Agilent
4288A Capacitance Meter
1 kHz/1 MHz

Data Sheet

This document contains specifications and supplemental information about Agilent's 4288A capacitance meter.

Agilent Technologies
Innovating the HP Way

Definitions

All specifications apply over a 0°C to 45°C range and 10 minutes after the instrument has been turned on, unless otherwise stated.

Specification (spec.): Warranted performance. Specifications include guardbands to account for the expected statistical performance distribution, measurement uncertainties, and changes in performance due to environomental conditions.

Supplemental information is intended to provide useful information about the instrument, but is not covered by the product warranty. The information is denoted as typical, or nominal.

Typical (typ.): Expected performance of an average unit which does not incude guardbands.

Nominal (nom.): A general, descriptive term that does not imply a level of performance.

Basic specifications

Measurement parameters

- Cp-D, Cp-Q, Cp-Rp, Cp-G
- Cs-D, Cs-Q, Cs-Rs

Where,

Cp: Capacitance value measured using the parallel equivalent circuit model

Cs: Capacitance value measured using the series equivalent circuit model

D: Dissipation factor

Q: Quality factor (inverse of D)

G: Equivalent parallel conductance measured using the parallel equivalent circuit model

Rp: Equivalent parallel resistance measured using the parallel equivalent circuit model

Rs: Equivalent series resistance measured using the series equivalent circuit model

Measurement signals

Table 1. Specifications of measurement signals

Frequency	Allowable frequencies		1 kHz 1 MHz 0.99 MHz (1 MHz -1%) 1.01 MHz (1 MHz +1%) 1.02 MHz (1 MHz +2%)
	Accuracy		± 0.02%
Level	Range		0.1 V - 1.0 V
	Resolution		0.1 V
	Accuracy		± 5%
Output impedance	Frequency: 1 kHz	Measurement range: 100 pF - 100 nF	20Ω (nominal)
		Measurement range: 220 nF - 10μ F	1Ω (nominal)
	Frequency: 1 MHz		20Ω (nominal)

Measurement cable length

0m, 1m, 2m

Measurement time modes

Short mode, long mode

For information on the measurement time in each mode, refer to "Measurement time" on page 7.

Measurement range selection

Auto (auto range mode), manual (hold range mode)

Measurement range

Table 2. 1 kHz and 1 MHz measurement range

Measurement signal frequency: 1 kHz			Measurement signal frequency: 1 MHz		
100 pF	220 pF	470 pF	1 pF	2.2 pF	4.7 pF
1 nF	2.2 nF	4.7 nF	10 pF	22 pF	47 pF
10 nF	22 nF	47 nF	100 pF	220 pF	470 pF
100 nF	220 nF	470 nF	1 nF		
1 µF	2.2 µF	4.7 µF			
10 µF					

For information on measurable range in each measurement mode, refer to "Available measurement ranges" on this page and Tables 6 and 7 on page 4.

Averaging

Table 3. Averaging range and resolution

Range	1 - 256 measurements
Resolution	1

Trigger mode

Internal trigger (Int), manual trigger (Man), external trigger (Ext), GPIB trigger (Bus)

Trigger delay time

Table 4. Range and resolution of trigger delay time

Range	0 - 1.000 s
Resolution	1 ms

Measurement display ranges

Table 5 shows the range of the measured value that can be displayed on the screen.

Table 5. Allowable measured value display range

Parameter	Measurement display range
Cs, Cp	- 99.9999 µF to - 0.00001 pF, 0, 0.00001 pF to 99.9999 µF
D	- 9.99999 to - 0.00001, 0, 0.00001 to 9.99999
Q	- 99999.9 to - 0.1, 0, 0.1 to 99999.9
Rs, Rp	- 999.999 MΩ to - 0.001 mΩ, 0, 0.001 mΩ to 999.999 MΩ
G	- 9.99999 kS to - 0.00001 µS, 0, 0.00001 µS to 9.99999 kS
Δ%	- 999.999% to - 0.001%, 0, 0.001% to 999.999%

Available measurement ranges

Table 6 and 7 on page 4 show recommended measurement ranges (recommendation for accurate measurement) and significant measurement ranges (range that does not cause overload) for each measurement range under the condition D (dissipation factor) ≤ 0.5.

Table 6. Measurable capacitance range when measurement frequency is 1 kHz

Measurement range	Recommended measurement range	Significant measurement range
100 pF	68 pF - 150 pF	0 F - 150 pF
220 pF	150 pF - 330 pF	0 F - 330 pF
470 pF	330 pF - 680 pF	0 F - 680 pF
1 nF	680 pF - 1.5 nF	0 F - 1.5 nF
2.2 nF	1.5 nF - 3.3 nF	0 F - 3.3 nF
4.7 nF	3.3 nF - 6.8 nF	0 F - 6.8 nF
10 nF	6.8 nF - 15 nF	0 F - 15 nF
22 nF	15 nF - 33 nF	0 F - 33 nF
47 nF	33 nF - 68 nF	0 F - 68 nF
100 nF	68 nF - 150 nF	0 F - 150 nF
220 nF	150 nF - 330 nF	0 F - 330 nF
470 nF	330 nF - 680 nF	0 F - 680 nF
1 µF	680 nF - 1.5 µF	0 F - 1.5 µF
2.2 µF	1.5 µF - 3.3 µF	0 F - 3.3 µF
4.7 µF	3.3 µF - 6.8 µF	0 F - 6.8 µF
10 µF	6.8 µF - 20 µF	0 F - 20 µF

Table 7. Measurable capacitance range when measurement frequency is 1 MHz

Measurement range	Recommended measurement range	Significant measurement range
1 pF	680 fF - 1.5 pF	0 F - 1.5 pF
2.2 pF	1.5 pF - 3.3 pF	0 F - 3.3 pF
4.7 pF	3.3 pF - 6.8 pF	0 F - 6.8 pF
10 pF	6.8 pF - 15 pF	0 F - 15 pF
22 pF	15 pF - 33 pF	0 F - 33 pF
47 pF	33 pF - 68 pF	0 F - 68 pF
100 pF	68 pF - 150 pF	0 F - 150 pF
220 pF	150 pF - 330 pF	0 F - 330 pF
470 pF	330 pF - 680 pF	0 F - 680 pF
1 nF	680 pF - 1.5 nF	0 F - 1.5 nF

Measurement accuracy

Measurement accuracy is defined when all the following conditions are met.

- Warm-up time: 10 minutes or longer
- Ambient temperature: 18°C - 28°C
- Execution of the OPEN compensation
- Measurement cable length: 0 m, 1m, or 2m (16048A/B/D)
- D (dissipation factor) ≤ 0.5

Accuracy of Cp, Cs, D, G, and Rs

Tables 10 and 11 on page 5, show the measurement accuracy of Cp, Cs, D, G, and Rs when D ≤ 0.1. Note the following when you calculate accuracy with these tables.

- The equation to calculate the accuracy varies depending on the measurement time mode. In tables 10 and 11 on page 5, the upper equation is for the short mode; the lower equation corresponds to the long mode.
- Interpret your calculated accuracy as ± (percentage of the measured value of an error) for Cp and Cs, ± (absolute value of an error) for D, G, and Rs.

When 0.1 < D ≤ 0.5, multiply the accuracy obtained from Table 10 or Table 11 by the coefficient in Table 8 below.

Table 8. Coefficient caused by D value @ > 0.1, ≤ 0.5

Parameter	Coefficient
Cp, Cs, G, Rs*1	$1 + D^2$
D	1 + D

Accuracy of Q

The following equation is used to calculate the accuracy of Q from the accuracy of D.

Equation 1. Equation to calculate Q

$$Qe = \frac{\pm Qx^2 \times De}{1 \mp Qx \times De}$$

Where, *Qe* is the accuracy of Q, *De* is the accuracy of D, and *Qx* is the measured Q value.

Accuracy of Rp

The following equation is used to calculate the accuracy of Rp from the accuracy of G.

Equation 2. Equation to calculate Rp

$$Rpe = \frac{\pm Rpx^2 \times Ge}{1 \mp Rpx \times Ge}$$

Where, *Rpe* is the accuracy of Rp, *Ge* is the accuracy of G, and *Rpx* is the measured Rp value.

Accuracy when ambient temperature exceeds the range between 18°C and 28°C (typical)

When the ambient temperature exceeds the range between 18°C and 28°C, multiply the accuracy obtained above by the coefficient shown in Table 9 below.

Table 9. Coefficient caused by ambient temparature

	Coefficient
0°C ≤ ambient temperature < 8°C	3
8°C ≤ ambient temperature < 18°C	2
18°C ≤ ambient temperature ≤ 28°C	1
28°C < ambient temperature ≤ 38°C	2
38°C < ambient temperature ≤ 45°C	3

*1. If you select a secondary measurement parameter other than D, calculate D.

Table 10. Measurement accuracy of Cp, Cs, D, G, and Rs (measurement frequency: 1 kHz)

Measurement range	Measurement parameter			
	Cp, Cs [%]	D	G [nS]	Rs [Ω]
100 pF	0.055 + 0.070 x K 0.055 + 0.030 x K	0.00035 + 0.00070 x K 0.00035 + 0.00030 x K	(3.5 + 4.5 x K) x Cx (3.5 + 2.0 x K) x Cx	(90 + 120 x K) / Cx (90 + 50 x K) / Cx
220 pF	0.055 + 0.045 x K 0.055 + 0.020 x K	0.00035 + 0.00045 x K 0.00035 + 0.00020 x K	(3.5 + 3.0 x K) x Cx (3.5 + 1.5 x K) x Cx	(90 + 75 x K) / Cx (90 + 35 x K) / Cx
470 pF 1 nF 2.2 nF 4.7 nF 10 nF 22 nF 47 nF 100 nF 220 nF 470 nF 1 μF 2.2 μF 4.7 μF 10 μF	0.055 + 0.030 x K 0.055 + 0.015 x K	0.00035 + 0.00030 x K 0.00035 + 0.00015 x K	(3.5 + 2.0 x K) x Cx (3.5 + 1.0 x K) x Cx	(90 + 50 x K) / Cx (90 + 25 x K) / Cx

Table 11. Measurement accuracy of Cp, Cs, D, G, and Rs (measurement frequency: 1 MHz)

Measurement range	Measurement parameter			
	Cp, Cs [%]	D	G [nS]	Rs [Ω]
1 pF	0.055 + 0.070 x K 0.055 + 0.030 x K	0.00035 + 0.00070 x K 0.00035 + 0.00030 x K	(3.5 + 4.5 x K) x Cx (3.5 + 2.0 x K) x Cx	(90 + 120 x K) / Cx (90 + 50 x K) / Cx
2.2 pF	0.055 + 0.045 x K 0.055 + 0.020 x K	0.00035 + 0.00045 x K 0.00035 + 0.00020 x K	(3.5 + 3.0 x K) x Cx (3.5 + 1.5 x K) x Cx	(90 + 75 x K) / Cx (90 + 35 x K) / Cx
4.7 pF 10 pF 22 pF 47 pF 100 pF 220 pF 470 pF 1 nF	0.055 + 0.030 x K 0.055 + 0.015 x K	0.00035 + 0.00030 x K 0.00035 + 0.00015 x K	(3.5 + 2.0 x K) x Cx (3.5 + 1.0 x K) x Cx	(90 + 50 x K) / Cx (90 + 25 x K) / Cx

In Tables 10 and 11, Cx is a measured value of the capacitance (Cp or Cs) [nF (for 1 kHz)/pF (for 1 MHz)] and K is defined as follows:

When $Cx \leq Cr$: $K = (1/Vs) \times (Cr/Cx)$

When $Cx > Cr$: $K = 1/Vs$

Where, Cr is a measurement range [nF (for 1 kHz)/pF (for 1 MHz)] and Vs is a measurement signal level [V].

Figure 1, Figure 2, Figure 3, and Figure 4 show the accuracy of Cp, Cs, and D measured within the recommended measurement range for each measurement range (refer to Table 6 and Table 7) when D ≤ 0.1 and the ambient temperature is between 18°C and 28°C.

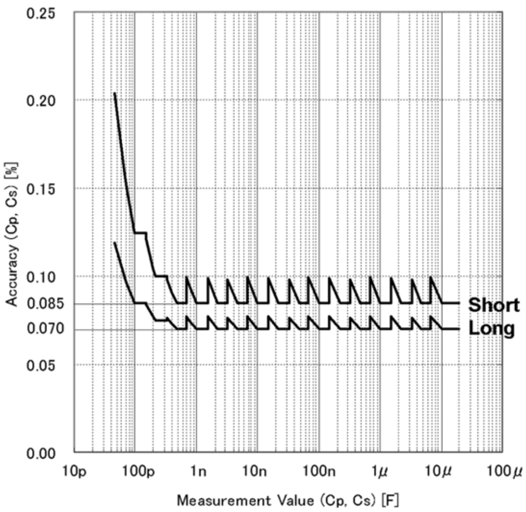

Figure 1. Accuracy of Cp and Cs when measurement frequency is 1 kHz (measurement signal level: 1V)

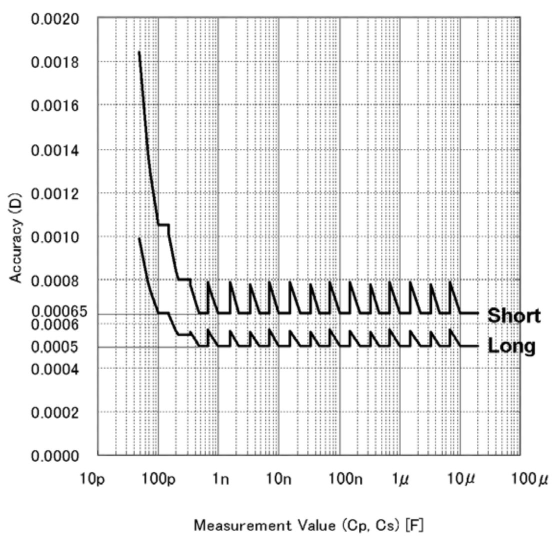

Figure 2. Accuracy of D when measurement frequency is 1 kHz (measurement signal level: 1V)

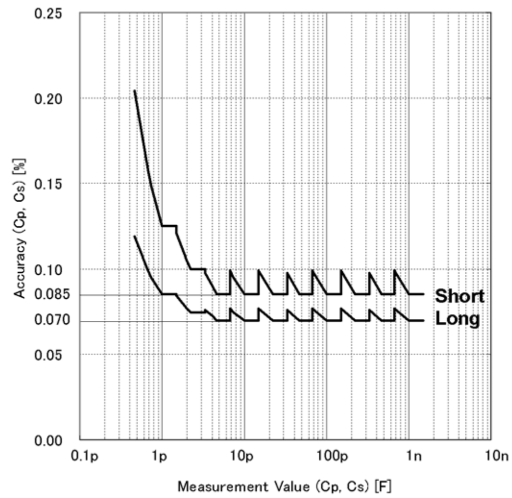

Figure 3. Accuracy of Cp and Cs when measurement frequency is 1 MHz (measurement signal level: 1V)

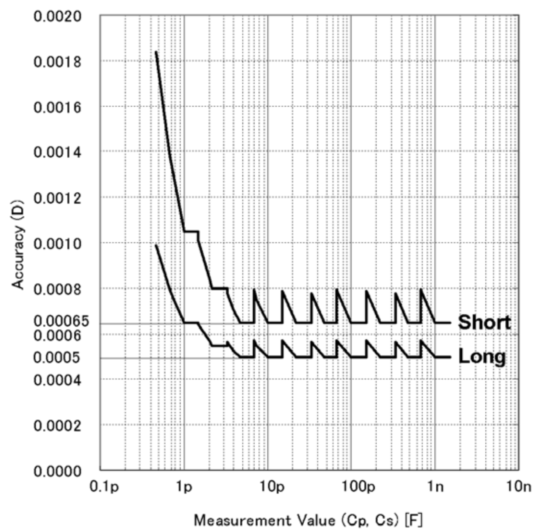

Figure 4 Accuracy of D when measurement frequency is 1 MHz (measurement signal level: 1V)

Measurement time

Table 12 shows the measurement time for each measurement time mode.

Table 12. Measurement time

Measurement time mode	Measurement time (T3 + T4 + T5 of Figure 5)
Short	6.5 ± 0.5 ms
Long	16.5 ± 1.0 ms

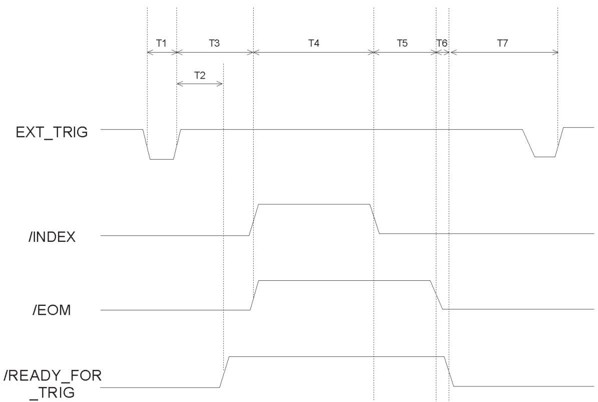

Figure 5. Timing chart and measurement time

Table 13 shows the values of T1 - T7 when the following conditions are met.

Display:	OFF
Measurement range mode:	Hold range mode (Hold)
Trigger delay time:	0 ms
Averaging factor:	1

(The ON/OFF of the compensation and comparator function does not affect the values of T1 - T7)

Table 13. Values of T1 - T7 (Typical)

			Measurement time mode	**Minimum value**	**Typical value**	**Maximum value**
T1	Trigger pulse width		Independent	1 μs*2	-	-
T2	Trigger response time of /READY_FOR_TRIG		Independent	-	200 μs	350 μs
T3	Measurement time (T3 + T4 + T5)	Trigger response time of /INDEX and /EOM	Independent	-	250 μs	400 μs
T4		Analog measurement time (/INDEX)	Short	-	4.25 ms	-
			Long	-	14.25 ms	-
T5		Measurement computation time	Independent	-	2.0 ms	-
T6	READY_FOR_TRIG setup time		Independent	-	15 μs	30 μs
T7	Trigger wait time		Independent	0 μs	-	-

*2. When trigger signal is input through the handler interface.

Display time

When the display is ON, the instrument needs the time (display time) to renew the displayed items. The display time shown in Table 14 depends on the display page of the instrument setup display area (use the [Show Setting] key in the front panel to select the item you want to display). The ON/OFF of the deviation measurement mode does not affect the display time.

Table 14. Display time

Display page of the instrument setup display area: Page number	Display item	Typical value
1	Frequency and level of measurement signal	2.5 ms
2	Averaging factor and measurement cable length	
3	Measurement range and trigger delay time	4.0 ms
4	Measurement signal level monitor values	
5	Multi compensation settings	
6	Handler output (comparator sorting result)	
7 to 18	Limit range settings of comparator	
19 to 24	BIN count results	

Display renewal timing

The display is renewed immediately after the measurement completes (the /EOM signal goes low level). However, the display is renewed after transferring the measurement data if the external controller transmits a request to read measurement data before end of measurement. (The measurement data is transferred after the display renewal completes if the external controller transmits a request to read the measurement data after the display renewal starts.)

Measurement time (T4) when averaging function is used

When the averaging factor is set to more than 1, T4 is calculated as follows. (See Table 15.)

Measurement data transfer time through GPIB

Table 16 shows the measurement data transfer time when the following conditions are met.

Host computer:	HP9000 Series, Model C200
Display:	ON
Measurement range mode:	Hold range mode (Hold)
OPEN/SHORT/LOAD compensation:	ON
Measurement signal monitor:	OFF
BIN count function:	OFF

Table 15. Measurement time @ averaging ≥ 2(typical)

Measurement frequency	Measurement time mode	Equation to calculate T4*3 [ms] (typical)
1 kHz	Short	$T4 = 4.85 \times Ave - 0.6$
	Long	$T4 = 14.85 \times Ave - 0.6$
1 MHz	Short	$T4 = (4 \times \frac{100}{100 + Fshift} + 0.85) \times Ave - 0.6$
	Long	$T4 = (14 \times \frac{100}{100 + Fshift} + 0.85) \times Ave - 0.6$

Table 16. Measurement Data Transfer Time (Typical)

		Data transfer format	Comparator On	Comparator Off
Required time for data readout of a measurement using :FETC? command (Total time of command transmission and data transfer)		ASCII	2.3 ms	2.1 ms
		Binary	2.5 ms	2.3 ms
Required time for data readout of a measurement using :READ? command	Command transmission	ASCII	1.9 ms	1.9 ms
	Data transfer		1.7 ms	1.5 ms
	Command transmission	Binary	1.9 ms	1.9 ms
	Data transfer		1.4 ms	1.2 ms
Required time for data readout of 1000 measurements using :DATA? BUF3 command (Total time of command transmission and data transfer)		ASCII	1.40 s	1.15 s
		Binary	0.65 s	0.49 s

*3. Ave: Averaging factor, F Shift: Frequency Shift setting (-1, 0, 1 or 2)

Measurement assistance functions

Compensation function

OPEN compensation, SHORT compensation, LOAD compensation, and OFFSET compensation are all available.

MULTI compensation function

- OPEN/SHORT/LOAD compensation for 64 channels
- The LOAD compensation standard value can be defined for each channel.

Display

Meter has a 40-column x 2-row LCD display.

Deviation measurement function

Deviation from reference value and percentage of deviation from the reference value can be output as the result.

Comparator function

BIN sort The primary parameter can be sorted into 9 BINS, OUT_OF_BINS, AUX_BIN, and LOW_C_REJECT.
The secondary parameter can be sorted into High, In, and Low.

Limit setup An absolute value, deviation value, and % deviation value are available for setup.

Bin count Countable from 0 to 999999.

Low C reject function

Extremely low measured capacitance values can be automatically detected as a measurement error.

Measurement signal level monitor function

- Measurement voltage and measurement current can be monitored.
- Level monitor accuracy (typical): ±(3% + 1 mV)

Data buffer function

Up to 1000 measurement results can be read out in a batch.

Save/recall function

Up to 10 setup conditions can be written to and read from the built-in non-volatile memory.

Resume function

- Recovers the instrument setup automatically saved at power-down at the next power-on.
- Memory retention time (typical):
  72 hours (23°C ±5°C)

Key lock function

The front panel keys can be locked.

GPIB interface

Complies with IEEE488.1, 2 and SCPI.

Handler interface

The input and output signals are negative logic and optically-isolated open collector signals.

Output signal Bin1 - Bin9, Out of Bins, Aux Bin, P-Hi, P-Lo, S-Reject, INDEX, EOM, Alarm, OVLD, Low C Reject

Input signal Keylock, Ext-Trigger

Scanner interface

The input and output signals are negative logic and optically-isolated open collector signals.

Output signal INDEX, EOM

Input signal Ch0 - Ch5, Ch valid, Ext-Trigger

Measurement circuit protection

See Table 17 for the maximum discharge withstand voltage that the internal circuit can be protected if a charged capacitor is connected to the UNKNOWN terminal is as follows.

NOTE: Discharge capacitors before connecting them to the UNKNOWN terminal (or a test fixture).

Table 17. Maximum discharge withstand voltage (typical)

Maximum discharge withstand voltage	Range of the capacitance value C of DUT
1000 V	C < 2 μF
$\sqrt{2/C}$ V	C ≥ 2 μF

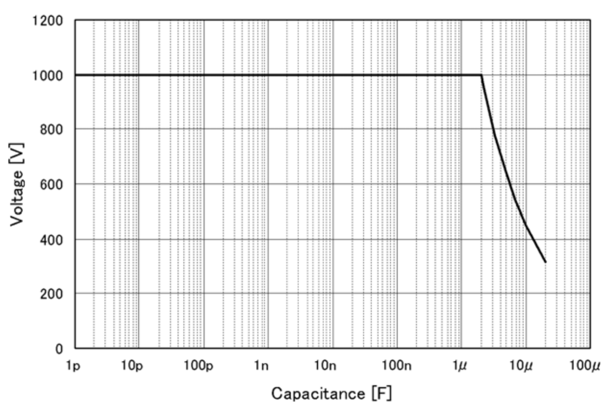

Figure 6. Maximum discharge withstand voltage (typical)

General specifications

Power source

Voltage	90 VAC - 132 VAC, 198 VAC - 264 VAC
Frequency	47 Hz - 66 Hz
Power consumption	Max. 35 W /Max. 100 VA

Operating environment

Temperature	0°C - 45°C
Humidity (≤ 40°C, no condensation)	15% - 95% RH
Altitude	0 m - 2000 m

Storage environment

Temperature	-40°C - 70°C
Humidity (≤ 65°C, no condensation)	0% - 90% RH
Altitude	0 m - 4572 m

Weight

3 kg (nominal), 6.6 lbs

Outer dimensions

320 (width) x 100 (height) x 300 (depth) mm (nominal)
12.6(W) x 3.9(H) x 11.8(D) inches (nominal)

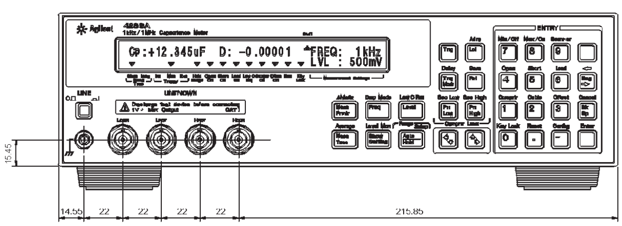

Figure 7. 4288A Front view

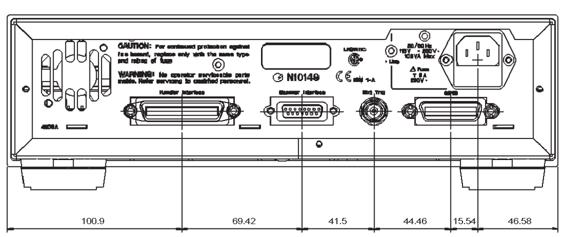

Figure 8. 4288A Rear view

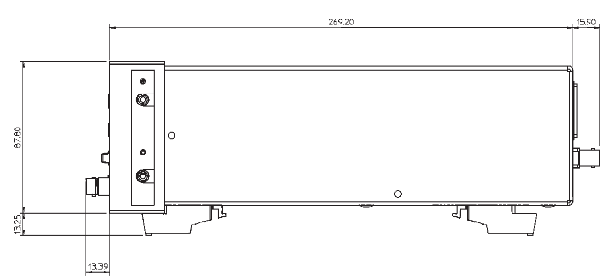

Figure 9. 4288A Side view

EMC

CE ISM 1-A

European Council Directive 89/336/EEC
IEC 61326-1:1997+A1
CISPR 11:1990 / EN 55011:1991 Group 1, Class A
IEC 61000-4-2:1995 / EN 61000-4-2:1995
4 kV CD / 4 kV AD
IEC 61000-4-3:1995 / EN 61000-4-3:1996
3 V/m, 80-1000 MHz, 80% AM
IEC 61000-4-4:1995 / EN 61000-4-4:1995
1 kV power / 0.5 kV Signal
IEC 61000-4-5:1995 / EN 61000-4-5:1995
0.5 kV Normal / 1 kV Common
IEC 61000-4-6:1996 / EN 61000-4-6:1996
3 V, 0.15-80 MHz, 80% AM
IEC 61000-4-11:1994 / EN 61000-4-11:1994
100% 1 cycle

Note: When tested at 3 V/m according to IEC 61000-4-3:1995 / EN 61000-4-3:1996, the measurement accuracy is double the accuracy of basic specification when the test frequency is 1 kHz and the instrument measurement range is 100 pF.

N10149

AS / NZS 2064.1/2 Group 1, Class A

Safety

CE ISM 1-A

European Council Directive 73/23/EEC
IEC 61010-1:1990+A1+A2 / EN 61010-1:1993+A2
INSTALLATION CATEGORY II, POLLUTION DEGREE 2
INDOOR USE
IEC60825-1:1994 CLASS 1 LED PRODUCT

LR95111C

CAN / CSA C22.2 No. 1010.1-92

Sample calculations of measurement accuracy

This section describes an example of calculating the measurement accuracy for each measurement parameter, assuming the following measurement conditions:

Measurement signal frequency	1 kHz
Measurement signal level	0.5 V
Measurement range	10 nF
Measurement time mode	Short mode
Ambient temperature	28°C

When measurement parameter is Cp-D (or Cs-D)

The following is an example of calculating accuracy of Cp (or Cs) and D, assuming that measured result of Cp (or Cs) is 8.00000 nF and measured result of D is 0.01000.

From Table 10, the equation to calculate the accuracy of Cp (or Cs) is $0.055+0.030 \times K$ and the equation to calculate the accuracy of D is $0.00035 + 0.00030 \times K$. The measurement signal level is 0.5, the measurement range is 10 nF, and the measured result of Cp (or Cs) is 8.00000 nF. Therefore, $K = (1/0.5) \times (10/8.00000) = 2.5$. Substitute this result into the equation. The result is: the accuracy of Cp (or Cs) is $0.055 + 0.030 \times 2.5 = 0.13\%$ and the accuracy of D is $0.00035 + 0.00030 \times 2.5 = 0.0011$.

Therefore, the true Cp (or Cs) value exists within $8.00000 \pm (8.00000 \times 0.13/100) = 8.00000 \pm 0.0104$ nF, that is, 7.9896 nF to 8.0104 nF, and the true D value exists within 0.01000 ± 0.0011, that is, 0.0089 to 0.0111.

When measurement parameter is Cp-Q (or Cs-Q)

The following is an example of calculating accuracy of Cp (or Cs) and Q, assuming that measured result of Cp (or Cs) is 8.00000 nF and measured result of Q is 20.0.

The accuracy of Cp (or Cs) is the same as that in the example of Cp-D.

From Table 10, the equation to calculate the accuracy of D is $0.00035 + 0.00030 \times K$. Substitute K = 2.5 (same as Cp-D) into this equation. The accuracy of D is $0.00035 + 0.00030 \times 2.5 = 0.0011$. Then, substitute the obtained D accuracy into Equation 1. The accuracy of Q is $\pm (20.0)^2 \times 0.0011/(1 \mp 20.0 \times 0.0011) = \pm 0.44/(1 \mp 0.022)$, that is, -0.43 to 0.45.

Therefore, the true Q value exists within 19.57 to 20.45.

When measurement parameter is Cp-G

The following is an example of calculating accuracy of Cp and G, assuming that measured result of Cp is 8.00000 nF and measured result of G is 1.00000 µS.

The accuracy of Cp is the same as that in the example of Cp-D.

From Table 10, the equation to calculate the accuracy of G is $(3.5 + 2.0 \times K) \times Cx$. Substitute K = 2.5 (same as Cp-D) and 8.00000 nF of the measured Cp result into this equation. The accuracy of G is $(3.5 + 2.0 \times 2.5) \times 8.00000 = 68$ nS(0.068 µS).

Therefore, the true G value exists within 1.00000 ± 0.068 µS, that is, 0.932 µS to 1.068 µS.

When measurement parameter is Cp-Rp

The following is an example of calculating accuracy of Cp and Rp, assuming that measured result of Cp is 8.00000 nF and measured result of Rp is 2.00000 MΩ.

The accuracy of Cp is the same as that in the example of Cp-D.

From Table 10, the equation to calculate the accuracy of G is $(3.5 + 2.0 \times K) \times Cx$. Substitute K = 2.5 (same as Cp-D) and 8.00000 nF of the measured Cp result into this equation. The accuracy of G is $(3.5 + 2.0 \times 2.5) \times 8.00000 = 68$ nS. Then, substitute the obtained G accuracy into Equation 2. The accuracy of Rp is $\pm (2 \times 10^6)^2 \times 68 \times 10^{-9}/(1 \mp 2 \times 10^6 \times 68 \times 10^{-9}) = \pm 0.272 \times 10^6/(1 \mp 0.136)$, that is, -0.23944 MΩ to 0.31481 MΩ.

Therefore, the true Rp value exists within 1.76056 MΩ to 2.31481 MΩ.

When measurement parameter is Cs-Rs

The following is an example of calculating accuracy of Cp and Rs, assuming that measured result of Cs is 8.00000 nF and measured result of Rs is 4.00000 kΩ.

Because the Cs accuracy is $D = 2 \times \pi \times Freq \times Cs \times Rp = 2 \times \pi \times 10^3 \times 8 \times 10^{-9} \times 4 \times 10^3 = 0.2 > 0.1$, multiply 0.13% (the result obtained for Cs-D) by $1 + D^2$. The result is $0.13 \times (1 + 0.2^2) = 0.1352\%$.

From Table 10, the equation to calculate the accuracy of Rs is $(90 + 50 \times K)/Cx$. Substitute K = 2.5 (same as Cs-D) and 8.00000 nF of the measured Cs result into this equation. The accuracy of G is $(90 + 50 \times 2.5)/8.00000 = 26.875$ Ω. Because D>0.1, multiply the result by $1 + D^2$ as in the case of Cs. The final result is 27.95 Ω.

Therefore, the true Cs value exists within $8.00000 \pm (8.00000 \times 0.1352/100) = 8.00000 \pm 0.01082$ nF, that is, 7.98918 nF to 8.01082 nF, and the true Rs value exists within 4.00000 ± 0.02795 kΩ, that is, 3.97205 to 4.02795 kΩ.

Agilent Technologies'
Test and Measurement Support, Services, and Assistance
Agilent Technologies aims to maximize the value you receive, while minimizing your risk and problems. We strive to ensure that you get the test and measurement capabilities you paid for and obtain the support you need. Our extensive support resources and services can help you choose the right Agilent products for your applications and apply them successfully. Every instrument and system we sell has a global warranty. Support is available for at least five years beyond the production life of the product. Two concepts underlie Agilent's overall support policy: "Our Promise" and "Your Advantage."

Our Promise
Our Promise means your Agilent test and measurement equipment will meet its advertised performance and functionality. When you are choosing new equipment, we will help you with product information, including realistic performance specifications and practical recommendations from experienced test engineers. When you use Agilent equipment, we can verify that it works properly, help with product operation, and provide basic measurement assistance for the use of specified capabilities, at no extra cost upon request. Many self-help tools are available.

Your Advantage
Your Advantage means that Agilent offers a wide range of additional expert test and measurement services, which you can purchase according to your unique technical and business needs. Solve problems efficiently and gain a competitive edge by contracting with us for calibration, extra-cost upgrades, out-of-warranty repairs, and on-site education and training, as well as design, system integration, project management, and other professional engineering services. Experienced Agilent engineers and technicians worldwide can help you maximize your productivity, optimize the return on investment of your Agilent instruments and systems, and obtain dependable measurement accuracy for the life of those products.

Key literature

Agilent 4288A Capacitance Meter product overview, publication number 5980-2861EN.

Web resources

Please visit our component manufacturer industry area at:

www.agilent.com/find/component_test

By internet, phone, or fax, get assistance with all your test and measurement needs

Online assistance:
www.agilent.com/find/assist

Phone or Fax
United States:
(tel) 1 800 452 4844

Canada:
(tel) 1 877 894 4414
(fax) (905) 282-6495

Europe:
(tel) (31 20) 547 2323
(fax) (31 20) 547 2390

Japan:
(tel) (81) 426 56 7832
(fax) (81) 426 56 7840

Latin America:
(tel) (305) 269 7500
(fax) (305) 269 7599

Australia:
(tel) 1 800 629 485
(fax) (61 3) 9210 5947

New Zealand:
(tel) 0 800 738 378
(fax) 64 4 495 8950

Asia Pacific:
(tel) (852) 3197 7777
(fax) (852) 2506 9284

Printed in USA December 28, 2000
5988-0362E

Agilent Technologies
Innovating the HP Way