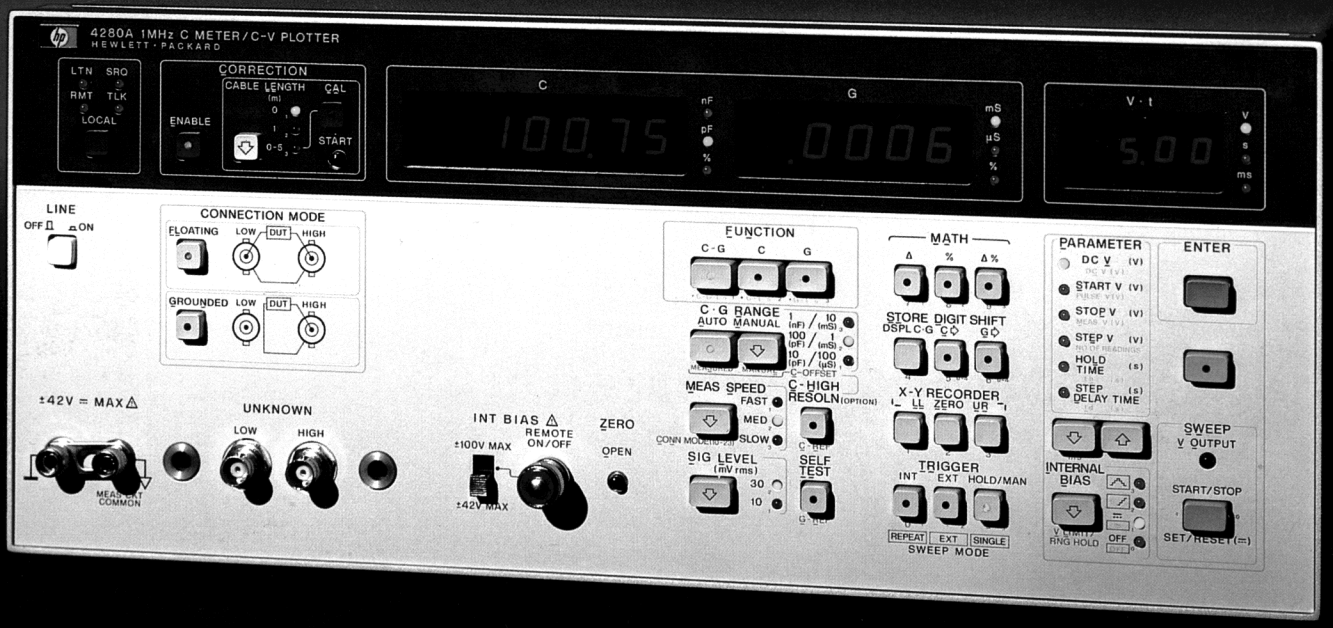
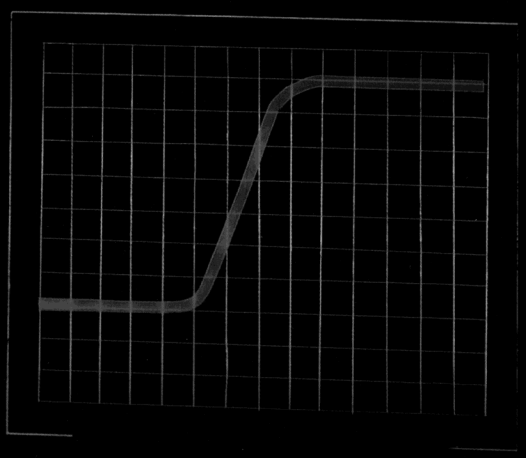
HP 4280A 1MHz C Meter/C-V Plotter

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

Technical Data August 1988



■ C-t Characteristics



■ C-V 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 (±100V) can be applied when needed.

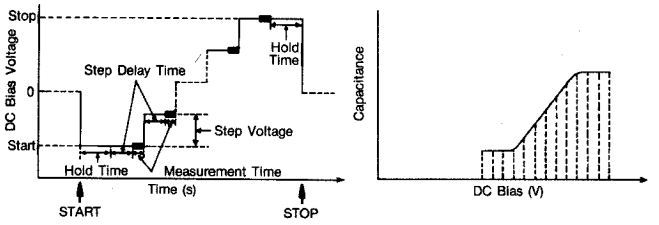
4280 Front Panel Displays C,G and DC bias

■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 ±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.)

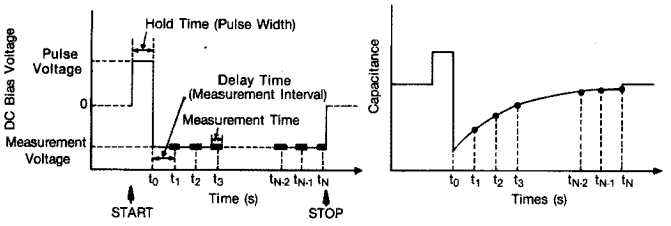
■Hard Copy Output

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.

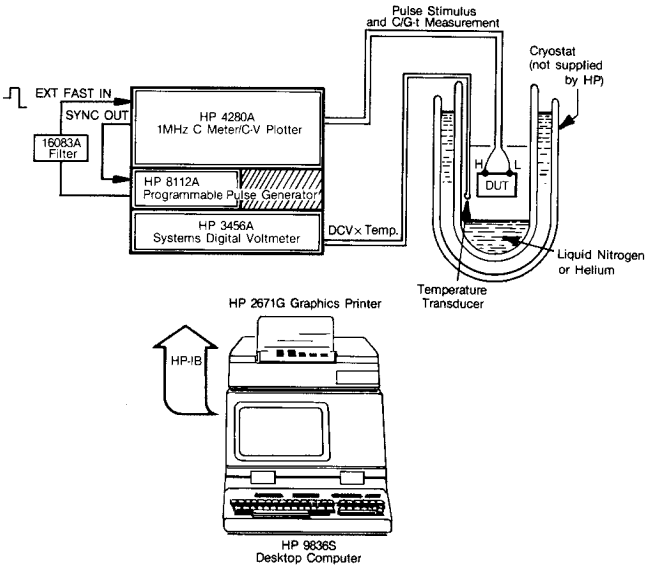
Delay time is the time between measurements. When delay time is set to 10 milliseconds or greater, the 4280A will apply a single pulse to the device under test. Then a BURST of measurements are made.



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 Transcient Spectroscopy (DLTS) – Example of Pulse Bias Application

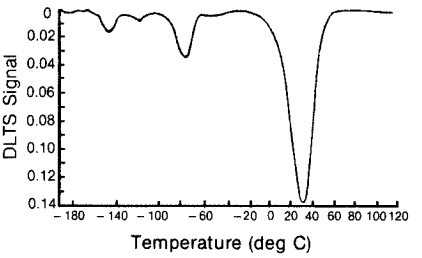
DLTS is used to analyze semiconductor imperfections which effect IC performance. Small imperfection concentrations which are too small for analysis by C-V techniques can often be analyzed by DLTS.



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 10μs when synchronized to an external pulse generator like HP's 8112A.

HP'S 4280A Offers New Measurement Ca

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 10μs 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.

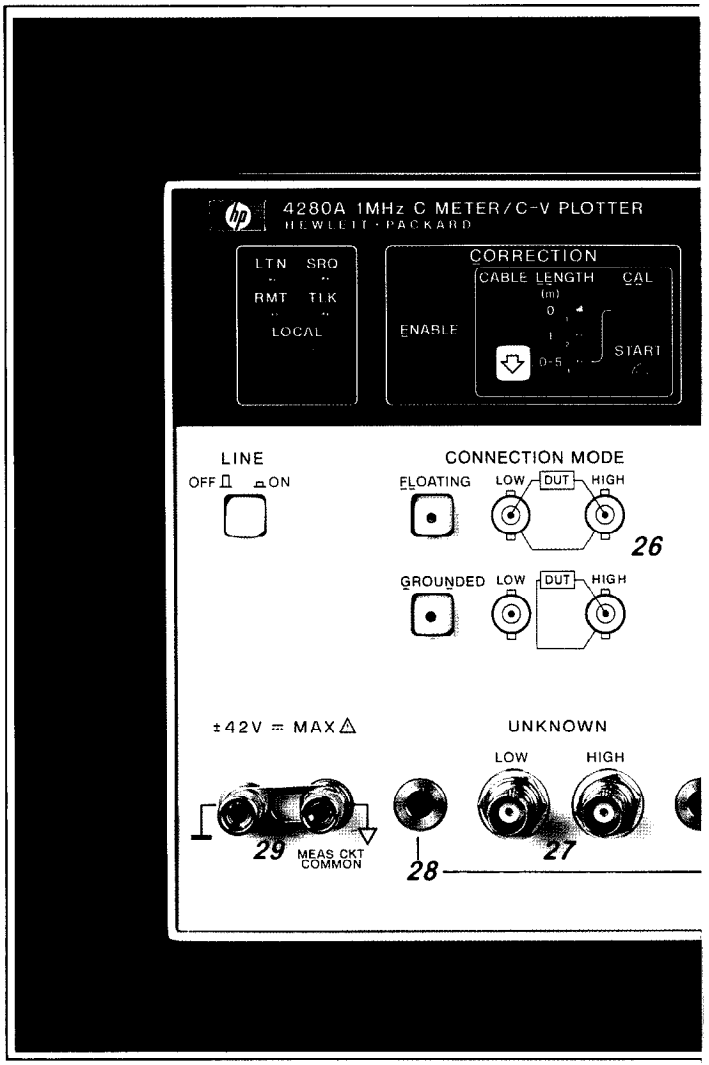
5 Conductance Digital Display
Standard conductance display resolution will be 3½ digits or 4½ digits depending on test conditions. This display also shows deviation.

6 Wide Conductance Measurement Range
Conductance measurement range is from 0.01μS 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 ± 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.

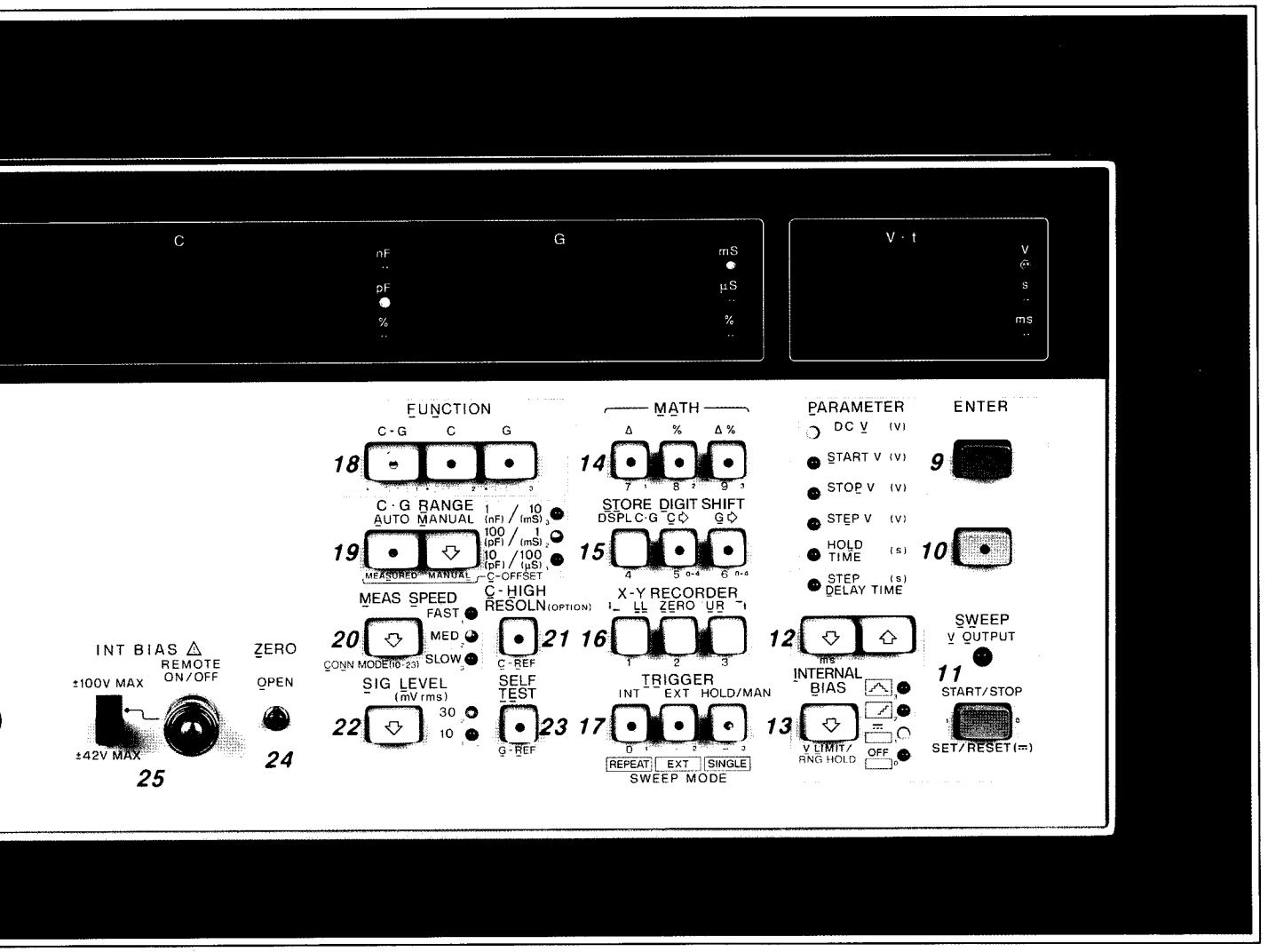
13 Select Bias Mode/Limit Output Voltage/Hold Range
Multi function key selects DC bias mode. Also allows entry of DC bias voltage limit from numeric keys and acts as Range Hold key.

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.

pability for Design and Production of IC'S



17 Trigger and Sweep Mode Control
In sweep mode, this key selects single or repetative 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 ±42V position, shorting cap has no effect. Max output is ±42V.

When switch is in ±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.

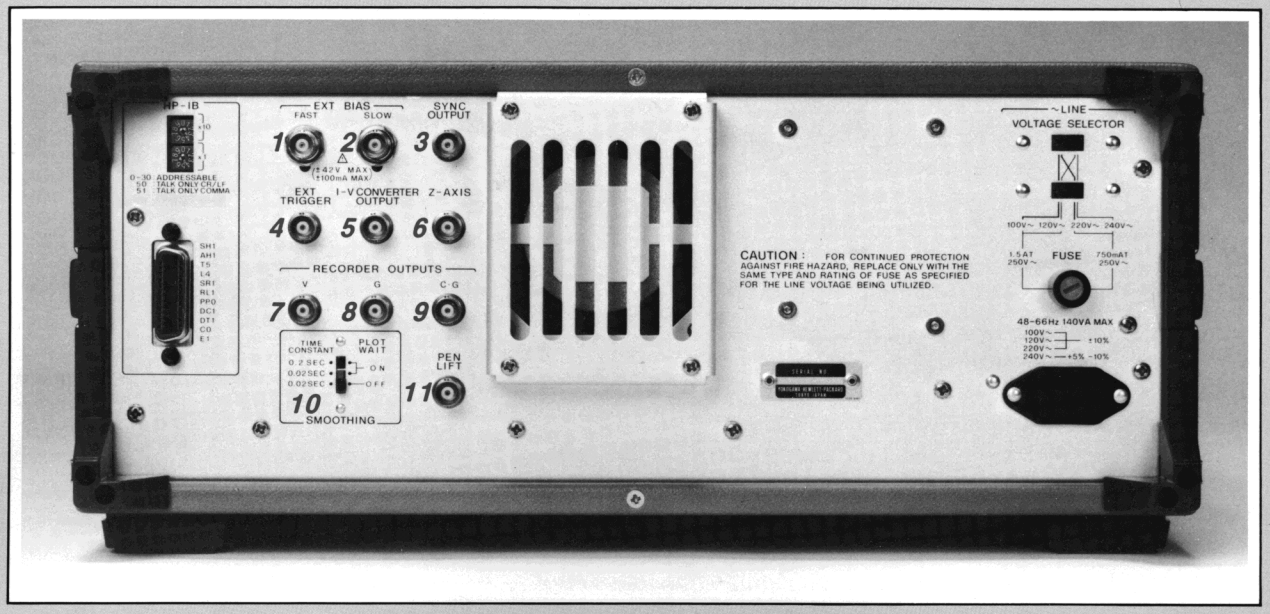
26 Test Floating or Grounded Devices
Floating devices can be tested over 4280A's entire measurement range. Grounded devices can be tested in top two ranges only (100pF/1mS and 1nF/10mS ranges).

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: ±10V for 1000 data points (20mV resoln).

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

8 G Recorder Output
Gives counts in G display: ±10V, ±1000 counts (10mV resoln).

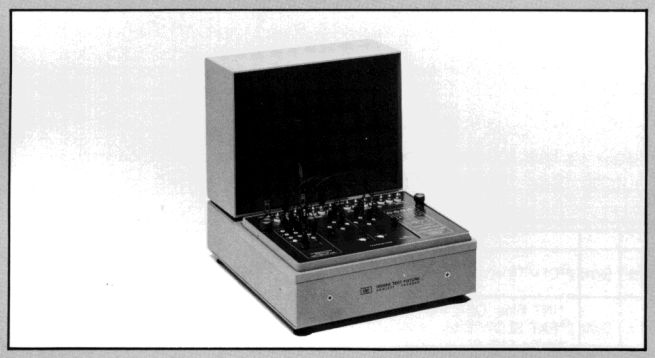
9 C-G Recorder Output
a) Use in C, C-V, C-t, C&G-V, C&G-t modes to give C display counts: ±10V, ±1000 counts (10mV resoln).

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

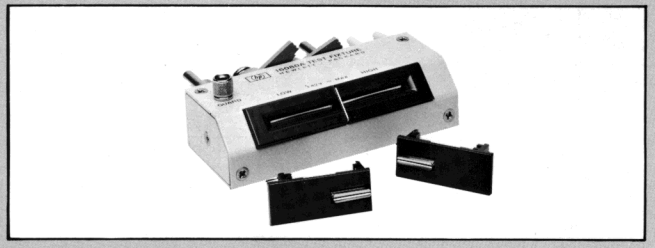
10 Smooth recorder outputs.

11 Pen Lift outputs TTL level.

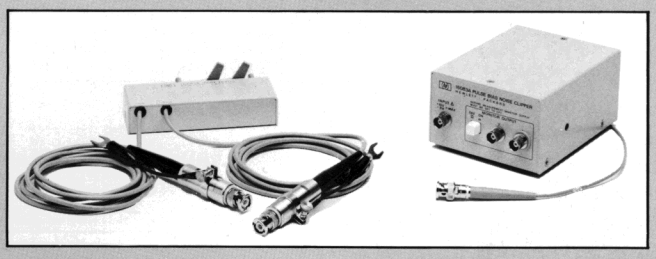
Accessories



16058A: Test Fixture for Packaged Semiconductor Testing.

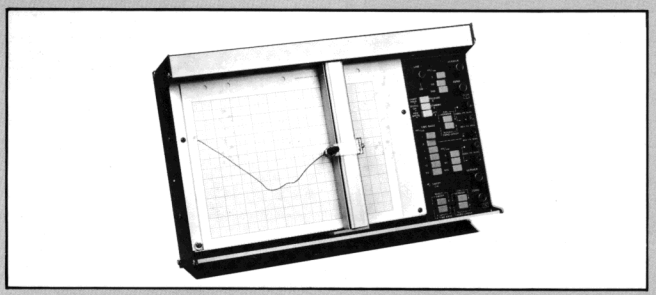


16080A: Test Fixture (furnished with 4280A).



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).

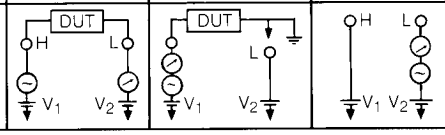
AC Test Signal:

Frequency: 1MHz ±0.01%
OSC Level: 30mVrms ± 10% or 10mVrms ± 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: ±1mV (DC Bias OFF)
Max Resistance: ±20Ω
Max Allowable Current: ±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			

V_1 = Internal DC bias source when an external bias source (pulse generator) is used. V_1 and V_2 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 = 100μS	C = 0.001pF to 19.000pF G = 0.01μS to 120.00μS	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

[1]Typical values

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 repetative measurements are made with specified time interval between measurements. Used when delay time setting ≥10mS.

Sampling Mode: Repetative 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
MED	10mV	3½
	30mV	4½
SLOW	10mV/30mV	4½

Measurement Accuracy:

Measurement accuracy in the following tables is valid when these conditions are met: 1) ≥30-minute warm up, 2) ZERO/OPEN calibration is performed, 3) CORRECTION ENABLE IS ON, and 4) Temperature 23°C ± 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 ≤ 0.05 when using C&G, C&G-V and C&G-t display modes. C accuracies are specified when D ≤ 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 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.

	DUT Connection Mode	Floating DUT Mode		Grounded DUT Mode	
C/G Measuring Range	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	
		OSC = 30mVrms	OSC = 10mVrms	OSC = 30mVrms	OCS = 10mVrms
	10pF 100μS	±(0.1% rdg + 5 cnts) $\pm[0.2\%\ rdg + (5 + \frac{N_C^{1}}{250})\ cnts]$	±(0.2% rdg + 5 cnts) $\pm[0.3\%\ rdg + (5 + \frac{N_C^{1}}{250})\ cnts]$	This C/G range is not available in Grounded DUT mode.	
	100pF 1mS	±(0.1% rdg + 3 cnts) $\pm[0.2\%\ rdg + (3 + \frac{N_C^{1}}{250})\ cnts]$	±(0.2% rdg + 3 + cnts) $\pm[0.3\%\ rdg + (3 + \frac{N_C^{1}}{250})\ cnts]$	±[0.3% rdg + 3 + cnts) $\pm[0.4\%\ rdg + (30 + \frac{N_C^{1}}{250})\ cnts]$	±(0.4% rdg + 30 + cnts) $\pm[0.5\%\ rdg + (30 + \frac{N_C^{1}}{250})\ cnts]$
	1nF[2] 10mS	±(0.1% rdg + 3 cnts) $\pm[1.2\%\ rdg + (3 + \frac{N_C^{1}}{100})\ cnts]$	±(0.2% rdg + 3 cnts) $\pm[1.2\%\ rdg + (3 + \frac{N_C^{1}}{100})\ cnts]$	±(0.3% rdg + 10 cnts) $\pm[1.4\%\ rdg + (10 + \frac{N_C^{1}}{100})\ cnts]$	±(0.4% rdg + 10 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.

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

1. N_G = G display counts in C&G mode with CORRECTION ENABLE OFF.
   N_C = C display counts in C&G mode with CORRECTION ENABLE OFF.
2. C accuracy is not specified for C display ≥200pF.
3. G accuracy is not specified for G display ≥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	OSC = 10mVrms
	10pF	$\pm[(0.4 + \frac{5}{T^1})\%\ rdg + (40 + \frac{300}{T^1} + 2T^1 * 10^{-6})\ cnts]$	$\pm[(0.5 + \frac{5}{T^1})\%\ rdg + (40 + \frac{900}{T^1} + 2T^1 * 10^{-6})\ cnts]$
	100μS	$\pm[(0.5 + \frac{5}{T^1})\%\ rdg + (40 + \frac{N_C{}^1}{250} + \frac{300}{T^1} + 2T^1 * 10^{-6})\ cnts]$	$\pm[(0.6 + \frac{5}{T^1})\%\ rdg + (40 + \frac{N_C{}^1}{250} + \frac{900}{T^1} + 2T^1 * 10^{-6})\ cnts]$
	100pF	$\pm[(0.4 + \frac{5}{T^1})\%\ rdg + (33 + \frac{300}{T^1} + 2T^1 * 10^{-6})\ cnts]$	$\pm[(0.5 + \frac{5}{T^1})\%\ rdg + (33 + \frac{900}{T^1} + 2T^1 * 10^{-6})\ cnts]$
	1mS	$\pm[(0.5 + \frac{5}{T^1})\%\ rdg + (33 + \frac{N_C{}^1}{250} + \frac{300}{T^1} + 2T^1 * 10^{-6})\ cnts]$	$\pm[(0.6 + \frac{5}{T^1})\%\ rdg + (33 + \frac{N_C{}^1}{250} + \frac{900}{T^1} + 2T^1 * 10^{-6})\ cnts]$
	1nF	$\pm[(1.4 + \frac{5}{T^1})\%\ rdg + (43 + \frac{300}{T^1} + 2T^1 * 10^{-6})\ cnts]$	$\pm[(1.5 + \frac{5}{T^1})\%\ rdg + (43 + \frac{900}{T^1} + 2T^1 * 10^{-6})\ cnts]$
	10mS	$\pm[(2.5 + \frac{5}{T^1})\%\ rdg + (43 + \frac{N_C{}^1}{100} + \frac{300}{T} + 2T^1 * 10^{-6})\ cnts]$	$\pm[(2.5 + \frac{5}{T^1})\%\ rdg + (43 + \frac{N_C{}^1}{100} + \frac{900}{T^1} + 2T^1 * 10^{-6})\ cnts]$

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*delay time (t_d)*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 = 10μS). 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
$T = N * t_d * 10^6 = 5 * 10^{-5} * 10^6 = 50$

$C = 50.00pF \pm [(0.4 + \frac{5}{T})\%\ rdg + (33 + \frac{300}{T} + 2T * 10^{-6})\ cnts]$

$C = 50.00pF \pm [(0.4 + \frac{5}{50})\%\ rdg + (33 + \frac{300}{50} + 2 * 50 * 10^{-6})\ cnts]$

$C = 50.00pF \pm (.25pF + .39pF)$

$C = 50.00PF \pm .61pF$

$G = 1.0000mS \pm [(0.5 + \frac{5}{T})\%\ rdg + (33 + \frac{N_C}{250} + \frac{300}{T} + 2T * 10^{-6})\ cnts]$

$G = 1.0000mS \pm [(0.5 + \frac{5}{50})\%\ of\ rdg + (33 + \frac{5000}{250} + \frac{300}{50} + 2 * 50 * 10^{-6})\ cnts]$

$G = 1.0000mS \pm (0.006mS + 0.0059mS)$

$G = 1.0000mS \pm 0.0119mS$

***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	OSC = 10mVrms
	10pF	$\pm[(0.6 + \frac{5}{T^1})\%\ rdg\ (40 + \frac{N_G{}^1}{20} + \frac{300}{T^1} + 2T^1 * 10^{-6})\ cnts]$	$\pm[(0.7 + \frac{5}{T^1})\%\ rdg + (40 + \frac{N_G{}^1}{20} + \frac{900}{T^1} + 2T^1 * 10^{-6})\ cnts]$
	100μS	$\pm[(0.7 + \frac{5}{T^1})\%\ rdg\ (40 + \frac{N_C{}^1}{40} + \frac{300}{T^1} + 2T^1 * 10^{-6})\ cnts]$	$\pm[(0.8 + \frac{5}{T^1})\%\ rdg + (40 + \frac{N_C{}^1}{40} + \frac{300}{T^1} + 2T^1 * 10^{-6})\ cnts]$
	100pF	$\pm[(0.6 + \frac{5}{T^1})\%\ rdg + (33 + \frac{N_G{}^1}{20} + \frac{300}{T^1} + 2T^1 * 10^{-6})\ cnts]$	$\pm[(0.8 + \frac{5}{T^1})\%\ rdg + (33 + \frac{N_G{}^1}{20} + \frac{900}{T^1} + 2T^1 * 10^{-6})\ cnts]$
	1mS	$\pm[(0.7 + \frac{5}{T^1})\%\ rdg + (33 + \frac{N_C{}^1}{40} + \frac{300}{T^1} + 2T^1 * 10^{-6})\ cnts]$	$\pm[(0.8 + \frac{5}{T^1})\%\ rdg + (33 + \frac{N_C{}^1}{40} + \frac{900}{T^1} + 2T^1 * 10^{-6})\ cnts]$
	1nF[2]	$\pm[(1.6 + \frac{5}{T^1})\%\ rdg + (43 + \frac{N_G{}^1}{20} + \frac{300}{T^1} + 2T^1 * 10^{-6})\ cnts]$	$\pm[(1.7 + \frac{5}{T^1})\%\ rdg + (43 + \frac{N_G{}^1}{20} + \frac{900}{T^1} + 2T^1 * 10^{-6})\ cnts]$
	10mS	$\pm[(2.7 + \frac{5}{T^1})\%\ rdg + (43 + \frac{N_C{}^1}{30} + \frac{300}{T^1} + 2T^1 * 10^{-6})\ cnts]$	$\pm[(2.7 + \frac{5}{T^1})\%\ rdg + (43 + \frac{N_C{}^1}{30} + \frac{900}{T^1} + 2T^1 * 10^{-6})\ cnts]$

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

■ *Math Functions:*

Display measured C/G values as differential values (Δ), % ratio (%) or differential % (Δ%) 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: 10Ω

Max Output Current: ±6mA

Output Voltage Range/Resolution/Accuracy:

Voltage Range	Resolution	Accuracy* ±(% of setting + volts)
+ 1.999V	1mV	±(0.2% + 0.01V)
+ 19.99V	10mV	±(0.1% + 0.02V)
±100.0V	100mV	±(0.1% + 0.1V)

*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: ±(% of setting + seconds)

Time ≤65ms: ±[0.02% setting + (100ns + bias settling time)]

Time ≥65ms: ±[0.02% setting + (0.5ms + 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 EXT BIAS SLOW EXT BIAS FAST	10ms – 32s 50μS – 32s 10μs – 32s	10μS ≤ t_h ≤ 65ms = 10μS 65ms ≤ t_h ≤ 1s = 500μs 1s ≤ t_h ≤ 10s = 1ms 10s ≤ t_h ≤ 32s = 10ms

*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: 10μs – 32s

Resolution: 10μs ≤ t_d ≤ 65ms: 10μs
65ms ≤ t_d ≤ 1s: 500μs
1s ≤ t_d ≤ 10s: 1ms
10s ≤ t_d ≤ 32s: 10ms

Delay Time Range in Burst Mode:

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

Delay Time Range in Sampling Mode:
EXT BIAS SLOW: 200μs to 5s
EXT BIAS FAST: 10μs 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: ±(% of setting + seconds)

Time ≤65ms: ±[0.02% + (100ms*1 + Bias Settling Time)]*2

Time ≥65ms: ±[0.2% + (0.5ms + 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 * ΔV + 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 Voltgage: ±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. OV 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	
		100pF/1mS	1nF/10mS
FAST	10mV/30mV	±19.00pF ±120.0μS	±190.0pF ±1.200mS
MED	10mV		
	30mV	±19.000pF ±120.00μS	±190.00pF ±1.2000mS
SLOW	10mV/30mV		

■*Reference Data:*

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

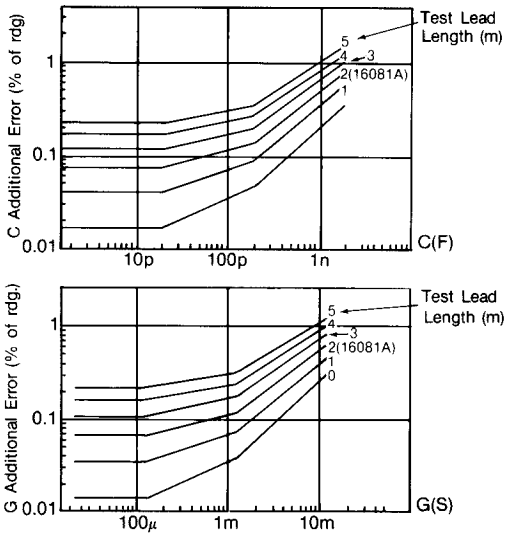
■*Residual Impedance of the 16080A:*

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: $\pm[0.5\%\ \text{rdg} + (20 + \frac{N_R{}^1}{500})\ \text{counts}]$

R: $\pm[1.2\%\ \text{rdg} + (10 + \frac{N_L{}^1}{500})\ \text{counts}]$

^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:
50μS 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: 1μs

EXT SLOW: 6μs

■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

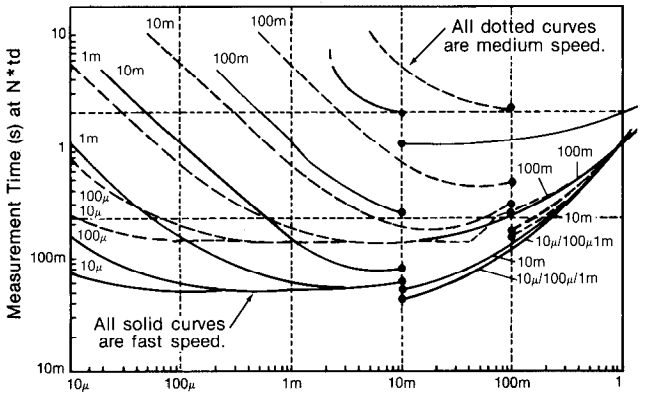
Burst Mode Measurement Time: Hold time plus (delay time * no. of readings).

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: 100μs to within 99.9% of final value.

■C Measurement Errors Caused by High D Devices:

.05≤D≤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≥1: Multiply C error by $(1+D^2)$.

■G Measurement Errors Caused by High Q Devices:

0.5≤Q≤1: Add Q/10% to G measurement error

Q>1: Multiply G measurement error*$(1+Q^2)$

■General Specifications

■Operating Temperature:

0°C – 55°C and Relative Humidity ≤90% at 40°C

■Power Requirement:

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

■Dimensions:

426mm (W) × 177mm (H) × 499mm (D) or 16.7″ (W) × 7.0″ (H) × 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.

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