

HP 4280A 1MHz C Meter/C-V Plotter



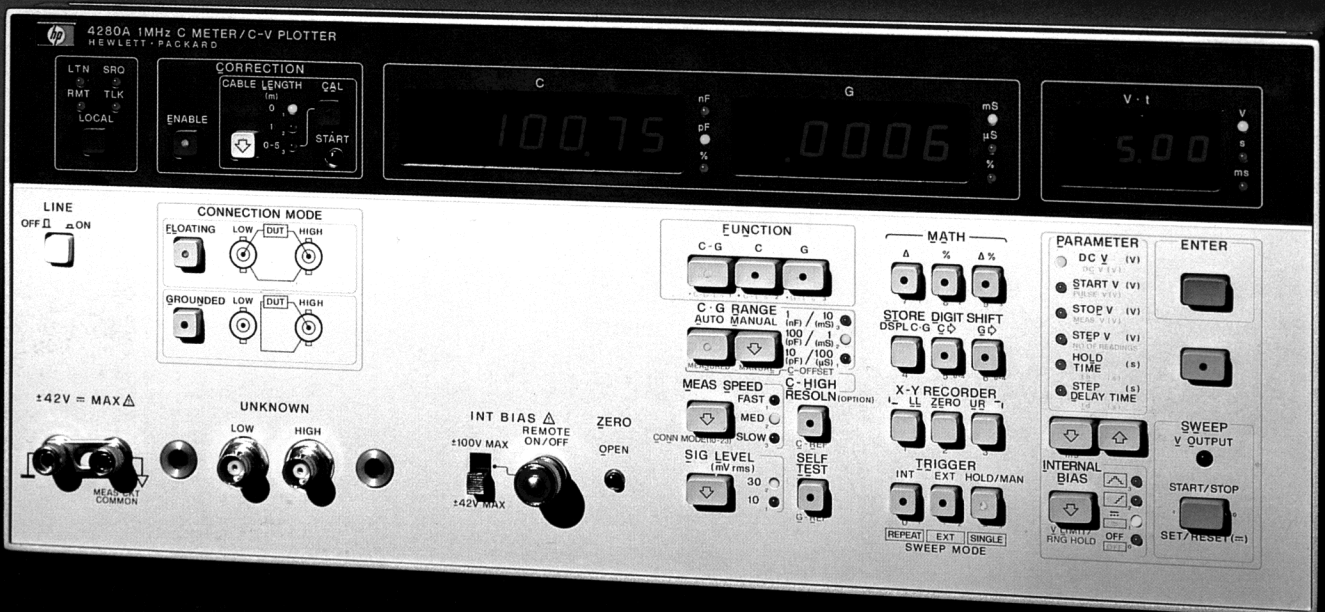
Fast, High Resolution Capacitance and Conductance Testing with Built-in Staircase and Pulsed Bias

Technical Data August 1988

This literature was published years prior to the establishment of Agilent Technologies as a company independent from Hewlett-Packard and describes products or services now available through Agilent. It may also refer to products/services no longer supported by Agilent. We regret any inconvenience caused by obsolete information. For the latest information on Agilent's test and measurement products go to:

www.agilent.com find products

Or in the US, call Agilent Technologies at 1-800-452-4844 (8am-8pm EST)



■ C-V Characteristics

■ C-t Characteristics

4280A Applications

Capacitance and Conductance With or Without Constant DC Bias

HP's 4280A 1MHz C Meter/C-V Plotter can measure and display capacitance and conductance. A 1MHz test signal with level of 10mVrms or 30mVrms is used.

Internal DC bias ($\pm 100V$) can be applied when needed.



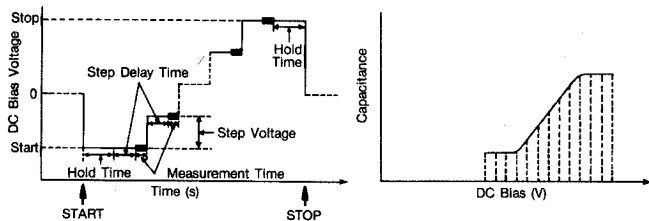
4280 Front Panel Displays C,G and DC bias

Test Floating and Grounded Devices

Both Floating and Grounded devices can be tested. This is important because wafer probers will have either floating or grounded chucks. Both configurations are in common use.

Capacitance and Conductance Using Staircase Bias Sweep

4280's built-in $\pm 100V$ DC bias supply can be controlled from the front panel to sweep in staircase fashion. Capacitance and conductance can be measured at each step.



Hold Time: Initial wait time
Step Delay Time: Wait time after each voltage increment

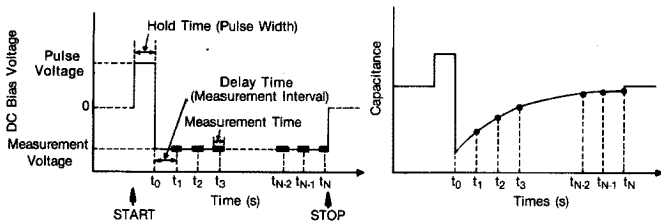
Hard Copy Output

C-V and G-V measurements require no external equipment and are internally synchronized. Results can be output to analog X-Y recorders or to computers via HP-IB (IEEE 488).

Capacitance and Conductance vs. Time (Pulse Bias)

Minority carrier lifetime and surface generation velocity in MIS structures can be obtained using C-t results. 4280A uses two different C-t methods depending on measurement resolution required on the time axis.

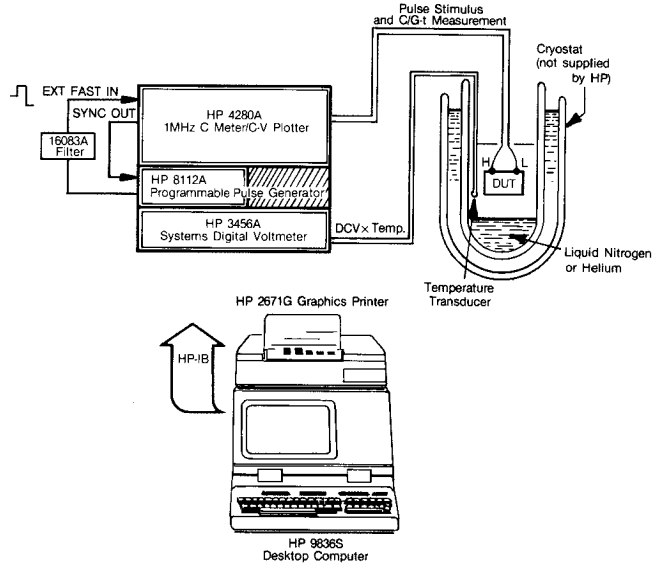
Delay time is the time between measurements. When delay time is set to 10 milliseconds or greater, the 4280A will apply a single pulse to the device under test. Then a BURST of measurements are made.



When delay time is less than 10 milliseconds, an external pulse generator like HP's 8112A must be used. The external pulse generator applies repetitive pulses to the device under test. The 4280A makes a single measurement after each pulse. In the SAMPLING MODE, the 4280A provides synchronization signals to the external pulse generator.

Deep Level Transient Spectroscopy (DLTS) - Example of Pulse Bias Application

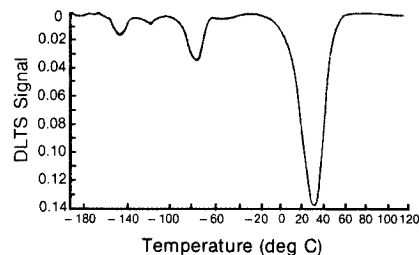
DLTS is used to analyze semiconductor imperfections which effect IC performance. Small imperfection concentrations which are too small for analysis by C-V techniques can often be analyzed by DLTS.



High speed C-t testing and variable supercooled temperature are major requirements of DLTS test systems. Shown here is system hardware including HP's 4280A for C-t testing with pulses of 10ms to 32 sec in duration. HP's 8112A pulse generator is added when pulse duration shorter than 10m sec is required.

DLTS is a high-frequency capacitance transient thermal scanning method useful for observing a wide variety of traps in semiconductors. This new technique, aimed at studying these centers, uses the capacitance of a p-n junction or Schottky barrier as a probe to monitor the changes in the charge state of the centers. Complete C-t characteristics are obtained at multiple supercooled temperatures.

Real devices have multiple trap levels and different trap concentrations. Resulting DLTS curve has multiple peaks as shown below.



Important parameters which can be derived from DLTS include: 1) surface state density, 2) trap concentration, 3) energy level of traps, and 4) trap capture cross section.

Advantages offered by HP's 4280A are to expand the range of analysis to shallower energy levels by offering resolution to $10\mu s$ when synchronized to an external pulse generator like HP's 8112A.

HP'S 4280A Offers New Measurement Capabilities

Introduction

Hewlett-Packard's Model 4280A 1MHz C Meter/C-V Plotter offers new measurement capability and flexibility for the design and production of IC's. Benefits are improved IC quality and improved engineering productivity.

HP's 4280A has capability previously requiring the following complicated test set up: 1) capacitance/conductance meter, 2) function generator, and 3) computer for test synchronization.

New measurement capability is featured in transient C-t measurements with 10 microsecond resolution. Such testing is used to analyze deep level impurity concentrations which effect IC performance. Transient C-t resolution of 10 microseconds is up to 1000 times better than ever before available. 4280A features 10ms C-t resolution using internal pulse generator. Add HP 8112A pulse generator or equivalent to achieve 10 μ s resolution.

Convenience features include the ability to test both floating and grounded devices. Also 4280A's has capability to compensate a wide range of stray impedances. This helps eliminate the effect of test fixture residuals.

4280A Front Panel Features

1 HP-IB - Construct Your Own System

Standard on 4280A, HP-IB can help you construct an automatic system. Such systems are used in applications ranging from materials research, device R&D, process engineering, wafer production and quality assurance.

2 Residual Compensation and Capacitance Offset

Compensate test fixture residuals including up to 5 meters of standard cable (HP P/N 8120-4195). Also use with Option 001 when offsetting large values of capacitance to obtain extra digit of resolution on 100pF/1nF ranges.

3 Capacitance Digital Display

Standard capacitance display resolution will be 3½ digits or 4½ digits depending on test conditions. Option 001 features 5½ digit capacitance resolution using capacitance offset function. This display also can show deviation.

4 Wide Capacitance Measurement Range

Capacitance measurement range is from 0.001pF to 1.9000nF.

5 Conductance Digital Display

Standard conductance display resolution will be 3½ digits or 4½ digits depending on test conditions. This display also shows deviation.

6 Wide Conductance Measurement Range

Conductance measurement range is from 0.01 μ S to 12.000mS.

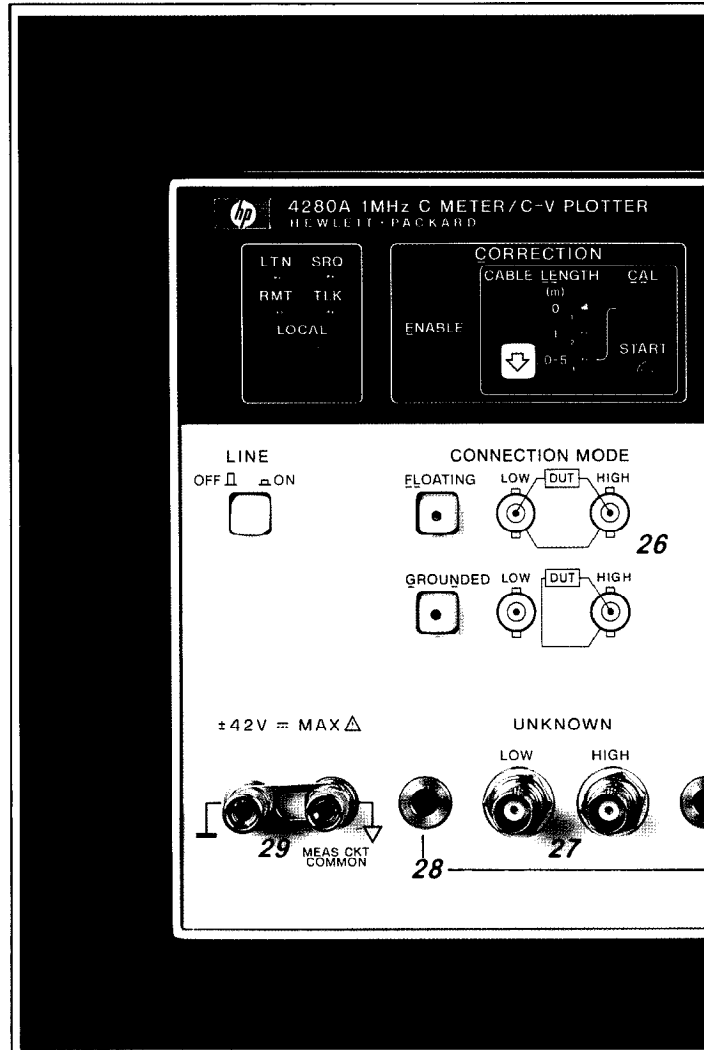
7 DC Bias and Time Display

DC bias parameters in volts or time in seconds is displayed depending on operating mode.

8 Wide Range of DC Bias and Time

DC bias can be varied in $\pm 100V$ range. Bias can be 1) constant, 2) staircase sweep (C/G-V) or 3) pulsed (C/G-t).

V-t display shows values of voltage staircase sweep parameters in C/G-V modes. These parameters include hold time, and step delay time. V-t display also shows C/G-t parameters like delay time.



9 Enter Numeric Values of Voltage and Time

After selecting bias and time parameters and keying in numeric values, this key enters value into 4280A memory.

10 Numeric Data Ready to Enter

This LED must be lit before numeric sweep parameter can be entered.

11 Sweep Start/Stop

Start/Stop key controls DC bias and time sweep output. V output LED lights when bias voltage is applied.

12 Select Sweep Parameter or Constant DC Bias

Use up/down keys to select constant DC bias voltage or time sweep parameter. Enter numeric values using numeric keys.

13 Select Bias Mode/Limit Output Voltage/Hold Range

Multi function key selects DC bias mode. Also allows entry of DC bias voltage limit from numeric keys and acts as Range Hold key.

14 Display Deviation, Percent or Deviation Percent

Perform math operations and display results on C/G displays.

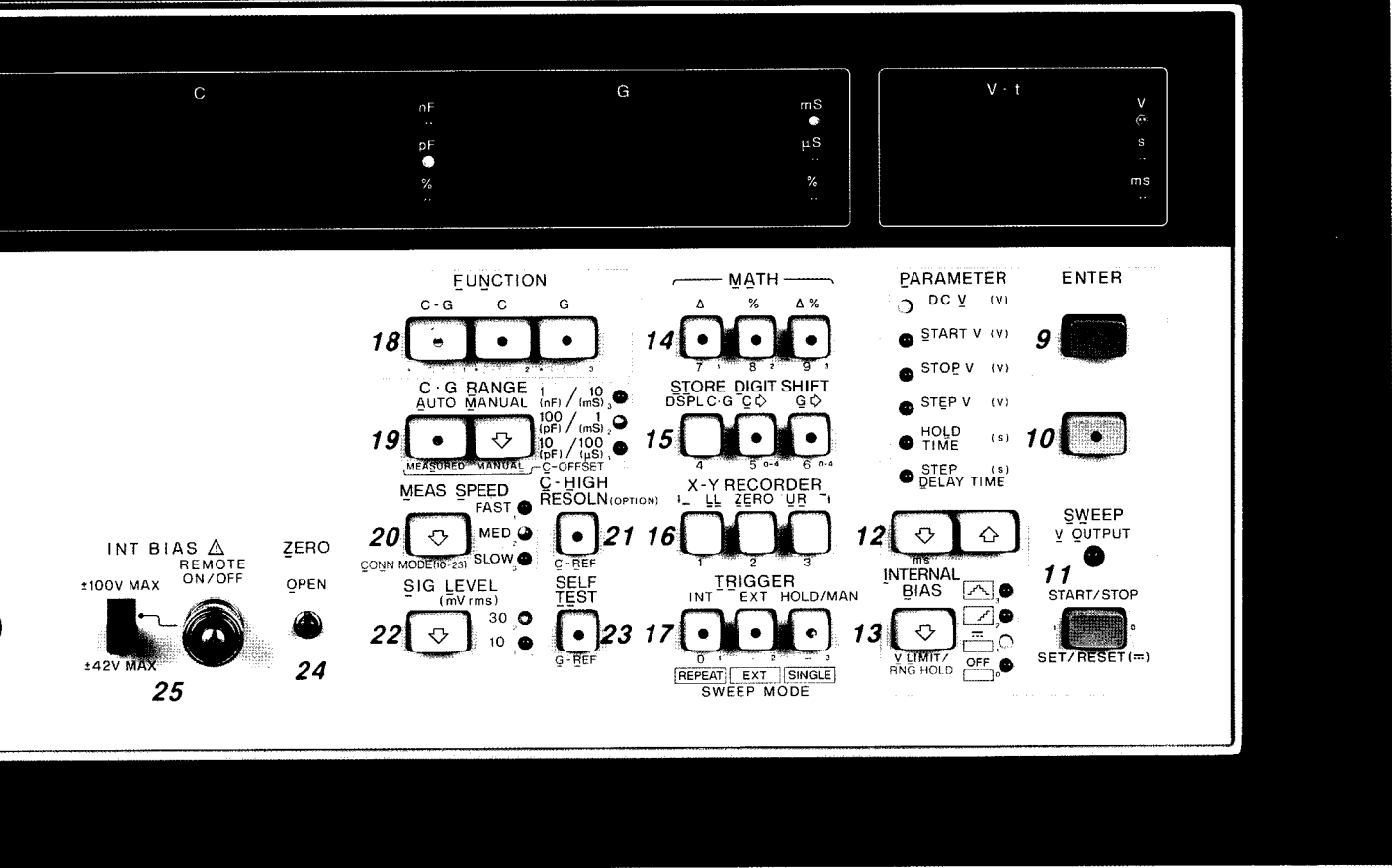
15 Change Number of Display Digits

Reduce number of display counts to less than 1000. Use before X-Y recording

16 Set-up X-Y Recorder

Analog output voltage represents C/G display counts and DC bias/time sweep. Establish origin and size of X-Y plotting area.

Ability for Design and Production of IC'S



17 Trigger and Sweep Mode Control

In sweep mode, this key selects single or repetitive sweep triggered from front panel, or select single sweep triggered externally. Also can trigger single measurement internally or externally.

18 Select Display Function

In C only function, G displays blanks and vice versa. Advantage is test speed approximately doubles.

19 Measurement Range Control

Manual ranging may be needed during X-Y recording. Also needed using C offset capability to obtain one extra digit of C resolution.

20 Measurement Speed Control

Fast mode requires approximately 70ms per measurement in C or G only modes and 150ms per measurement in C and G mode. Medium mode requires approximately 100ms per measurement in C or G only modes and 190ms per measurement in C and G mode.

Slow mode requires approximately 330ms per measurement in C or G only mode and 520ms in C and G mode. (Advantage is noise rejection and in some cases 1 more digit display resolution).

21 Add One Digit to Capacitance Resolution

Option 001 and C-offset enables one extra digit of resolution on 100pF and 1nF ranges.

22 Select From Two Test Levels

Choose 30mVrms or 10mVrms AC test level.

23 Verify Normal Operation

Self test does not check calibration.

24 Compensate Fixture Residuals

With fixture open, store residual capacitance and conductance. Residuals are compensated when CORRECTION ENABLE is turned on.

25 Protection From High Voltage Bias.

When switch is in $\pm 42V$ position, shorting cap has no effect. Max output is $\pm 42V$.

When switch is in $\pm 100V$ position - center pin and shield of Remote on/off connector must be shorted to turn bias on. This should be accomplished by removing shorting cap and shorting center pin to shield through remote switch.

26 Test Floating or Grounded Devices

Floating devices can be tested over 4280A's entire measurement range. Grounded devices can be tested in top two ranges only (100pF/1mS and 1nF/10mS ranges).

27 Two Terminal Pair

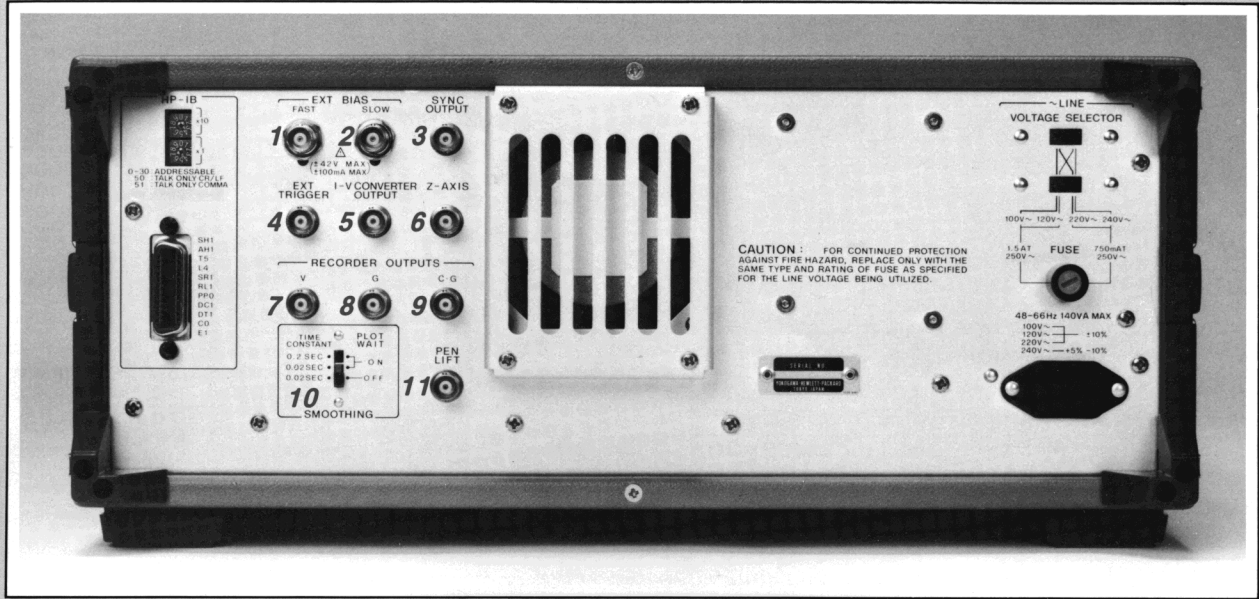
Hi and Low terminals have guard on coaxial shields.

28 Mounting Guides for 16080A and 16081A Fixtures

16080A, 16081A and 16082A fixtures mounts directly on 4280A front panel. These guide holes accept fixture guide pins.

29 Connect Circuit Ground to Chassis Ground

4280A Rear Panel Features



1 Input Fast Pulses from External Pulse Source

Use during C-t, G-t, C&G-t "sampling" mode operation. This pulse input can be summed with DC offset from 4280A internal bias or EXT SLOW bias.

2 Input Slow Pulses from External Pulse Source

Use during C-t, G-t, C&G-t "burst" mode operation. This pulse input can be summed with DC offset from 4280A internal bias.

3 Synchronize External Pulse Source

TTL output signal provides synchronization to external pulse source like HP 8112A.

4 Start a Measurement or Sweep Using External Trigger

External trigger must be 0.4 to 2.4V.

5 Monitor 4280A I-V Converter Output.

When 4280A front panel displays are blanked during fast measurements—connect this output to an oscilloscope to monitor 4280A's I-V converter.

6 Z-Axis Blanking for Oscilloscope.

7 V Recorder Output

a) Use in C-V, C&G-V, C-t, G-t, C&G-t modes to drive recorder X-axis: $\pm 10V$ for 1000 data points (20mV resoln).

b) Use in C only mode with TRIGGER HOLD/MANUAL to drive recorder X-axis: $\pm 10V$ for 1000 data points (20mV resoln).

8 G Recorder Output

Gives counts in G display: $\pm 10V$, ± 1000 counts (10mV resoln).

9 C-G Recorder Output

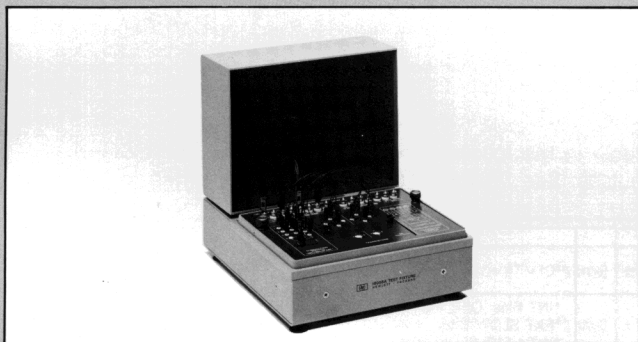
a) Use in C, C-V, C-t, C&G-V, C&G-t modes to give C display counts: $\pm 10V$, ± 1000 counts (10mV resoln).

b) Use in G, G-V, G-t modes to give G display counts: $\pm 10V$, ± 1000 counts (10mV resoln).

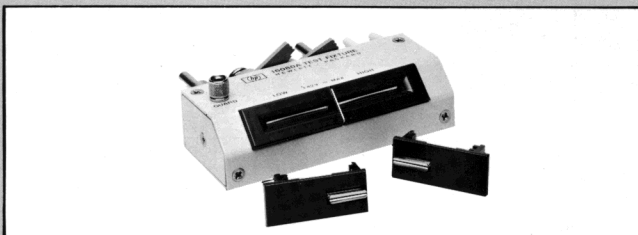
10 Smooth recorder outputs.

11 Pen Lift outputs TTL level.

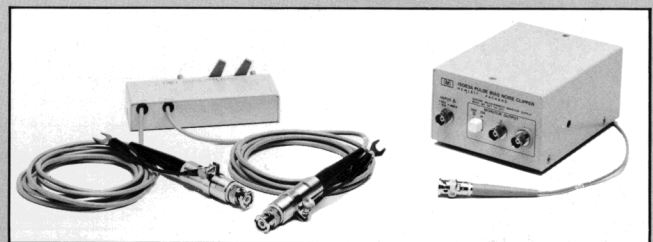
Accessories



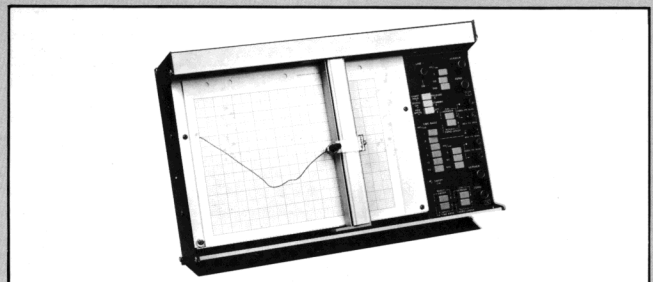
16058A: Test Fixture for Packaged Semiconductor Testing.



16080A: Test Fixture (furnished with 4280A).



16081A: Test Leads, 2 Meter, Double Shielded. **16083A:** Pulse Bias Noise Clipper



7015B: Analog X-Y recorder is recommended for hard copy output.

4280A Specifications

4280A Measurement Functions:

Capacitance (C), conductance (G), capacitance and conductance (C&G), capacitance vs. DC bias (C-V), conductance vs. DC bias (G-V), capacitance and conductance vs. DC bias (C&G-V), capacitance vs. time (C-t), conductance vs. time (G-t) and capacitance and conductance vs. time (C&G-t).

AC Test Signal:

Frequency: 1MHz \pm 0.01%

OSC Level: 30mVrms \pm 10% or 10mVrms \pm 10%

Display: Max 4½ digits (5½ digits for Opt 001)

Maximum Display Counts: C = 19000,
G = 12000

Measurement Terminals: Two-terminal pair

Configuration: High and Guard, Low and Guard

Max Offset Voltage: \pm 1mV (DC Bias OFF)

Max Resistance: \pm 20 Ω

Max Allowable Current: \pm 100mA

Connection Mode: Set connection configuration between DUT and Measurement circuit.

	Connection Mode		
	Floating	Grounded	
Usage	To measure Floated Device	To measure Grounded Device	To measure strays for compensation
Connection			

V₁ = Internal DC bias source when an external bias source (pulse generator) is used. V₁ and V₂ can be set either from internal or external DC bias source.

C/G Measurement Range (Error Compensation Off)

Measurement Range		
C/G Range	Floating DUT	Grounded DUT
C = 10pF G = 100 μ S	C = 0.001pF to 19.000pF G = 0.01 μ S to 120.00 μ S	This C/G range is not available in Grounded DUT mode.
C = 100pF G = 1mS	C = 0.01pF to 190.00pF G = 0.0001mS to 1.2000mS	C = 0.01pF to 50.00pF ¹ G = 0.0001mS to 1.2000mS
C = 1nF G = 10mS	C = 0.0001nF to 1.9000nF G = 0.001mS to 12.000mS	C = 0.0001nF to 1.7600nF ¹ G = 0.001mS to 12.000mS

¹Typical values

Accuracy Table 1 – C&G Display Modes: Use this table in the following measurement modes: 1) C&G, 2) C&G-V and 3) C&G-t when not applying external fast pulses. See tables 3 and 4 for accuracy when applying external fast pulses.

C/G Measuring Range	DUT Connection Mode	Floating DUT Mode		Grounded DUT Mode	
		OSC = 30mVrms	OSC = 10mVrms	OSC = 30mVrms	OSC = 10mVrms
10pF 100 μ S 100pF 1mS 1nF ² 10mS	Available Bias Modes	*INT Bias: OFF, or *EXT SLOW Bias: or *INT + EXT SLOW Bias		*INT Bias: OFF, or *EXT SLOW Bias: or *INT + EXT SLOW Bias	
	10pF	\pm (0.1% rdg + 5 cnts)	\pm (0.2% rdg + 5 cnts)	This C/G range is not available in Grounded DUT mode.	
	100 μ S	\pm [0.2% rdg + (5 + $\frac{N_C^1}{250}$) cnts]	\pm [0.3% rdg + (5 + $\frac{N_C^1}{250}$) cnts]		
	100pF	\pm (0.1% rdg + 3 cnts)	\pm (0.2% rdg + 3 cnts)	\pm [0.3% rdg + 3 cnts]	\pm (0.4% rdg + 30 cnts)
	1mS	\pm [0.2% rdg + (3 + $\frac{N_C^1}{250}$) cnts]	\pm [0.3% rdg + (3 + $\frac{N_C^1}{250}$) cnts]	\pm [0.4% rdg + (30 + $\frac{N_C^1}{250}$) cnts]	\pm [0.5% rdg + (30 + $\frac{N_C^1}{250}$) cnts]
1nF ²	\pm (0.1% rdg + 3 cnts)	\pm (0.2% rdg + 3 cnts)	\pm (0.3% rdg + 10 cnts)	\pm (0.4% rdg + 10 cnts)	
10mS	\pm [1.2% rdg + (3 + $\frac{N_C^1}{100}$) cnts]	\pm [1.2% rdg + (3 + $\frac{N_C^1}{100}$) cnts]	\pm [1.4% rdg + (10 + $\frac{N_C^1}{100}$) cnts]	\pm [1.4% rdg + (20 + $\frac{N_C^1}{250}$) cnts]	

1. N_C = C display counts in C & G mode with CORRECTION ENABLE OFF.

C-V Measurement:

Measures C-V, G-V or C&G-V characteristics using internal staircase bias.

C-t Measurement:

Measures C-t, G-t or C&G-t characteristics using internal bias source, external pulse bias source, or combination of internal and external bias sources.

Burst Mode: One pulse is applied then repetitive measurements are made with specified time interval between measurements. Used when delay time setting \geq 10mS.

Sampling Mode: Repetitive pulses are applied with single samples taken between pulses. Delay between application of measure voltage and sample can be specified. Used when delay time setting is less than 10ms. This mode requires addition of an external pulse generator like HP's 8112A.

Measurement Speed vs. Oscillator Level and Display Resolution:

Measurement Speed	OSC Level	Display Digit
FAST	10mV/30mV	3½
	10mV	
MED	30mV	4½
	10mV/30mV	

Measurement Accuracy:

Measurement accuracy in the following tables is valid when these conditions are met: 1) \geq 30-minute warm up, 2) ZERO/OPEN calibration is performed, 3) CORRECTION ENABLE IS ON, and 4) Temperature 23°C \pm 5°C. Note that correction enable compensates for measurement residuals and reduces measurement range by the amount of residual compensation.

Accuracy is valid at 4280A front panel with cable length switch in "0" position. Additional error must be added when using the 16082A test cables and with cable length switch in the "1m" position. Add 0.1% of reading for C and 0.2% of reading for G when 16082A is used.

C accuracies are specified when D \leq 0.05 when using C&G, C&G-V and C&G-t display modes. C accuracies are specified when D \leq 0.01 when using C only, G only, C-V, G-V, C-t and G-t display modes. See page 10 Reference Data for more.

Accuracy Table 2 – C only and G only Display Modes: Use this table in the following measurement modes: 1) C only, 2) G only, 3) C-V, 4) G-V, 5) C-t and 6) G-t. Do not use this table when applying external fast pulse bias. See tables 3 and 4 for fast external pulse bias accuracy.

	DUT Connection Mode	Floating DUT Mode		Grounded DUT Mode	
C/G Measuring Range	Available Bias Modes	*INT Bias: OFF, or or *EXT SLOW Bias: or *INT + EXT SLOW Bias		*INT Bias: OFF, or or *EXT SLOW Bias: or *INT + EXT SLOW Bias	
		OSC = 30mVrms		OSC = 10mVrms	
	10pF	$\pm [0.15\% \text{ rdg} + (5 + \frac{N_G^1}{20}) \text{ cnts}]$	$\pm [0.25\% \text{ rdg} + (5 + \frac{N_G^1}{20}) \text{ cnts}]$	This C/G range is not available in Grounded DUT mode.	
	100µS	$\pm [0.25\% \text{ rdg} + (5 + \frac{N_C^1}{40}) \text{ cnts}]$	$\pm [0.35\% \text{ rdg} + (5 + \frac{N_C^1}{40}) \text{ cnts}]$		
	100pF	$\pm [0.15\% \text{ rdg} + (3 + \frac{N_G^1}{20}) \text{ cnts}]$	$\pm [0.25\% \text{ rdg} + (3 + \frac{N_G^1}{20}) \text{ cnts}]$	$\pm [0.3\% \text{ rdg} + (40 + \frac{N_G^1}{20}) \text{ cnts}]$	$\pm [0.4\% \text{ rdg} + (40 + \frac{N_G^1}{20}) \text{ cnts}]$
	1mS	$\pm [0.25\% \text{ rdg} + (3 + \frac{N_C^1}{40}) \text{ cnts}]$	$\pm [0.35\% \text{ rdg} + (3 + \frac{N_C^1}{40}) \text{ cnts}]$	$\pm [0.4\% \text{ rdg} + (40 + \frac{N_C^1}{40}) \text{ cnts}]$	$\pm [0.5\% \text{ rdg} + (40 + \frac{N_C^1}{40}) \text{ cnts}]$
1nF ²	$\pm [0.15\% \text{ rdg} + (3 + \frac{N_G^1}{20}) \text{ cnts}]$	$\pm [0.25\% \text{ rdg} + (3 + \frac{N_G^1}{20}) \text{ cnts}]$	$\pm [0.3\% \text{ rdg} + (20 + \frac{N_G^1}{20}) \text{ cnts}]$	$\pm [0.4\% \text{ rdg} + (20 + \frac{N_G^1}{20}) \text{ cnts}]$	
10mS ³	$\pm [1.25\% \text{ rdg} + (3 + \frac{N_C^1}{30}) \text{ cnts}]$	$\pm [1.25\% \text{ rdg} + (3 + \frac{N_C^1}{30}) \text{ cnts}]$	$\pm [1.4\% \text{ rdg} + (20 + \frac{N_C^1}{30}) \text{ cnts}]$	$\pm [1.4\% \text{ rdg} + (20 + \frac{N_C^1}{30}) \text{ cnts}]$	

1. N_G = G display counts in C&G mode with CORRECTION ENABLE OFF. 2. C accuracy is not specified for C display $\geq 200pF$.
 N_C = C display counts in C&G mode with CORRECTION ENABLE OFF. 3. G accuracy is not specified for G display $\geq 2mS$.

Accuracy Table 3 – C&G-t Modes: Use this table in the C&G-t display mode when applying fast pulses through external fast connector.

	DUT Connection Mode	Floating DUT Mode (Note: Grounded DUT Mode not available)	
C/G Measuring Range	Available Bias Modes	*EXT FAST Bias: *EXT FAST + INT Bias: + *EXT FAST + EXT SLOW Bias: +	
		OSC = 30mVrms	
	10pF	$\pm [(0.4 + \frac{5}{T})\% \text{ rdg} + (40 + \frac{300}{T} + 2T^1 \cdot 10^{-6}) \text{ cnts}]$	$\pm [(0.5 + \frac{5}{T})\% \text{ rdg} + (40 + \frac{900}{T} + 2T^1 \cdot 10^{-6}) \text{ cnts}]$
	100µS	$\pm [(0.5 + \frac{5}{T})\% \text{ rdg} + (40 + \frac{N_C^1}{250} + \frac{300}{T} + 2T^1 \cdot 10^{-6}) \text{ cnts}]$	$\pm [(0.6 + \frac{5}{T})\% \text{ rdg} + (40 + \frac{N_C^1}{250} + \frac{900}{T} + 2T^1 \cdot 10^{-6}) \text{ cnts}]$
	100pF	$\pm [(0.4 + \frac{5}{T})\% \text{ rdg} + (33 + \frac{300}{T} + 2T^1 \cdot 10^{-6}) \text{ cnts}]$	$\pm [(0.5 + \frac{5}{T})\% \text{ rdg} + (33 + \frac{900}{T} + 2T^1 \cdot 10^{-6}) \text{ cnts}]$
	1mS	$\pm [(0.5 + \frac{5}{T})\% \text{ rdg} + (33 + \frac{N_C^1}{250} + \frac{300}{T} + 2T^1 \cdot 10^{-6}) \text{ cnts}]$	$\pm [(0.6 + \frac{5}{T})\% \text{ rdg} + (33 + \frac{N_C^1}{250} + \frac{900}{T} + 2T^1 \cdot 10^{-6}) \text{ cnts}]$
1nF	$\pm [(1.4 + \frac{5}{T})\% \text{ rdg} + (43 + \frac{300}{T} + 2T^1 \cdot 10^{-6}) \text{ cnts}]$	$\pm [(1.5 + \frac{5}{T})\% \text{ rdg} + (43 + \frac{900}{T} + 2T^1 \cdot 10^{-6}) \text{ cnts}]$	
10mS	$\pm [(2.5 + \frac{5}{T})\% \text{ rdg} + (43 + \frac{N_C^1}{100} + \frac{300}{T} + 2T^1 \cdot 10^{-6}) \text{ cnts}]$	$\pm [(2.5 + \frac{5}{T})\% \text{ rdg} + (43 + \frac{N_C^1}{100} + \frac{900}{T} + 2T^1 \cdot 10^{-6}) \text{ cnts}]$	

1. N_C = C display counts in C&G-t mode with CORRECTION ENABLE OFF.
T is calculated at Nth measurement point of a C&G-t curve. $T = N \cdot \text{delay time } (t_d) \cdot 10^6$. T is in seconds.

Example: Uncertainty calculation

A C&G-t measurement is made using external 8112A pulse generator with 10µs pulse interval ($t_d = 10\mu s$). The DUT is floating and a signal level of 30mV is used. It is required to determine measurement uncertainty at the 5th data point occurring 50µs after the start of measurement.

Capacitance reading = 50.00pF
Conductance reading = 1.0000mS
 $T = N \cdot t_d \cdot 10^6 = 5 \cdot 10^{-5} \cdot 10^6 = 50$

$C = 50.00pF \pm [(0.4 + \frac{5}{T})\% \text{ rdg} + (33 + \frac{300}{T} + 2T^1 \cdot 10^{-6}) \text{ cnts}]$
 $C = 50.00pF \pm [(0.4 + \frac{5}{50})\% \text{ rdg} + (33 + \frac{300}{50} + 2 \cdot 50 \cdot 10^{-6}) \text{ cnts}]$
 $C = 50.00pF \pm (25pF + 39pF)$
 $C = 50.00PF \pm 61pF$

$G = 1.0000mS \pm [(0.5 + \frac{5}{T})\% \text{ rdg} + (33 + \frac{N_C}{250} + \frac{300}{T} + 2T^1 \cdot 10^{-6}) \text{ cnts}]$
 $G = 1.0000mS \pm [(0.5 + \frac{5}{50})\% \text{ rdg} + (33 + \frac{5000}{250} + \frac{300}{50} + 2 \cdot 50 \cdot 10^{-6}) \text{ cnts}]$
 $G = 1.0000mS \pm (0.006mS + 0.0059mS)$
 $G = 1.0000mS \pm 0.0119mS$

Accuracy Table 4 – C-t, G-t Modes: Use this table when in the C-t or G-t display mode and applying fast pulses through external fast bias connector.

	DUT Connection Mode	Floating DUT Mode (Note: Grounded DUT Mode not available)	
C/G Measuring Range	Available Bias Modes	*EXT FAST Bias: *EXT FAST + INT Bias: + *EXT FAST + EXT SLOW Bias: +	
		OSC = 30mVrms	
	10pF	$\pm [(0.6 + \frac{5}{T})\% \text{ rdg} + (40 + \frac{N_G^1}{20} + \frac{300}{T} + 2T^1 \cdot 10^{-6}) \text{ cnts}]$	$\pm [(0.7 + \frac{5}{T})\% \text{ rdg} + (40 + \frac{N_G^1}{20} + \frac{900}{T} + 2T^1 \cdot 10^{-6}) \text{ cnts}]$
	100µS	$\pm [(0.7 + \frac{5}{T})\% \text{ rdg} + (40 + \frac{N_C^1}{40} + \frac{300}{T} + 2T^1 \cdot 10^{-6}) \text{ cnts}]$	$\pm [(0.8 + \frac{5}{T})\% \text{ rdg} + (40 + \frac{N_C^1}{40} + \frac{900}{T} + 2T^1 \cdot 10^{-6}) \text{ cnts}]$
	100pF	$\pm [(0.6 + \frac{5}{T})\% \text{ rdg} + (33 + \frac{N_G^1}{20} + \frac{300}{T} + 2T^1 \cdot 10^{-6}) \text{ cnts}]$	$\pm [(0.8 + \frac{5}{T})\% \text{ rdg} + (33 + \frac{N_G^1}{20} + \frac{900}{T} + 2T^1 \cdot 10^{-6}) \text{ cnts}]$
	1mS	$\pm [(0.7 + \frac{5}{T})\% \text{ rdg} + (33 + \frac{N_C^1}{40} + \frac{300}{T} + 2T^1 \cdot 10^{-6}) \text{ cnts}]$	$\pm [(0.8 + \frac{5}{T})\% \text{ rdg} + (33 + \frac{N_C^1}{40} + \frac{900}{T} + 2T^1 \cdot 10^{-6}) \text{ cnts}]$
1nF ²	$\pm [(1.6 + \frac{5}{T})\% \text{ rdg} + (43 + \frac{N_G^1}{20} + \frac{300}{T} + 2T^1 \cdot 10^{-6}) \text{ cnts}]$	$\pm [(1.7 + \frac{5}{T})\% \text{ rdg} + (43 + \frac{N_G^1}{20} + \frac{900}{T} + 2T^1 \cdot 10^{-6}) \text{ cnts}]$	
10mS	$\pm [(2.7 + \frac{5}{T})\% \text{ rdg} + (43 + \frac{N_C^1}{30} + \frac{300}{T} + 2T^1 \cdot 10^{-6}) \text{ cnts}]$	$\pm [(2.7 + \frac{5}{T})\% \text{ rdg} + (43 + \frac{N_C^1}{30} + \frac{900}{T} + 2T^1 \cdot 10^{-6}) \text{ cnts}]$	

1. N_G = G display counts in C&G mode with CORRECTION ENABLE OFF. 2. C accuracy is not specified for C display $\geq 200pF$.
 N_C = C display counts in C&G mode with CORRECTION ENABLE OFF. 3. G accuracy is not specified for G display $\geq 2mS$.
T is calculated at Nth measurement point of a C-t or G-t curve.
 $T = N \cdot \text{delay time } (t_d) \cdot 10^6$. T is in seconds.

Math Functions:

Display measured C/G values as differential values (Δ), % ratio (%) or differential % ($\Delta\%$) of the reference value.

$$\Delta = C - C_{ref} \text{ or } G - G_{ref}$$




$$\% = \frac{C}{C_{ref}} \times 100\% \text{ or } \frac{G}{G_{ref}} \times 100\%$$



$$\Delta\% = \frac{C - C_{ref}}{C_{ref}} \times 100\% \text{ or } \frac{G - G_{ref}}{G_{ref}} \times 100\%$$


Self Test:

Verifies functional operation but does not calibrate.

DC Bias Source:

Output Mode: OFF, === (DC), ,  or 

 or  : Selected when using C-V, G-V, C&G-V modes

, === or OFF: Selected when using C-t, G-t or C&G-t modes

=== or OFF : Selected when using C only or G only modes.

Output Resistance: 10 Ω

Max Output Current: $\pm 6\text{mA}$

Output Voltage Range/Resolution/Accuracy:

Voltage Range	Resolution	Accuracy* \pm (% of setting + volts)
+ 1.999V	1mV	$\pm(0.2\% + 0.01\text{V})$
+ 19.99V	10mV	$\pm(0.1\% + 0.02\text{V})$
$\pm 100.0\text{V}$	100mV	$\pm(0.1\% + 0.1\text{V})$

*Accuracy is specified at 23°C + 5°C. Error doubles at 0°C-55°C.

Ranging: Auto ranging. Fixed range is provided in === mode when V Limit/Range hold is in use.

Staircase Sweep Parameter Settings (C-V Function Only):

Start/Stop Voltage: Any voltage within the output voltage range.

Step Voltage: Resolution of step voltage is automatically set as lesser of Start or Stop voltage setting. Example, if Start is 1.000V and Stop is 30.0V, resolution of Step is 0.01V.

0V to 3.999V: 1mV step

4.00V to 39.99V: 10mV step

40.0V to 200.0V: 100mV step

Hold Time, Step Delay Time (t_h , t_d):

3ms – 65ms: 1ms step

0.07s – 99.99s: 10ms step

100.0s – 650.0: 100ms step

Hold Time/Step Delay Time Setting

Accuracy: \pm (% of setting + seconds)

Time $\leq 65\text{ms}$: $\pm[0.02\% \text{ setting} + (100\text{ns} + \text{bias settling time})]$

Time $\geq 65\text{ms}$: $\pm[0.02\% \text{ setting} + (0.5\text{ms} + \text{bias settling time})]$

Pulse Bias Parameter Settings (C-t Function Only):

DC/Pulse/Measurement Voltage: Any voltage within the output voltage range.

DC Bias Source (continued)

Number of Readings Which Can Be Obtained:

Burst Mode: 1 to 9999

Sampling Mode: 1 to $5/t_d$ (t_d = delay time)

Hold Time (t_h):

Biasing Mode	t_h Range*	t_h Resolution
Internal	10ms – 32s	$10\mu\text{s} \leq t_h \leq 65\text{ms} = 10\mu\text{s}$
EXT BIAS SLOW	$50\mu\text{s} - 32\text{s}$	$65\text{ms} \leq t_h \leq 1\text{s} = 500\mu\text{s}$
EXT BIAS FAST	$10\mu\text{s} - 32\text{s}$	$1\text{s} \leq t_h \leq 10\text{s} = 1\text{ms}$ $10\text{s} \leq t_h \leq 32\text{s} = 10\text{ms}$

*Maximum Hold Time Setting in sampling mode is limited as follows:

Function	Measuring Speed	Maximum Hold Time (whichever is shorter)
C/C-t C&G-t	FAST	$500 * t_d$ or 5s
C/G-t	MED	$200 * t_d$ or 5s
C&G-t	MED	$100 * t_d$ or 5s

N = Nth measurement point, t_d = delay time

Delay Time (t_d):

Range: $10\mu\text{s} - 32\text{s}$

Resolution: $10\mu\text{s} \leq t_d \leq 65\text{ms}$: $10\mu\text{s}$

$65\text{ms} \leq t_d \leq 1\text{s}$: $500\mu\text{s}$

$1\text{s} \leq t_d \leq 10\text{s}$: 1ms

$10\text{s} \leq t_d \leq 32\text{s}$: 10ms

Delay Time Range in Burst Mode:

Function	Measurement Speed	Block Mode	Non Block Mode Output Data Format	
			Binary	ASCII
C-t	FAST	10ms – 32s	20ms – 32s	150ms – 32s
G-t	MED	50ms – 32s	200ms – 32s	200ms – 32s
C&G-t	FAST			
	MED	100ms – 32s	250ms – 32s	

Delay Time Range in Sampling Mode:

EXT BIAS SLOW: $200\mu\text{s}$ to 5s

EXT BIAS FAST: $10\mu\text{s}$ to 5s

Number of C/G-t Readings which can be

obtained: This determines the resolution which can be obtained.

Burst Mode: 1 to 9999 readings

Sample Mode: 1 to $\frac{5}{\text{delay time in seconds}}$ (readings)

Hold Time/Delay Time Setting Accuracy: \pm (% of setting + seconds)

Time $\leq 65\text{ms}$: $\pm[0.02\% + (100\text{ms} * 1 + \text{Bias Settling Time})]^2$

Time $\geq 65\text{ms}$: $\pm[0.2\% + (0.5\text{ms} + \text{Bias Settling Time})]^2$

*1: 10ms when internal bias is used.

*2: 10ms to 100ms delay will be added to delay time when doing C&G-t measurements.

DC Bias Source: Reference Data

Settling Time: $0.05 * \Delta V + 1.7$ (ms) to within 99.9% of final value. ΔV = voltage swing

Ranging Time: 10ms

Bias Voltage Output Set/Reset Logic Processing

Time: 120ms

Bias Voltage Setting Change Logic

Processing Time (=== mode): 120ms

Recorder Output:

Output DC voltage proportional to C/G display counts and voltage/time sweep range.

Output Voltage: ±10V for C, G and V/t data.

C or G Data: ±10V for ±1000 counts (10mV/count)

V Data: -10V for Start/Stop voltage, whichever is more negative. +10V for Start/Stop voltage, whichever is more positive. Max 1000 data points (20mV resolution).

Time (t) Data: -10V at the application of measurement voltage. +10V at the final data point. Max 1000 data points (20mV resolution).

Output Voltage Accuracy: ±(% of output voltage + volts)

C or G = ±(0.5% + 20mV)

V or t = ±(0.5% + 40mV)

Pen Lift Output: Normally +5V. 0V during C-V/t measurement.

Smoothing Function: Output filter time constant can be set 0.02s or 0.2s. Initial and post delay time of 2s and 1.5s can be inserted in C-V/t basic function.

Scaling Output: L.L., Zero and U.R.

	V/t	C/G
L.L. (Lower Left)	-10V	-10V
Zero	0V	0V
U.R. (Upper Right)	+10V	+10V

Data Output/Remote Control:

HP - IB: Not just IEEE-488, but the hardware, documentation and support that delivers the shortest path to a measurement system.

Block Mode Output: Perform C-V/t characteristics measurement and store measured data in an internal data buffer. Then, packed data can be output. In this mode, front panel display, math function and recorder output do not function. Data with/without error compensation can be output.

Maximum Number of Data Which Can be Stored:

C, G, C-V/t or G-V/t Function: 680 data points

C-G, C&G-V/t Function: 400 data points

Option 001 High Resolution Offset Capacitance Measurement:

Increase C measurement resolutions by one digit on 100pF/1nF ranges using capacitance offset reference. This option cannot be field installed.

C Offset Range: 0 to 1023 picofarads. C offset value can be set by measured data or numeric keys.

C Offset Resolution: 1 picofarad

C Offset Setting Accuracy: ±(0.2% of reference value + 0.5pF). This error can be compensated using CORRECTION ENABLE key.

Measurement Accuracy: Accuracy is the sum of 1) accuracy reading before offset plus 2) accuracy of reading after offset.

High Resolution C Mode ON/OFF Time: 350m

Measurement Range/Resolution/Display Digit:

Measuring Time	OSC Level	Measurement Range From Reference Value Range of Offset Value	
FAST	10mV/30mV	100pF/1mS	1nF/10mS
		± 19.00pF ± 120.0μS	± 190.0pF ± 1.200mS
MED	10mV	± 19.000pF ± 120.00μS	± 190.00pF ± 1.2000mS
	30mV		
SLOW	10mV/30mV		

Reference Data:

Reference data are given for information purposes and should not be considered specifications.

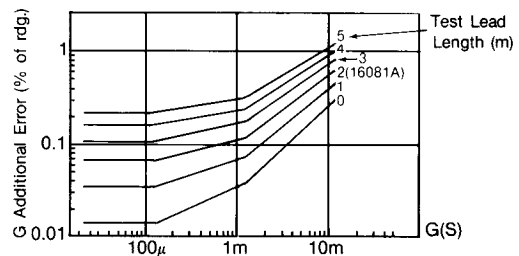
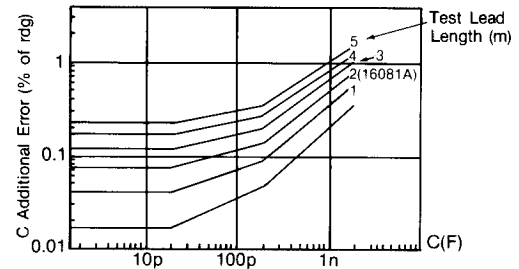
Residual Impedance of the 16080A:

Radial Lead Contact Block: 70nH, 50mΩ

Axial Lead Contact Block: 90nH, 50mΩ

Additional Errors Due to Test Lead Length:

When using 16081A, 16082A or P/N 8120-4195 coaxial cable up to 5m long, use below figures to estimate additional error.



Error Compensation:

Cable Length Compensation: 0m, 1m or 0-5m. Residuals of standard cable (HP P/N 8120-4195) up to 5 meters long can be internally compensated.

Zero Open: Internally compensate stray capacitance and conductance of test fixture with fixture open.

Additional L-R Compensation: Compensate residuals not included above using external computer.

Measurement Conditions:

Connection Mode: Grounded for compensation

Test Signal Level: 30mVrms

Compensation Range: L-R data will be displayed as L (in C display) and R (in G display).

L: 19.000μH

R: 190.00Ω

Compensation Accuracy = ±(% rdg + counts):

L: ±[0.5% rdg + (20 + $\frac{N_R}{500}$) counts]

R: ±[1.2% rdg + (10 + $\frac{N_L}{500}$) counts]

¹N_R = resistance display counts
N_L = inductance display counts

Reference Data: (Continued)

■ C/G Measurement Time:

Total Measurement Time is the sum of 1) Net Measurement Time, 2) Internal Error Compensation Time, 3) Math Function Time, and 4) Display Time.

The table below shows Total Measurement Time in milliseconds. Net Measurement Time is shown in parentheses.

Measurement Speed	C	G	C&G
FAST	70 (10)	70 (10)	150 (30)
MED	100 (40)	95 (35)	190 (70)
SLOW	330 (270)	280 (220)	520 (400)

Ranging Time: 100ms

OSC Level Changing Time: 40ms

Connection Mode Changing Time: 110ms

Initial Setting Time: 650ms

Time Constant of C/G Measurement Circuit:

50 μ s when measurement time interval is <10ms in FAST mode and <100ms in MED mode, in the C-t, G-t, and C&G-t functions.

EXT FAST: 1 μ s

EXT SLOW: 6 μ s

■ C-V Characteristic Measurement Time:

$$2 * A + (B + C) * \text{INTEGER} \left(\frac{D-E}{F} + 1 \right)$$

where A = Hold Time, B = Step Delay Time, C = C/G Measurement Time, D = Step Voltage, E = Start Voltage, and F = Step Voltage

■ C-t Characteristic Measurement Time

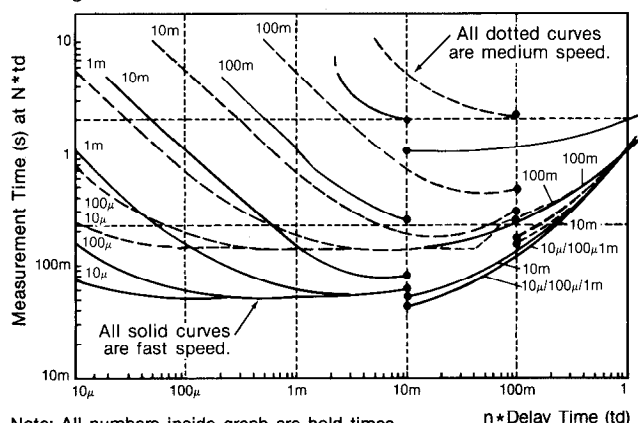
Burst Mode Measurement Time: Hold time plus (delay time * no. of readings).

Sampling Mode Measurement Time: Sum of measurement time for n data points.

Measurement Time of nth Data:

C/G-t Measurement: See below figure

C&G-t Measurement: Measurement time in below figure times two.



Note: All numbers inside graph are hold times.

■ External DC Bias:

Response Time of EXT SLOW Bias Circuit: 100 μ s to within 99.9% of final value.

■ C Measurement Errors Caused by High D Devices:

$.05 \leq D \leq 1$: Add $\frac{D\%}{10}$ rdg to C error. Except for floating DUT mode using EXT. BIAS FAST add $\frac{D\%}{2}$ on 10pF/100pF ranges and D% on 1nF range.

$D \geq 1$: Multiply C error by $(1 + D^2)$.

■ G Measurement Errors Caused by High Q Devices:

$0.5 \leq Q \leq 1$: Add Q/10% to G measurement error

$Q > 1$: Multiply G measurement error*(1 + Q²)

General Specifications

■ Operating Temperature:

0°C – 55°C and Relative Humidity $\leq 90\%$ at 40°C

■ Power Requirement:

100V, 120V, 220V $\pm 10\%$, 240V + 5% – 10%, 48 – 66Hz, max 140VA

■ Dimensions:

426mm (W) \times 177mm (H) \times 499mm (D) or 16.7" (W) \times 7.0" (H) \times 19.7" (D)

■ Weight:

Approximately 15.6kg or 34.3 lbs.

Ordering Information

■ Standard Instrument:

4280A 1MHz C Meter/C-V Plotter

■ Options:

- Opt. 001: High Resolution Offset Capacitance Measurement increases C Resolution by 1 digit on 100pF/1nF Ranges. Cannot be field installed.
- Opt. 907: Front Handle Kit (HP P/N 5061-0090)
- Opt. 908: Rack Flange Kit (HP P/N 5061-0078)
- Opt. 909: Rack Flange & Front Handle Kit (HP P/N 5061-0084)
- Opt. 910: Extra Manual (HP P/N 04280-90000)

■ Accessories:

- 16058A: Test Fixture for Packaged Semiconductor Testing
- 16080A: Test Fixture (furnished with 4280A)
- 16081A: Test Leads, 2 Meter, Double Shielded.
- 16082A: Test Leads, 1 Meter, Single Shielded.
- 16083A: Pulse Bias Noise Clipper (for use with external Pulse Generator)

HP P/N 1250-0929: Remote ON/OFF Shorting Cap (furnished with 4280A)

For more information, call your local HP Sales Office or nearest Regional Office: • Eastern (201) 265-5000; • Midwestern (312) 255-9800; • Southern (404) 955-1500; • Western (213) 970-7500; • Canadian (416) 678-9430. Ask the operator for instrument sales. Or write Hewlett-Packard, 1501 Page Mill Road, Palo Alto, CA 94304. In Europe: Hewlett-Packard S.A., 7, rue du Bois-du-Lan, P.O. Box, CH 1217 Meyrin 2, Geneva, Switzerland. In Japan: Yokogawa-Hewlett-Packard Ltd., 29-21, Takaido-Higashi 3-chome, Suginami-ku, Tokyo 168.