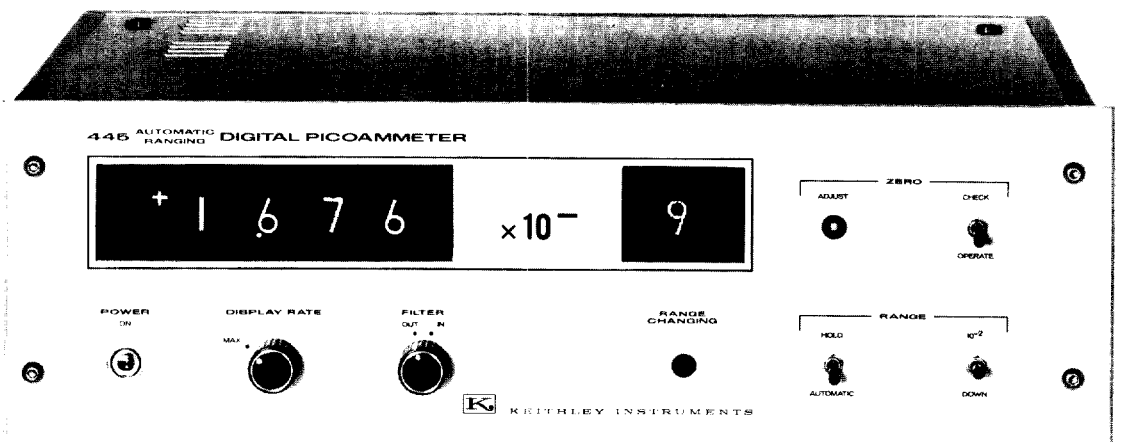
MODELS 445, 18000-20
PICOAMMETERS



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MODEL 445 DIGITAL PICOAMMETER

- *eight ranges from 10^{-9} to 10^{-2} A*
- *resolution to 10^{-12} A per digit*
- *accuracy from ±0.2% to ±0.5% of reading*
- *automatic ranging*
- *digital output and remote controls*
- ***can be calculator controlled — see page 16***

The Model 445 Digital Picoammeter is a fast, accurate and sensitive picoammeter. The Range dial, in line with the three digit display, is designated in engineering units with time-saving automatic decimal positioning for operator convenience. The 445 is designed for use in a wide range of applications in research, development and production, particularly in automated testing systems.

Individually calibrated ranges assure high accuracy. Internal adjustments assure that accuracy is maintained through years of use. Excellent immunity to power line interference allows the Model 445 to detect small dc signals in the presence of noise. Connection to the current source is simple and quick, and little shielding of the leads and input is necessary. Complete overload protection is provided in the input circuit. To prevent gathering inaccurate data, the digital display is blanked during overload. Overload recovery is almost instantaneous.

Autoranging of the 445 is fast and stable. It will sweep through all of its eight ranges in less than 500 milliseconds. Changes over a smaller number of ranges require still less time.

Range changing of the 445 Picoammeter, indicated by a front panel light, is uni-directional, from the less sensitive to the most sensitive range. An under-range condition — less than 100 digits — causes one range change to the next more sensitive range. If the input signal increases beyond 1999 digits on any range, the 445 returns to the 10^{-2} ampere range and then downranges to the most sensitive on-scale range.

The 445 has buffered BCD outputs (1-2-4-8, positive true logic) for all information — digital display, range, polarity, overload, zero check and range changing. All data outputs change simultaneously, so that the data presentation is coordinated.

Multiple inputs can be added to the 445 with the Keithley 702/7028 Low-current Scanner (see page 19). For automatic data collection and analysis, the 445 can be incorporated into the Keithley System 1 — a calculator-based system for automatic data acquisition and reduction (page 16).

MODEL 18000-20 PROGRAMMABLE LINEAR PICOAMMETER

1/4 actual size

- *six ranges from 10^{-10} to 10^{-5} A*
- *remotely programmable*
- *0.5 millisecond response at 10^{-8} A*
- *zero stability better than ±0.5% per week*

The Model 18000 is a versatile high-speed, programmable linear picoammeter designed for computer-controlled or automated low-current measurements where signal lead lengths and physical location are critical to the measurement.

Its sensitivity, fast response, stability and low power consumption show its adaptability for custom installation in analytical instrumentation, nuclear monitoring systems or component test sets.

Custom modification of the 18000 is possible for adaptability to a particular application. Modifications are possible for increasing the response speed, changing range selection logic, changing scale factor or range combination, or adding ranges.

Your local Keithley measurement engineer is ready to discuss the adaption of the Model 18000 to your measurement problem.

RANGE: 10^{-9} ampere full scale (10^{-12} ampere, least significant digit) to 10^{-2} ampere in eight decade ranges with 100% overranging on all ranges.
DISPLAY: Four digits from 000 to 1999; range exponent digit from 2 to 9; polarity, overload and Range Changing indication.
POLARITY: Automatic.
RANGE SELECTION:
Automatic: Range change possible after each A to D conversion. An underrange condition (<100 digits) causes one range change to next more sensitive range. An overrange condition (>1999 digits) on any range causes range change to 10^{-2} ampere range.
Manual: Front panel switches permit manual range control.
ACCURACY AND RESPONSE TIME:

Range ampere	Calibrated Accuracy[1] (% of reading)	Range Resistor Stability	Range Resistor Temperature Coefficient	Analog Rise Time[3] (10%-90%)
10^{-2} to 10^{-4}	±0.2%±1 digit	0.01%/yr.	.005%/°C	Less than 1 ms
10^{-5}	±0.2%±1 digit	0.05%/yr.	.015%/°C	4 ms
10^{-6}	±0.2%±1 digit	0.5%/yr.	.015%/°C	5 ms
10^{-7}	±0.4%±1 digit	1%/yr.	.05%/°C	8 ms
10^{-8}	±0.5%±1 digit[2]	2%/yr.	.05%/°C	20 ms
10^{-9}	±0.5%±1 digit[2]	3%/yr.	.2%/°C	40 ms

1. Calibrated at factory (23°C ambient). Internal adjustments on 10^{-9} to 10^{-5} ampere ranges for recalibration.
2. ±2 digits with minimum damping and 500 picofarads shunting the input.
3. With minimum damping and up to 500 picofarads shunting the input.

DAMPING: Filter improves ac rejection by lengthening rise time to approximately ¾ second on 10^{-7} to 10^{-9} ampere ranges.
ZERO DRIFT: Less than 0.5% of full scale per week; less than 0.05%/°C, after ½-hour warm-up with source voltages greater than 2 volts.
DISPLAY RATE: 24 readings per second maximum (20 per second with 50 Hz units) adjustable to approximately 1 reading per two seconds. (With Filter in, max. display rate is about 1 reading per second).
INPUT DROP: Less than 1 millivolt for full-scale display on all ranges when properly zeroed.
LINE FREQUENCY REJECTION: 60 dB (ratio of peak-to-peak current of power line frequency or multiple which will cause less than 1 digit of error, to that error). Peak input current should not exceed 20 milliamperes. 100 dB on 10^{-9} to 10^{-7} ampere ranges with Filter in.
MAXIMUM OVERLOAD: 1000 volts using a Keithley or other current limited (up to 20 milliamperes) High Voltage Supply with Model 445 in autorange mode. Instantaneous input current must never exceed 125 milliamperes.
ANALOG OUTPUT: ±1 volt from a 500-ohm source for full-scale display. Maximum output, 1 milliampere. Output polarity is opposite input polarity.
ISOLATION: Circuit ground to chassis ground isolation is greater than 10^{8} ohms shunted by .02 microfarad. Circuit ground may be floated up to 100 volts with respect to chassis ground.
COMMON MODE REJECTION: 100 volts dc or 200 volts p-p at line frequency will not affect reading.
DIGITAL OUTPUTS: BCD positive output represents each of the four digits, range, polarity, overrange and zero check. Standard code is 1-2-4-8. "0" <+0.4 volt; "1" >+10 volts at up to one milliampere; 0 = 0000.
Print Command: Positive pulse of 14 volts from a 2200-ohm source with 1 volt per microsecond rise time. 100 microseconds minimum pulse width. Print command given after each A to D conversion.
Remote Controls:
Hold #1: Closure* to ground inhibits A to D conversion at that instant.
Hold #2: Closure* to ground inhibits A to D conversion after reading has been completed.
Trigger: Closure* to ground initiates one conversion when in Hold #2. Integration period starts 8.3 ms (10 ms on 50-Hz models) after "Trigger" or release of Hold #2.
Connector: 50-pin Amphenol Micro-Ribbon. Output mating connector supplied with 4401.
*or saturated NPN transistor.
CONNECTORS: Input: Teflon-insulated triaxial. **Output:** Amphenol 80-PC2F. **Ground:** Binding posts.
POWER: 105-125 or 210-250 volts (switch selected), 60 Hz. 50 Hz models available. 30 watts.
DIMENSIONS, WEIGHT: Standard 133 mm x 483 mm (5¼ in. x 19 in.) rack mounting 305 mm (12 in.) depth behind front panel; net weight, 5,8 kg (13 lbs.).
ACCESSORIES FURNISHED: Model 6011 Input Cable: 0,9 m (3 ft.) triaxial cable with triaxial connector and 3 alligator clips.
ACCESSORIES AVAILABLE: (See ACCESSORIES, pages 60 through 63.)
Model 3001 Bench Mounting Kit ..... $ 35
Model 4406 Extender Cards (Card Puller included) ..... $ 67
Model 6011 Input Cable (extra) ..... $ 53
Model 6012 Triaxial-to-Coaxial UHF Adapter ..... $ 33
Model 6106 Electrometer Connection Kit $175
PRICES: (For export pricing see inside front cover.)
Model 445 Automatic Ranging Digital Picoammeter (60 Hz) **$1995**
50 Hz models available at slight extra cost.

Expand the performance of the Model 445 through the use of Keithley Scanners and Digital Printer (see page 18), or Calculator-based Systems (see page 16) for automatic data acquisition and control of your measurement.

RANGE: ±10^{-10} ampere for full output to ±10^{-3} ampere in decade steps.
RANGE SELECTION: Three line binary input, "0" (000) corresponds to the 10^{-10} ampere range, "7" (111) corresponds to the 10^{-3} ampere range. Logic level is DTL compatible (0 = closure to ground, 1 = +5 volts). Range Switching Time: Less than 2 milliseconds to any range, 10^{-3} through 10^{-8} ampere. Less than 10 milliseconds to the 10^{-9} or 10^{-10} ampere ranges.

Range ampere	Rise Time (10%-90%)	Noise p-p (% of full output)
10^{-3}	0.2 milliseconds	0.1%
10^{-4}	0.2 milliseconds	0.1%
10^{-5}	0.2 milliseconds	0.1%
10^{-6}	0.2 milliseconds	0.1%
10^{-7}	0.5 milliseconds	0.1%
10^{-8}	0.5 milliseconds	1.0%
10^{-9}	2.0 milliseconds	2.0% (Typical)
10^{-10}	2.0 milliseconds	*

*Typically 3% with 10 picofarads shunting input, 5% at 50 pF, increasing to 15% at 500 pF). Transfer Function (= Δ Eout/ΔIn) is factory adjusted to within 1% of nominal. Internal adjustments are provided for recalibration.

ZERO DRIFT: Less than ±0.5% of full output per week, noncumulative; better than 0.05% of full output per °C after ½-hour warm-up. Voltage offset is adjustable to zero. Offset current is less than 10^{-11}A.
INPUT DROP: Less than 5 millivolts.
MAXIMUM OVERLOAD: Transient: 1000 volts from a capacitance 0.01 microfarad. **Continuous:** 30 volts (or 10 milliamperes current from a current-limited supply). Recovery from overload within 10 milliseconds.
ANALOG OUTPUT: ±10 volts at up to 2 milliamperes, noninverting.
CONNECTORS: Input: Microdot S-50 ohm series, screw type. **Output:** 15-pin card-edge with 0.156 in. spacing.
POWER: ±15 volts regulated to ±1%. 10 mA. Power requirement is ±15 volts with 1% regulation, current consumption is +30 and -10 milliamperes. Other options available on special order.
DIMENSIONS, WEIGHT: 25 mm high x 76 mm wide x 127 mm deep (1 in. x 3 in. x 5 in.); Net weight, 184 g (6½ ounces).
ACCESSORIES FURNISHED: Mating Input Connector, Mating card-edge connector for Output, Power, and Range Control.
PRICE: (For export pricing see inside front cover.)
Model 18000-20 High Speed Current Amplifier **$895**