejection are available *only* in Dranetz instrumentation.

On the pages that follow, the Series 305 has been considered as an entity – i.e., the *overall* capability of the complete system has been summarized. Many of the modes, functions, and ranges described are available only when appropriate modules are plugged into the appropriate mainframe; however, the breakdown of individual module capabilities is given on pages 23 and 25.

*e.g., U.S. Pat. #3,725,781

DESIGN FEATURES

HIGHEST ACCURACY

Accuracy to better than ±0.03° is attained with precision mainframes and carefully designed plug-ins. Mainframes exhibit precise zero-crossing detection, angle-to-DC conversion linearity to approximately ±0.01°, and compatibly high DC stability. Plug-ins are designed for accurate conversion of sine wave (also square wave) inputs to square waves through carefully controlled amplifier circuitry, use of gain auto-ranging, and harmonic filters where necessary.

"NO-HANDS" OPERATION

Series 305 Phasemeters require no controls or adjustments by the operator. These units are equipped with several significant automatic features. These include automatic selection of angle range, automatic sensing of leading or lagging angle, automatic selection of the output time constants, and automatic setting of AC gains (over 90dB range).

WIDE FREQUENCY RANGE

The basic mainframe provides a direct frequency coverage of 2Hz to 700kHz with high accuracy. By the use of frequency converting plug-ins, such as the 305-PA-3005, standard units can handle frequencies up to 11MHz. Special units can be provided for even higher frequencies.

INSENSITIVITY TO INPUT LEVEL

Series 305 plug-ins are available with a guaranteed accuracy of better than ± 0.05° even with independent input level variations of 60dB. See curves on page 22.

NON-AMBIGUOUS ANGLE READINGS

Two phase-angle ranges in the 305 eliminate the ambiguity or "dead zone" error inherent in all other phasemeters (usually at 0°/360° or −180°/+180°). An automatic system switches to the 0°/360° range for angles near 180° and to the −180°/+180° range for angles near 0°. Unique guard bands prevent dead zones near switching points.

REPEATABILITY, STABILITY, AUTOCALIBRATION

Repeatability of the 305 is better than ± 0.005°; temperature coefficient is ± 0.001°/°C; and DC output drift is less than ± 0.05° over any 30-day period. The autocalibration feature eliminates virtually all DC errors in digital panel readout and BCD rear-panel outputs.

PROGRAMMABLE OPERATION

Standard mainframes are available with rear connections for overriding the automatic time constant and angle range selectors by relay contact closures. Options are also provided for control by DTL and TTL logic.

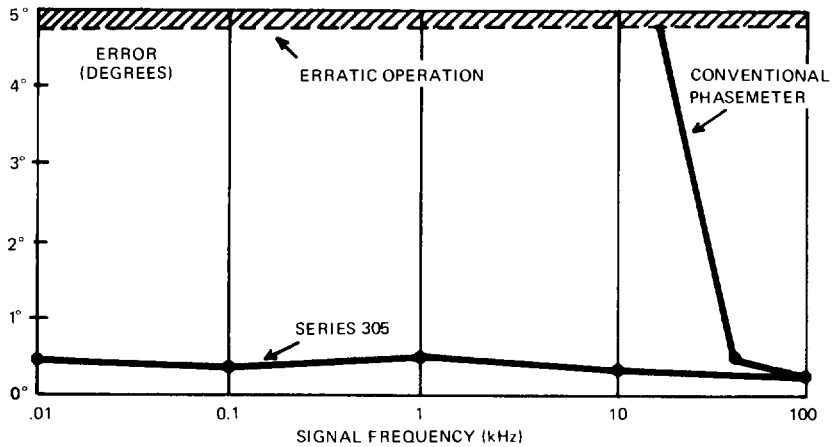
RAPID PHASE NULLING

For production testing of filters and other networks, an additional analog-deviation panel meter (305D) provides an easy means of adjusting a test angle to any accurate value. Presetting can be done in seconds without any other equipment. The precision digital panel meter monitors actual test angle continuously.

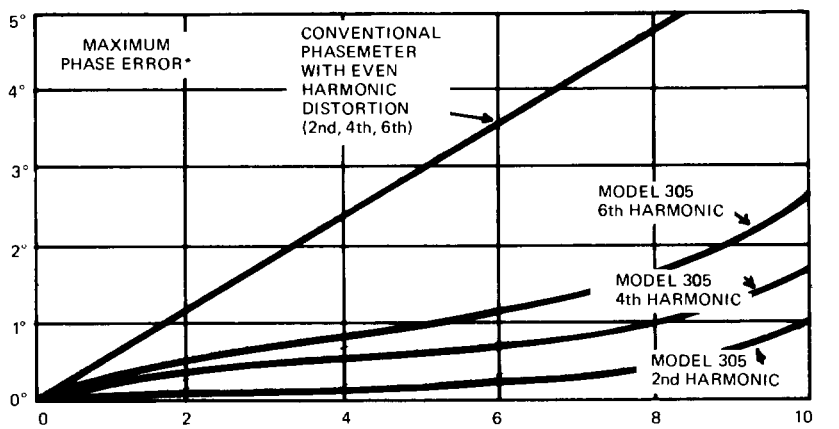
DIGITAL READOUT

In addition to analog DC output, standard mainframes are available with up to 5 digit panel readouts (i.e., 0.00° to ± 180.00° and 0.00° to +360.00°) and BCD outputs for each digit. Autocalibration feature eliminates virtually all meter drift and scaling errors.

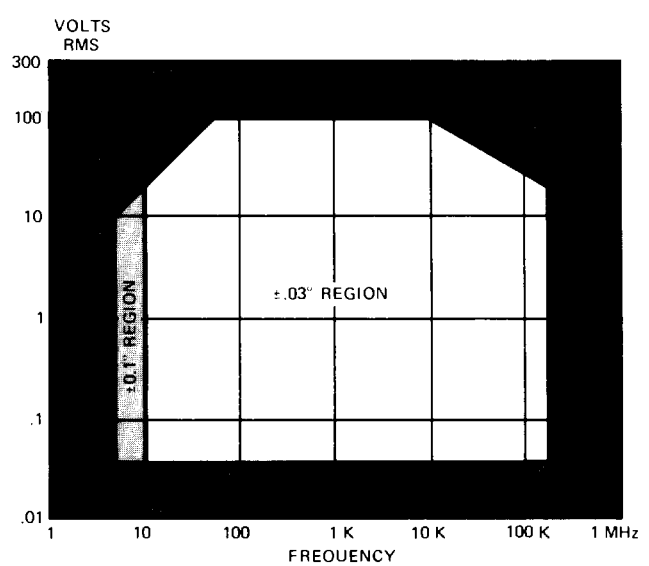
PERFORMANCE FEATURES



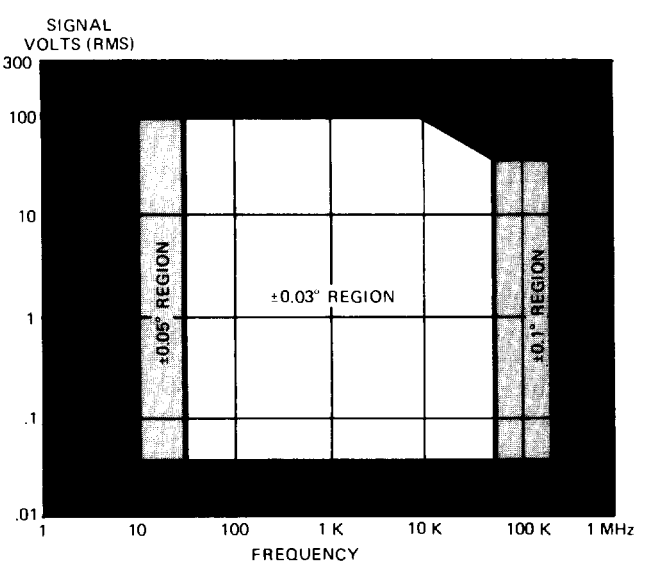
PHASE READING ERROR VS SIGNAL FREQ.
FOR GAUSSIAN NOISE (FLAT TO 5 MHz)
IN BOTH CHANNELS FOR S/N = 10



COMPARISON OF ERRORS DUE TO EVEN HARMONIC DISTORTION
(*For worst case phase relationship between harmonic and fundamental)



TYPICAL ERROR CONTOURS FOR 305 w/305-PA-3001
FOR EQUAL SIGNAL INPUTS



TYPICAL ERROR CONTOURS FOR 305 w/305-PA-3001
FOR UNEQUAL INPUTS – REF. 0.3 VOLTS RMS

NOISE IMMUNITY

Unique patented circuitry minimizes noise errors and makes possible accurate phase measurements under noise conditions under which other phasemeters become completely useless. The graph to the left compares the phase error of the 305 with that of a conventional phasemeter with broad band noise in both channels.

ABILITY TO REDUCE HARMONICS

The 305 is designed to reduce significantly the errors due to even-harmonic distortion without the use of filters. The curve to the left compares the error due to even-harmonic distortion (maximized for worst case harmonic angle) on conventional phasemeters and on the Model 305. (Odd harmonics in-phase with fundamental contribute no error.)

WIDE INPUT-SIGNAL DYNAMIC RANGE

As the graphs below show, auto-ranging (see description of 305-PA-3001 plug-in, page 23) provides sustained high accuracy over a wide dynamic range of input signal level and a wide input-signal frequency range. While the accuracies shown on the graphs apply to sine-wave inputs, the auto-ranging feature, and its benefits, can be used to optimize phase measurements for square-wave and amplitude modulated signals.

INDIVIDUAL PLUG-IN CHARACTERISTICS—SERIES 305

In addition to the standard plug-ins described here, many custom modifications and special-purpose units (like the 305-PA-3009 described below) are available. Consult Dranetz Engineering for recommendations. See page 20 for photographs of these plug-ins, and page 25 for specifications.

305-PA-3001 AUTORANGING PLUG-IN

This plug-in features high accuracy over a broad range of input levels and frequencies. Auto-ranging of gain in each channel assures high accuracy (±0.05° guaranteed) over a dynamic range of 60dB (50mV to 50 Vrms) for independent levels of inputs, with a useful range of 90dB (10mV to 300 Vrms). This plug-in covers the range from 2Hz to 700kHz, with its highest accuracy in the 50Hz to 50kHz range. (See page 22 for typical amplitude/frequency performance.) The 305-PA-3001 also features compatibility with Textronix probes and includes front panel lamps to indicate when either input signal is below 50mV or above 50 Vrms.

305-PA-3002 SINGLE RANGE PLUG-IN

The 305-PA-3002 is similar to the model 305-PA-3001, except that it does not include auto-ranging or limit-indicator lamps. For sine wave inputs, the standard unit is designed for guaranteed ± 0.05° accuracy (typically ±0.03°) over independent signal levels of 50mV to 500mV rms, with a slight reduction in accuracy from 10mV to 3 Vrms. Other level ranges can be supplied on special order. Tektronix probes can be used for high input levels. This plug-in is useful for sine-wave, square-wave, and amplitude-modulated signals.

305-PA-3005 HIGH FREQUENCY PLUG-IN

This high-frequency plug-in is designed for high accuracy to 11MHz. Using a self-tracking oscillator, the input signals are converted to 40kHz for precision measurement by the mainframe. Input attenuators (50 Ohms) are provided with 10dB steps, to cover a range of 1mV to 3 Vrms in either channel. Front-panel lamps indicate when input levels are out of range or when level controls are improperly set. The self-tracking oscillator can be controlled by channel A signal, or by a third (independent) signal.

305-PA-3007 PROGRAMMABLE AND AUTORANGING PLUG-IN

This programmable plug-in features all of the characteristics of the model 305-PA-3001. In addition, it includes increased input gain to achieve operation down to 1mVrms. The unit can be operated either in an automatic or programmable mode. Without rear connections, the plug-in operates automatically as a 305-PA-3001; however, by utilizing rear connectors, the internal auto-ranging can be over-ridden and additional internal gain can also be inserted. Programming is available by DTL and TTL logic.

305-PA-3008 POWER FREQUENCY PLUG-IN

The 305-PA-3008 is a special-purpose plug-in designed for precision calibration of 50Hz, 60Hz and 400Hz power line equipment such as wattmeters, phase detectors and watt-hour meters. This instrument can measure phase difference between two voltages, two currents, or a voltage and a current. The unit covers a voltage range of 25V to 250 Vrms and a current range of .05 to 5 A rms. The basic plug-in covers the frequency range of 50Hz to 500Hz. Plug-in filters, available for 50Hz, 60Hz and 400Hz, assure reduction of second harmonic by at least 40dB and higher harmonics by at least 50dB. A front panel zero control provides adjustment for high accuracy (±0.1°) at any single frequency.

305-PA-3009 WIDEBAND NETWORK ANALYZER PLUG-IN (GAIN/PHASE/AMPLITUDE)

This plug-in measures the voltage amplitude of each signal input (in volts or dBV, selectable by operator), the phase difference between inputs, and the amplitude ratio of inputs (dB). Featuring auto-ranging of gain in both channels, it requires no manual setting of gains for any measurement. Simultaneous DC outputs on mainframe are proportional to all four functions. A front-panel switch selects the measuring mode for digital panel readout – channel A voltage, channel B voltage, phase difference, or amplitude ratio. Lamps on the front panel of the plug-in indicate the proper decade multiplier. The 305-PA-3009A is designed for extending the low frequency range to 1Hz.

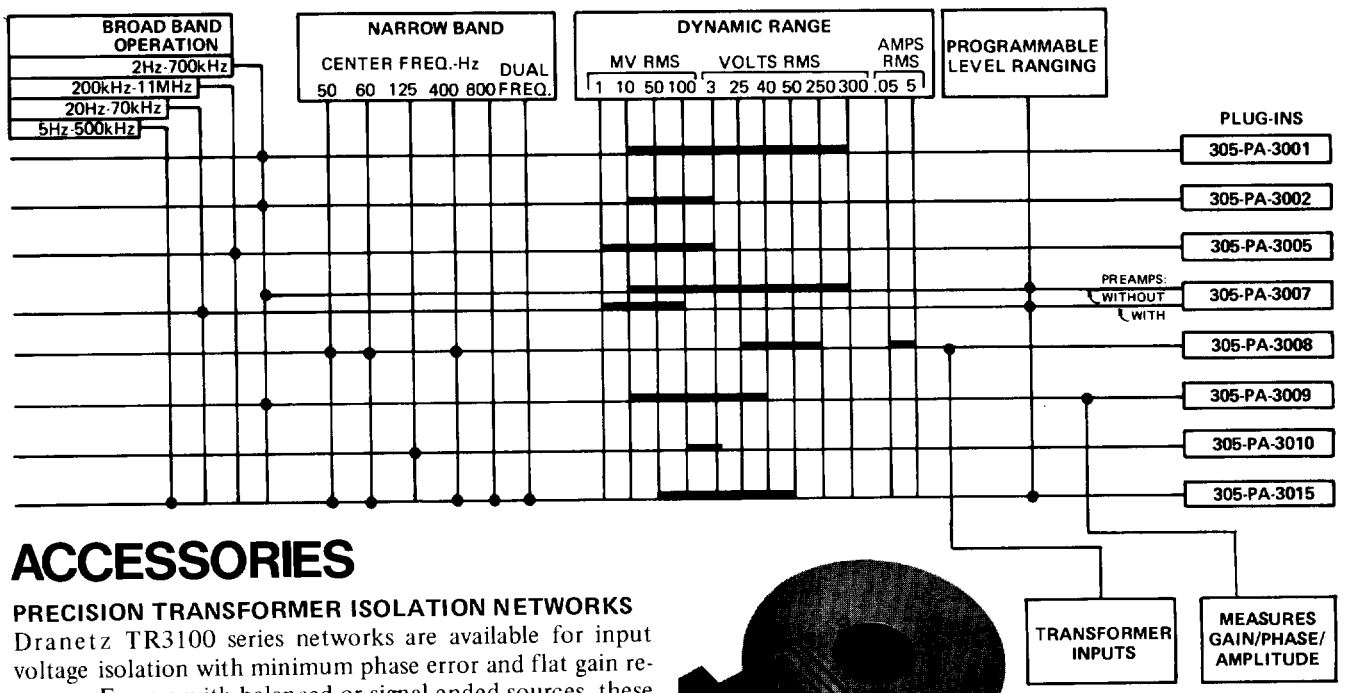
305-PA-3010 SPECIAL-PURPOSE PLUG-IN

This plug-in is typical of special-purpose plug-ins that can be supplied to meet unique requirements. Having high input impedance, it is equipped with closely matched low-pass filters to pass 125Hz signals while rejecting 400Hz signals, solving problems in many types of servo control systems. Similar units can be readily designed for other special voltage and frequency applications.

305-PA-3015 PROGRAMMABLE PLUG-IN

Intended for use in automatic test systems, this plug-in has two selectable filters for harmonic rejection and selectable gains to handle inputs from 50mV to 50V rms. Filter (or filter-out) selection as well as gain switching is accomplished by contact closures across terminals on the rear of the mainframe.

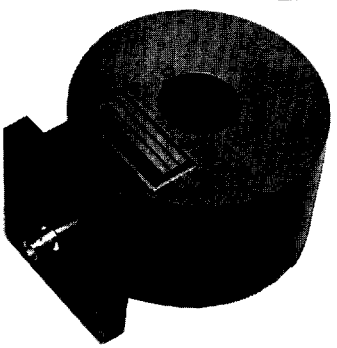
QUICK SELECTION GUIDE TO STANDARD SERIES 305 MAINFRAMES & MODULES



ACCESSORIES

PRECISION TRANSFORMER ISOLATION NETWORKS

Dranetz TR3100 series networks are available for input voltage isolation with minimum phase error and flat gain response. For use with balanced or signal-ended sources, these units are equipped with internal preamplifiers to produce outputs in the 30mV to 3 Vrms range (for use with 305 Series Phasemeters) for input levels from 50mV to 500 Vrms. These transformer units are packaged for direct plug-in into the input BNC's of the phasemeter, and draw power from the front-panel accessory connector of the phasemeter plug-in. Size: 2 3/4" x 2 3/4" x 2". Input: banana jack. Output: BNC.



Model TR	Zin	Com. Mode Rej: >60 dB for frequency	Range for ±0.1° typical shift	Range for ±0.3° typical shift	Gain ±2%
3101	1 megΩ 70 pF	Below 1 kHz	20-400 V rms 50 Hz-20 kHz	5-400 V rms 10 Hz-25 kHz	x 0.01
3102	100 kΩ 70 pF	Below 10 kHz	2-40 V rms 50 Hz-20 kHz	0.5-40 V rms 10 Hz-25 kHz	x 0.1
3103	10 kΩ 70 pF	Below 25 kHz	0.2-4 V rms 50 Hz-20 kHz	0.05-4 V rms 10 Hz-25 kHz	x 1.0

PRECISION CURRENT TRANSFORMERS

Dranetz TR-2004 and TR-2005 current transformers feature wide frequency range, wide dynamic level range, excellent pulse response, low phase shift, excellent voltage isolation (15kV peak), low capacitance. They are particularly useful in coupling current signals into a phase meter. Designed for use by threading current-carrying conductor through center hole.

CHARACTERISTICS	TR 2004	TR 2005
Sensitivity per Primary Turn (V rms/A rms)	0.1; +0, −1%	1.0; +0, −1%
Square Pulse Input		
Max. Current	10,000 A pk	1,000 A pk
Rise Time	For rise times > 1 microsec.	40 nanosec. approx.
Droop	10^{-4}%/microsec.	10^{-3}%/microsec.
Max. Amp-sec. per pulse	1	0.1
For Sinusoidal Input		
Amplitude Limit	100 A rms above 17 Hz; 9 A pk/Hz below 17 Hz; 90 A pk at 10 Hz	10 A rms above 100 Hz; 0.15 A pk/Hz below 100 Hz; 7.5 A pk at 50 Hz
Useful Frequency Range	0.25 Hz to 700 kHz	20 Hz to 10 MHz
Amplitude Response with Frequency +0%, −1% Limits		1 kHz to 4 MHz
Low Frequencies	4 Hz to 100 kHz, 3 dB at 0.25 Hz	3 dB at 20 Hz; −3% at 200 Hz; −5% at 100 Hz
High Frequencies	3 dB up to 700 kHz; +2.5% at 300 kHz; +7% at 400 kHz	3 dB at 10 MHz
Phase Response ±0.8° Limit	20 Hz to 100 kHz	1 kHz to 2 MHz
Low Frequencies	1.5° at 10 Hz; 2.9° at 5 Hz	2° at 500 Hz; 4° at 250 Hz; 8° at 100 Hz; 13° at 50 Hz
High Frequencies	1.5° at 200 kHz; 2.2° at 300 kHz	2.7° at 5 MHz
Electrostatic Shielding With 1000 volts rms at 5 kHz on primary, secondary output corresponds to less than:	10^{-4} ampere turns through primary	10^{-5} ampere turns through primary
Maximum Insertion Impedance	0.0002 ohms	0.02 ohms

SPECIFICATIONS
SERIES 305 HIGH-PERFORMANCE PHASEMETERS

MAINFRAME SPECIFICATIONS

Frequency Range: 2 Hz to 11 MHz (see plug-in data)

Angle Ranges: 0.00° to ±180.00° or 0.00° to +360.00° manually or automatically selected. End-of-range measurement errors are prevented by 15° automatic guard zones.

Analog Output

Range: −1.8000 to +3.6000 Vdc corresponding to measured angle; 10.0 mVdc per degree

Accuracy: See plug-in specifications

Output Impedance: 100 ohms

DC Resolution: Infinite

Linearity: Approx. ±0.01°

Repeatability: Better than ±0.005°

Time Constants: Automatically selected; 10 ms for frequency >5 kHz, 50 ms >500 Hz, 350 ms >50 Hz, 700 ms >2 Hz (Note: 4.6 time constants to respond to better than 99% of step change).

Warm-up Drift: Approx. 0.05° after first minute.

Long Term Drift: Typically less than ±0.05° per month

Temp. Coefficient: Approx. ±0.001°/°C

Recommended Output Devices: Recorders, DVM's, A-D Converters, Printers

Self Check: Front panel switches; dc outputs correspond to −180.00°, 0.00°, +180.00° and +360.00°

Error Rejection: False triggers due to high frequency noise are locked out for signal to noise ratios better than 10:1. Errors and fluctuations due to waveform dissymmetry or low frequency noise reduced by at least 10 to 1.

Harmonic Rejection: Worst case errors due to even harmonic distortion reduced by approximately 5:1 without filters. Odd harmonics in-phase with fundamental contribute no error.

Operator Adjustments: None.

Operating Temp. Range: 0° to +50°C

Grounding: Independent grounds for signal, chassis, and power line. (For safety, chassis and power line grounds connected at factory.)

Remote Programmability (standard on all mainframes): By rear connector pins. Over-ride by contact closure of automatic time constant selection and angle range. Factory installed wiring from rear connector to plug-in for use with programmable plug-ins.

Modular Construction: Circuits on removable plug-in cards, extenders supplied for ease in servicing.

Size: 3½" high, 16" deep, 19" rack/portable package.

Weight: 20 lbs; shipping 30 lbs.

Power: 115/230 V, 50-400 Hz, <0.75 A (specify voltage and frequency when ordering).

Plug-In Accommodation: Accepts 305-PA-( ) plug-ins. Mainframes and plug-ins are interchangeable.

ANGLE PRESENTATION

	Model 305	Model 305B	Model 305C	Model 305D
DIGITAL				
Display	None	4 digit plus sign	5 digit plus sign	
Angle Ranges	Not Applicable	0.0° to ±180.0° and 0.0° to +360.0°	0.00° to ±180.00° and 0.00° to +360.00°	
Resolution	NA	0.1°	0.01°	
BCD Output	None	BCD coded (1248), 4 lines per digit plus polarity line; TTL/DTL compatible (<0.8 V to > +2.4 V dc). Read and hold on command, and data ready features available on rear connector.		
Warm-up Time	NA	30 minutes (1 minute with option 107)		
Zero & FS Controls	NA	Front panel for FS & O (no adjustments with option 107)		
ANALOG				
DC Output	10.0 mV/°; 0.0000 V to 3.6000 V and −1.8000 V to +1.8000 V corresponding to 0.00° to 360.00° and −180.00° to +180.00°; infinite resolution.			
DC Offset	None			Continuously adjustable angle offset. Analog panel meter and DC output indicate deviation from offset.

OPTIONS

#101 Rear connectors for signal and reference inputs, BNC[4]

#102 Full mainframe programmability; includes self check, angle range and time constant selection, DTL and TTL compatible.

#103 High speed analog output response. Time to respond to within 99% of step change: 1 ms for frequency >5 kHz, 10 ms >500 Hz, 100 ms >50 Hz, 1 second >5 Hz. (Temp. stability ±0.01°/°C)

#107 Automatic calibration checks and automatically readjusts digital readout and BCD output circuits and at 0° and 360° to reduce readout errors to ±0.01°. This option available only on 305C.

COMBINED PLUG-IN AND MAINFRAME SPECIFICATIONS

MODEL	FREQUENCY RANGE	INPUT LEVELS (independent)	INPUT Z	ACCURACY[2] WITH INDEPENDENT LEVELS UNLESS OTHERWISE INDICATED Analog output accuracy: As specified below. Digital phase accuracy: For model 305C, same as analog accuracy. For model 305B, add ±0.15° digital readout error to analog accuracy specified.
305-PA-3001 Auto Ranging Plug-in	2 Hz to 700 kHz	10 mV to 300 V rms up to 10 kHz and to 50 V rms up to 700 kHz; can be extended to 40 kV rms with Textronix probes. Each channel has automatic gain ranging, and lamps which indicate when level is below 50 mV and above 50 V rms.	1 megohm shunted with 40 pF	±0.05°, 50 mV to 50 V rms from 50 Hz to 50 kHz; typically ±0.03°, 50 mV to 50 V rms from 50 Hz to 50 kHz, ±0.05° to 10 Hz, ±0.1° to 250 kHz, and ±0.25° at other levels to 500 kHz.
305-PA-3002 Single Range Plug-in	2 Hz to 700 kHz	10 mV to 3 V rms[1]; can be extended to 3 kV rms with Textronix probes. Other ranges available on request.	1 megohm shunted with 40 pF	±0.05°, 50 mV to 500 mV rms from 50 Hz to 50 kHz; typically ±0.03°, 50 mV to 500 mV rms from 50 Hz to 50 kHz, ±0.05° to 10 Hz, ±0.1° to 250 kHz, and ±0.25° at other levels to 500 kHz.
305-PA-3005 High Frequency Plug-in	200 kHz to 11 MHz	1 mV to 3 V rms; manual level controls in 10 dB steps. Lamps indicate when inputs are out of range or when level controls are improperly set.	50 ohms	Broadband with equal inputs above 10 mV rms: ±0.4° from 200 kHz to 4 MHz; ±1° from 4 MHz to 11 MHz. With independent levels above 10 mV rms: ±1° up to 4 MHz and ±2° up to 11 MHz. Single frequency — above 10 mV rms: ±0.3° at any frequency from 200 kHz to 11 MHz at any fixed levels.
305-PA-3007 Programmable and Auto-Ranging Plug-in	2 Hz to 700 kHz	Auto-ranging: similar to levels of 305-PA-3001. Programmable: over-rides autoranging; extends low levels to 1 mV rms; DTL, TTL logic; program connector in rear of mainframe.	1 megohm shunted with 40 pF	Same as 305-PA-3001 for levels above 10 mV rms; typically ±0.35° from 50 Hz to 50 kHz for levels below 10 mV rms.
305-PA-3008 Power Freq. Plug-in	50-500 Hz without filters. 50 Hz, 60 Hz and 400 Hz L.P. filters available[3]	25 V to 250 V rms; .05 A to 5 A rms. Inputs are transformer isolated.	100 k ohm (voltage) 1 Ω max. (current)	At any single frequency, with filter set: ±0.1°, 25 V to 250 V rms, or 0.1 A to 5 A rms.
305-PA-3009 Network Analyzer (Gain/Phase/ Amplitude)	5 Hz to 700 kHz (Note: 305-PA-3009A operates to 1 Hz with 305 mod. 14)	10 mV to 40 V rms. Each channel has automatic gain ranging. Direct reading of phase angle, amplitude ratio and level of each input. Compatible with Tektronix probes.	1 megohm shunted with 40 pF	Phase: ±0.1° from 40 mV to 40 V rms from 50 Hz to 50 kHz; typically ±0.25° at all other levels from 5 Hz to 500 kHz. Voltage Amplitude: above 40 mV (channel A or B): ±2% reading ±0.03% FS, 50 Hz to 50 kHz; ±5% reading ±0.03% FS, 100 kHz to 500 kHz.[5] Ratio: ±0.5 dB, 50 Hz to 50 kHz; ±1 dB, 50 kHz to 500 kHz.[5]
305-PA-3010 Special Purpose Plug-in (with filter)	For use at 125 ±10 Hz; matched filters in both channels reject higher frequencies	500 mV to 5 V rms. Other ranges available on request.	1 megohm shunted with 40 pF	±0.1°, 500 mV to 5V rms; ±0.25°, 100 mV to 500 mV rms.
305-PA-3015 Selectable Filter Plug-in	5 Hz to 500 kHz without filters; uses 2 of type 305-PA-3008-( ) filters [3]; filter selection programmable	Ranges of 50-500 mV rms, 0.5 to 5 V rms, and 5-50 V rms selectable by remote contact closures.	1 megohm shunted with 40 pF	With filters, ±0.1° at fixed frequencies over all levels; without filters ±0.1° from 50 Hz to 50 kHz at all levels (typically ±0.03°), typically ±.25°, 5 Hz to 500 kHz.

(1) Can be provided for other voltage levels.

(2) For sinusoidal signal; can be used for square wave inputs over limited frequency range; can be used for amplitude modulated signals up to 97% modulation, depending upon model, level and frequency.

(3) 50 Hz filter, P/N 305-PA-3008-50; 60 Hz filter, P/N 305-PA-3008-60; 400 Hz filter, P/N 305-PA-3008-400. (Other frequencies available on request.)

(4) Available for use with 305-PA-3001, -3002, -3007 and -3010. Specify when ordering plug-in.

(5) For higher accuracy below 50 Hz, specify Model 305-PA-3009A.