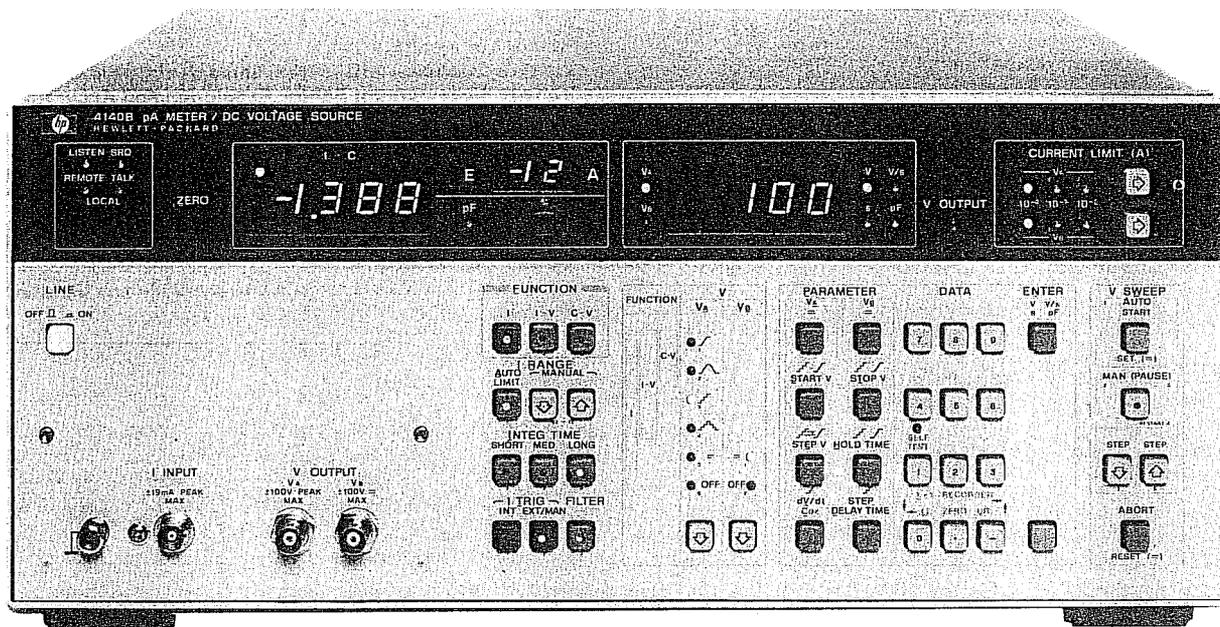


# SEMICONDUCTOR TEST EQUIPMENT

## pA Meter/DC Voltage Source

### Model 4140B

- 3 basic semiconductor measurements: I, I-V and quasi-static C-V
- Two programmable voltage sources
- Basic accuracy: 0.5%
- High resolution:  $0.001 \times 10^{-12}$
- HP-IB standard



HP 4140B



### Description

The HP 4140B pA Meter/DC Voltage Source is another in Hewlett-Packard's new generation of Component Measurement instrumentation. It consists of an extremely stable picoampere meter and two programmable dc voltage sources, one of which operates as a ramp and staircase generator as well as a dc source. These features make the HP 4140B ideal for making dc characteristic measurements such as leakage current, current-voltage characteristics and quasi-static C-V measurements required by the semiconductor industry for new product development and for improving production yields. It is equally useful in measurements of electronic components and materials to determine leakage currents or insulation resistances.

The HP 4140B can contribute to the development, production and quality control of semiconductor devices and to the improvement in the reliability of electronic components and equipment.

### Stable pA Measurements

Stable picoampere measurements can be made with the HP 4140B with a maximum resolution of  $10^{-15}$  A. This is made possible by a new measurement technique in conjunction with an offset current capability, low noise test leads, and an electrostatic and light shielded test fixture. These features provide both stable and fast picoampere measurements.

This measurement technique is very useful in making small leakage current measurements and determining dc parameters of semiconductor devices or measuring the insulation resistance and leakage current for dielectric absorption measurements necessary in the analysis of capacitors or insulation materials.

### Synchronized I-V Measurements

The HP 4140B makes automatic, synchronized current-voltage measurements that have required a large instrumentation system in the past.

The two voltage sources in the HP 4140B operate over a range of  $-100$  V to  $+100$  V with a maximum resolution of 10 mV. One operates only as a stable dc source while the other generates a staircase voltage, a precise ramp or a stable dc level.

By adding precise, programmable timing capability, we can now make fast, accurate I-V and C-V measurements. Device stabilization times, (time between the applied voltage and the subsequent current

measurement) can now be programmed from the front panel of the HP 4140B or via the HP-IB bus.

### Quasi-Static C-V Measurements

Automatic quasi-static C-V measurements are easily accomplished by the ramp voltage capability of the HP 4140B. This measurement is highly significant in evaluating basic semiconductor characteristics.

The HP 4140B operates over a capacitance range of 0.1 pF to 1999 pF with a dc voltage ramp rate of 1 mV/s to 1 V/s in 1 mV/s increments. Capacitance, which is calculated from the measured current divided by the ramp rate, can also be provided as a percent of the capacitance of the oxide film ( $C_{ox}$ ) over a range of 0.0 to 199.9%. By providing the output voltage at each capacitance measurement point, we have the dc (quasi-static) C-V characteristics of the device under test.

### HP-IB Capability

Interfacing the HP 4140B to an HP-IB system improves measurement efficiency and takes advantage of its high speed (approx 5 ms) measurement rate. Such a system will minimize measurement time of dc parameters of semiconductors and the insulation resistance and leakage current of electric components and materials. This allows rapid feedback to production for fast evaluation of a new device in the development stage.

### Specifications

**Measurement functions:** I, I-V and C-V

**Voltage sources:** two separate sources ( $V_A$  and  $V_B$ )

$V_A$ :  $\pm 100$  V programmable source/function generator

$V_B$ :  $\pm 100$  V programmable dc voltage source

**Measurement Function/Source Selection**

Function	$V_A$	$V_B$
I		--- (DC)
I-V		--- (DC)
C-V		--- (DC)

**Voltage sweep:** auto or manual (pause)

**Current Measurements**

**Displays:** current, 3½ digits with 2 character annunciator. Voltage, 3½ digits.

**Measurement range:**  $\pm 0.001 \times 10^{-12}$  A to  $1.000 \times 10^{-2}$  A full scale in 11 ranges.

**Overrange capability:** 99.9% on all ranges.

**Range selection:** auto (lowest current range is selectable) and manual

**Measurement Accuracy/Integration Time**

Range	Accuracy* ± (% of rdg. + counts)	Integration Time** (ms)		
		Short	Medium	Long
$10^{-2} - 10^{-9}$	0.5 + 2	20	80	320
$10^{-10}$	2 + 2			
$10^{-11}$	5 + 3	80	320	1280
$10^{-12}$	5 + 8	160	640	2560

\* Accuracy for long integration time. 23°C ± 5°C. humidity ≤ 70%. For short and medium integration time, see reference data section.

\*\* Integration times specified at 50 Hz. For 60 Hz operation, multiple time by %.

**Zero offset:** cancels leakage current of test leads or test fixtures.

**Offset range:** 0 to  $\pm 100 \times 10^{-15}$  A.

**Trigger:** INT, EXT and HOLD/MAN

**Input terminal:** triaxial

**Capacitance-Voltage (C-V) Measurement**

**Measurement ranges:** 0.0 pF – 100.0 pF and 200 pF – 1000 pF full scale in two ranges; 99.9% overrange

**Ranging:** auto

**%C:** capacitance change of device under test is displayed as a percent of the set value of the oxide capacitance ( $C_{ox} = 100\%$ )

**%C range:** 0.0% – 199.9%

**Cox setting ranges (2 ranges):** 0.1 pF – 199.9 pF and 200 pF – 1999 pF

**Capacitance calculation accuracy:** accuracy is dependent on accuracy of both the current measurement and ramp voltage.

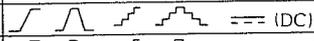
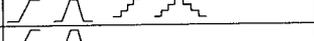
**Zero offset:** cancels stray capacitances of test fixtures and test leads.

**Offset range:** 0 to 100 pF

**High speed I data output:** available with HP-IB interface only. Outputs current measurement data at 4 ms intervals (max rate).

**DC Voltage Sources**

**Output Modes,  $V_A$  and  $V_B$**

Function	$V_A$	$V_B$
I		=== (DC)
I-V		=== (DC)
C-V		

**Voltage ranges ( $V_A$  and  $V_B$ ):** 0 to  $\pm 10.00$  V and 0 to  $\pm 100.0$  V in 2 ranges, auto range only.

**Maximum current:** 10 mA, both sources.

**Voltage sweep:** auto and manual (pause), up/down step in manual (pause) mode. Sweep abort standard.

**Operating Parameter Setting Ranges**

**Start voltage and stop voltage:** 0 –  $\pm 10.00$  V, 0.01 V steps; 0 –  $\pm 100.0$  V, 0.1 V steps

**Step voltage:** 0 –  $\pm 10.00$  V, 0.01 V steps; 0 –  $\pm 100.0$  V, 0.1 V steps

**Hold time:** 0 – 199.9 seconds in 0.1 s increments; 0 – 1999 seconds in 1.0 s increments

**Step delay time:** 0 – 10.00 seconds in 0.01 s increments; 0 – 100.0 seconds in 0.1 s increments

**Ramp rate (dV/dt):** 0.001 V/s – 1.000 V/s in 0.001 V/s increments

**Accuracy (at 23°C ± 5°C)**

**Output voltage:**  $\pm 10$  V,  $\pm(0.07\% + 11 \text{ mV})$ ;  $\pm 100$  V,  $\pm(0.09\% + 110 \text{ mV})$

**Linearity:** typically 0.5%, 0 –  $\pm 10$  V; < 5%, > 10 V.

**Current limit:** 100  $\mu$ A, 1 mA and 10 mA,  $\pm 10\%$  ( $V_A$  and  $V_B$ )

**Output terminals:** BNC; L-GND

**Reference Data**

**Current Measurement**

**Current Measurement Accuracy\***

Range	Integration Time	
	Short	Medium
$10^{-2} - 10^{-8}$	0.5 + 3	0.5 + 2
$10^{-9}$	0.5 + 3	0.5 + 3
$10^{-10}$	2 + 4	2 + 3
$10^{-11}$	5 + 10	5 + 4
$10^{-12}$	5 + 20	5 + 10

\* ± (% of rdg. + counts), 23°C

**Current ranging times\*:** 20 ms to 7.76 s. (longer ranging time needed for large changes in input signal level, especially on lowest current ranges).

\*When FILTER is on, current ranging time increases 60 ms (50 Hz power line) or 50 ms (60 Hz power line)

**Warm-up time:** ≥ 1 hour

**Common mode rejection ratio:** ≥ 120 dB (≤ 2 counts)

**Analog Output I, C and  $V_A$**

**Accuracy:**  $\pm(0.5\% + 20 \text{ mV})$

**Low pass filter:** 3 position: OFF, 0.22 s  $\pm 20\%$  and 1 s  $\pm 20\%$  applied to both  $V_A$  and I/C data outputs

**Pen lift output:** TTL low level (≤ 0.8V) during sweep period in I-V and C-V functions

**Recorder output scaling:** pushbutton scaling of lower left and upper right limits of X-Y recorder

**HP-IB Interface**

**Remote controlled functions:** measurement function, current range, integration time, I data output trigger, voltage sweep controls, current limit,  $V_A$  and  $V_B$  voltages, zero (offset), self test and parameter settings (voltages, sweep/hold/delay times)

**Data Output**

Measured data (I, C and  $V_A$ ),

Voltage setting ( $V_A$  and  $V_B$ ),

Parameter settings

**General Information**

**Power:** 100, 120, 220, V  $\pm 10\%$ , 240 V  $+5\% - 10\%$ ; 48-66 Hz, 135 VA max

**Size:** 426 mm W x 177 mm H x 498 mm D (16.5" x 7" x 19.6")

**Weight:** 14.4 kg (31.7 lb)

**Accessories Furnished**

**HP 16053A test leads:** consists of one triaxial cable, two each BNC-BNC cables and one connection plate with mating female panel-mount connectors. Cables are one meter in length.

**HP 16055A test fixture:** for general device measurements. Provides electrostatic and light shielding for stable pA measurements.

**Accessories Available**

**HP 16054A connection selector:** provides a simple method to select appropriate connection of low lead for the pA meter section.

**HP 16056A current divider (10:1):** for use only on the 10 mA range to extend the measurement capability to 100 mA.

**Ordering Information**

**Accessories**

HP 16054A Connection Selector

HP 16056A Current Divider (10:1)

**Options**

Opt 907 Front Handle Kit (HP P/N 5061-0090)

Opt 908 Rack Flange Kit (HP P/N 5061-0078)

Opt 909 Rack & Handle Kit (HP P/N 5061-0084)

Opt 910 Extra Manual

HP 4140B pA Meter/DC Voltage Source