

# E4980A Precision LCR Meter

20 Hz to 2 MHz

# E4980AL Precision LCR Meter

20 Hz to 300 kHz/500 kHz/1 MHz



Fully compliant to  
LXI Class C specification

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## Definitions

All specifications apply to the conditions of a 0 to 55°C temperature range, unless otherwise stated, and 30 minutes after the instrument has been turned on.

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

Supplemental information is provided as information that is useful in operating the instrument but is not covered by the product warranty. This information is classified as either typical or nominal.

**Typical (typ.):** Expected performance of an average unit without taking guardbands into account.

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

## How to Use Tables

When measurement conditions fall under multiple categories in a table, apply the best value.

For example, basic accuracy  $A_b$  is 0.10% under the following conditions:

|                       |          |
|-----------------------|----------|
| Measurement time mode | SHORT    |
| Test frequency        | 125 Hz   |
| Test signal voltage   | 0.3 Vrms |

## E4980A/E4980AL

The E4980A is the model number of the 20 Hz to 2 MHz frequency range LCR meter. The E4980AL is the model number of the 20 Hz to 300 kHz, 500 kHz or 1 MHz frequency range LCR meter. See the E4980A/E4980AL Configuration Guide (5989-8321EN) for more details.

| Frequency range  | Model number and option |
|------------------|-------------------------|
| 20 Hz to 2 MHz   | E4980A                  |
| 20 Hz to 1 MHz   | E4980AL-102             |
| 20 Hz to 500 kHz | E4980AL-052             |
| 20 Hz to 300 kHz | E4980AL-032             |

## Basic Specifications

### Measurement functions

#### Measurement parameters

- Cp-D, Cp-Q, Cp-G, Cp-Rp
- Cs-D, Cs-Q, Cs-Rs
- Lp-D, Lp-Q, Lp-G, Lp-Rp, Lp-Rdc
- Ls-D, Ls-Q, Ls-Rs, Ls-Rdc
- R-X
- Z- $\theta$ d, Z- $\theta$ r
- G-B
- Y- $\theta$ d, Y- $\theta$ r
- Vdc-I<sub>dc</sub><sup>1</sup>

#### Definitions

|                             |   |
|-----------------------------|---|
| <b>Cp</b>                   | Capacitance value measured with parallel-equivalent circuit model               |
| <b>Cs</b>                   | Capacitance value measured with series-equivalent circuit model                 |
| <b>Lp</b>                   | Inductance value measured with parallel-equivalent circuit model                |
| <b>Ls</b>                   | Inductance value measured with series-equivalent circuit model                  |
| <b>D</b>                    | Dissipation factor  |
| <b>Q</b>                    | Quality factor (inverse of D)   |
| <b>G</b>                    | Equivalent parallel conductance measured with parallel-equivalent circuit model |
| <b>Rp</b>                   | Equivalent parallel resistance measured with parallel-equivalent circuit model  |
| <b>Rs</b>                   | Equivalent series resistance measured with series-equivalent circuit model      |
| <b>Rdc</b>                  | Direct-current resistance   |
| <b>R</b>                    | Resistance  |
| <b>X</b>                    | Reactance   |
| <b>Z</b>                    | Impedance   |
| <b>Y</b>                    | Admittance  |
| <b><math>\theta</math>d</b> | Phase angle of impedance/admittance (degree)                                    |
| <b><math>\theta</math>r</b> | Phase angle of impedance/admittance (radian)                                    |
| <b>B</b>                    | Susceptance   |
| <b>Vdc</b>                  | Direct-current voltage  |
| <b>I<sub>dc</sub></b>       | Direct-current electricity  |

**Deviation measurement function:** Deviation from reference value and percentage of deviation from reference value can be output as the result.

**Equivalent circuits for measurement:** Parallel, Series

1. E4980A-001 is required.

**Impedance range selection:** Auto (auto range mode), manual (hold range mode)

**Trigger mode:** Internal trigger (INT), manual trigger (MAN), external trigger (EXT), GPIB trigger (BUS)

**Table 1. Trigger delay time**

|            |  |
|------------|--|
| Range      | 0 s - 999 s  |
| Resolution | 100 $\mu$ s (0 s $\leq$ - $\leq$ 100 s)<br>1 ms (100 s < - $\leq$ 999 s) |

**Table 2. Step delay time**

|            |  |
|------------|--|
| Range      | 0 s - 999 s  |
| Resolution | 100 $\mu$ s (0 s $\leq$ - $\leq$ 100 s)<br>1 ms (100 s < - $\leq$ 999 s) |

**Measurement terminal:** Four-terminal pair

**Test cable length:** 0 m, 1 m, 2 m, 4 m

**Measurement time modes:** Short mode, medium mode, long mode.

**Table 3. Averaging**

|            |                      |
|------------|----------------------|
| Range      | 1 - 256 measurements |
| Resolution | 1                    |

## Test signal

**Table 4. Test frequencies**

|                      |   |
|----------------------|---|
| Test frequencies     | 20 Hz - 2 MHz (E4980A)<br>20 Hz - 1 MHz (E4980AL-102)<br>20 Hz - 500 kHz (E4980AL-052)<br>20 Hz - 300 kHz (E4980AL-032)   |
| Resolution           | 0.01 Hz (20 Hz - 99.99 Hz)<br>0.1 Hz (100 Hz - 999.9 Hz)<br>1 Hz (1 kHz - 9.999 kHz)<br>10 Hz (10 kHz - 99.99 kHz)<br>100 Hz (100 kHz - 999.9 kHz)<br>1 kHz (1 MHz - 2 MHz) |
| Measurement accuracy | $\pm$ 0.01%   |

**Table 5. Test signal modes**

|          |   |
|----------|---|
| Normal   | Program selected voltage or current at the measurement terminals when they are opened or short-circuited, respectively. |
| Constant | Maintains selected voltage or current at the device under test (DUT) independently of changes in impedance of DUT.      |

## Signal level

**Table 6. Test signal voltage**

|            |                       |  |  |
|------------|-----------------------|--|--|
| Range      |                       | 0 Vrms - 2.0 Vrms  |  |
| Resolution |                       | 100 $\mu$ Vrms (0 Vrms $\leq$ - $\leq$ 0.2 Vrms)<br>200 $\mu$ Vrms (0.2 Vrms < - $\leq$ 0.5 Vrms)<br>500 $\mu$ Vrms (0.5 Vrms < - $\leq$ 1 Vrms)<br>1 mVrms (1 Vrms < - $\leq$ 2 Vrms) |  |
| Accuracy   | Normal                | $\pm$ (10% + 1 mVrms)  | Test frequency $\leq$ 1 MHz: spec.<br>Test frequency > 1 MHz: typ. |
|            | Constant <sup>1</sup> | $\pm$ (6% + 1 mVrms)   | Test frequency $\leq$ 1 MHz: spec.<br>Test frequency > 1 MHz: typ. |

**Table 7. Test signal current**

|            |                       |  |  |
|------------|-----------------------|--|--|
| Range      |                       | 0 Arms - 20 mArms  |  |
| Resolution |                       | 1 $\mu$ Arms (0 Arms $\leq$ - $\leq$ 2 mArms)<br>2 $\mu$ Arms (2 mArms < - $\leq$ 5 mArms)<br>5 $\mu$ Arms (5 mArms < - $\leq$ 10 mArms)<br>10 $\mu$ Arms (10 mArms < - $\leq$ 20 mArms) |  |
| Accuracy   | Normal                | $\pm$ (10% + 10 $\mu$ Arms)  | Test frequency $\leq$ 1 MHz: spec.<br>Test frequency > 1 MHz: typ. |
|            | Constant <sup>1</sup> | $\pm$ (6% + 10 $\mu$ Arms)   | Test frequency $\leq$ 1 MHz: spec.<br>Test frequency > 1 MHz: typ. |

**Output impedance:** 100  $\Omega$  (nominal)

Test signal level monitor function

- Test signal voltage and test signal current can be monitored.
- Level monitor accuracy (see next page)

1. When auto level control function is on.

**Table 8. Test signal voltage monitor accuracy (Vac)**

| Test signal voltage <sup>2</sup> | Test frequency          | Specification   |
|----------------------------------|-------------------------|---|
| 5 mVrms - 2 Vrms                 | $\leq$ 1 MHz<br>> 1 MHz | $\pm$ (3% of reading value + 0.5 mVrms)<br>$\pm$ 6% of reading value + 1 mVrms) |

**Table 9. Test signal current monitor accuracy (Iac)**

| Test signal current <sup>2</sup> | Test frequency          | Specification   |
|----------------------------------|-------------------------|---|
| 50 $\mu$ Arms - 20 mArms         | $\leq$ 1 MHz<br>> 1 MHz | $\pm$ (3% of reading value + 5 $\mu$ Arms)<br>$\pm$ (6% of reading value + 10 $\mu$ Arms) |

## Measurement display ranges

Table 10 shows the range of measured value that can be displayed on the screen. For the effective measurement ranges, refer to Figure 1 impedance measurement accuracy example.

**Table 10. Allowable display ranges for measured values**

| Parameter            | Measurement display range      |
|----------------------|--------------------------------|
| Cs, Cp               | ± 1.000000 aF to 999.9999 EF   |
| Ls, Lp               | ±1.000000 aH to 999.9999 EH    |
| D                    | ±0.000001 to 9.999999          |
| Q                    | ±0.01 to 99999.99              |
| R, Rs, Rp, X, Z, Rdc | ±1.000000 aΩ to 999.9999 EΩ    |
| G, B, Y              | ±1.000000 aS to 999.9999 ES    |
| Vdc                  | ±1.000000 aV to 999.9999 EV    |
| Idc                  | ±1.000000 aA to 999.9999 EA    |
| θr                   | ±1.000000 arad to 3.141593 rad |
| θd                   | ±0.0001 deg to 180.0000 deg    |
| Δ%                   | ±0.0001% to 999.9999%          |

a:  $1 \times 10^{-18}$ , E:  $1 \times 10^{18}$

1. When auto level control function is on.
2. This is not an output value but rather a displayed test signal level.

## Absolute measurement accuracy

The following equations are used to calculate absolute accuracy.

Absolute accuracy Aa of |Z|, |Y|, L, C, R, X, G, B (L, C, X, and B accuracies apply when  $D_x \leq 0.1$ , R and G accuracies apply when  $Q_x \leq 0.1$ )

When  $D_x \geq 0.1$ , multiply Acal by  $\sqrt{1 + D^2_x}$  for L, C, X, and B accuracies

When  $Q_x \geq 0.1$ , multiply Acal by  $\sqrt{1 + Q^2_x}$  for R and G accuracies

Under an AC magnetic field, the following equation is applied to the measurement accuracy.

$$A \times (1 + B \times (2 + 0.5 / V_s))$$

Where A Absolute accuracy  
 B Magnetic flux density [Gauss]  
 Vs Test signal voltage level [Volts]

**Equation 1.  $Aa = Ae + Acal$**

Aa Absolute accuracy (% of reading value)

Ae Relative accuracy (% of reading value)

Acal Calibration accuracy (%)

where G accuracy is applied only to G-B measurements.

**D accuracy (when  $Dx \leq 0.1$ )**

**Equation 2.  $De + \theta cal$**

Dx Measured D value

De Relative accuracy of D

$\theta cal$  Calibration accuracy of  $\theta$  (radian)

when  $0.1 < Dx \leq 1$ , multiply  $\theta cal$  by  $(1 + Dx)$

**Q accuracy (When  $Qx \times Da < 1$ )<sup>1</sup>**

**Equation 3.** 
$$\pm \frac{(Qx^2 \times Da)}{(1 \mp Qx \times Da)}$$

Qx Measured Q value

Da Absolute accuracy of D

<sup>1</sup> When  $Qx \times Da \geq 1$ , Q accuracy =  $\pm \infty$



## $\theta$ accuracy

### Equation 4. $\theta_e + \theta_{cal}$

$\theta_e$  Relative accuracy of  $\theta$  (degree)  
 $\theta_{cal}$  Calibration accuracy of  $\theta$  (degree)

## G accuracy (when $D_x \leq 0.1$ )

Equation 5.  $B_x + Da$  (S)

$$B_x = 2\pi f C_x = \frac{1}{2\pi f L_x}$$

$D_x$  Measured D value  
 $B_x$  Measured B value (S)  
 $Da$  Absolute accuracy of D  
 $f$  Test frequency (Hz)  
 $C_x$  Measured C value (F)  
 $L_x$  Measured L value (H)

where the accuracy of G is applied to Cp-G measurements.

## Absolute accuracy of $R_p$ (when $D_x \leq 0.1$ and $D_x > Da$ )<sup>1</sup>

Equation 6.  $\pm \frac{R_{px} \times Da}{D_x \mp Da}$  ( $\Omega$ )

$R_{px}$  Measured  $R_p$  value ( $\Omega$ )  
 $D_x$  Measured D value  
 $Da$  Absolute accuracy of D

## Absolute accuracy of $R_s$ (when $D_x \leq 0.1$ )

Equation 7.  $X_x \times Da$  ( $\Omega$ )

$$X_x = \frac{1}{2\pi f C_x} = 2\pi f L_x$$

$D_x$  Measured D value  
 $X_x$  Measured X value ( $\Omega$ )  
 $Da$  Absolute accuracy of D  
 $f$  Test frequency (Hz)  
 $C_x$  Measured C value (F)  
 $L_x$  Measured L value (H)

<sup>1</sup> When  $D_x \leq Da$ ,  $R_p$  accuracy =  $\pm \infty$

## Relative accuracy

Relative accuracy includes stability, temperature coefficient, linearity, repeatability, and calibration interpolation error. Relative accuracy is specified when all of the following conditions are satisfied:

- Warm-up time: 30 minutes
- Test cable length: 0 m, 1 m, 2 m, or 4 m (Keysight Technologies, Inc. 16048A/D/E)
- A “Signal Source Overload” warning does not appear. When the test signal current exceeds a value in table 11 below, a “Signal Source Overload” warning appears.

**Table 11.**

| Test signal voltage | Test frequency | Condition <sup>1</sup>  |
|---------------------|----------------|---|
| ≤ 2 Vrms            | –              | –   |
| > 2 Vrms            | ≤ 1 MHz        | The smaller value of either 110 mA or<br>130 mA - 0.0015 × Vac × (Fm / 1 MHz) × (L_cable + 0.5) |
|                     | > 1 MHz        | 70 mA - 0.0015 × Vac × (Fm / 1 MHz) × (L_cable + 0.5)   |

1. When the calculation result is a negative value, 0 A is applied.

Vac [V]            Test signal voltage  
Fm [Hz]            Test frequency  
L\_cable [m]        Cable length

- OPEN and SHORT corrections have been performed.
- Bias current isolation: Off
- The DC bias current does not exceed a set value within each range of the DC bias current
- The optimum impedance range is selected by matching the impedance of DUT to the effective measuring range.

|Z|, |Y|, L, C, R, X, G, and B accuracy (L, C, X, and B accuracies apply when  $D_x \leq 0.1$ , R and G accuracies apply  $Q_x \leq 0.1$ )

When  $D_x > 0.1$ , multiply  $A_e$  by  $\sqrt{1+D_x^2}$  for L, C, X, and B accuracies

When  $Q_x > 0.1$ , multiply  $A_e$  by  $\sqrt{1+Q_x^2}$  for R and G accuracies

Relative accuracy  $A_e$  is given as:

**Equation 8.**  $A_e = [A_b + Z_s / |Z_m| \times 100 + Y_o \times |Z_m| \times 100] \times K_t$

$Z_m$  Impedance of DUT  
 $A_b$  Basic accuracy  
 $Z_s$  Short offset  
 $Y_o$  Open offset  
 $K_t$  Temperature coefficient

## D accuracy

D accuracy  $D_e$  is given as - when  $D_x \leq 0.1$

**Equation 9.**  $D_e = \pm A_e / 100$

$D_x$  Measured D value  
 $A_e$  Relative accuracies of  $|Z|$ ,  $|Y|$ , L, C, R, X, G, and B

When  $0.1 < D_x \leq 1$ , multiply  $D_e$  by  $(1 + D_x)$

## Q accuracy (when $Q \times D_e < 1$ )<sup>1</sup>

Q accuracy  $Q_e$  is given as:

**Equation 10.** 
$$Q_e = \pm \frac{(Q_x^2 \times D_e)}{(1 \mp Q_x \times D_e)}$$

$Q_x$  Measured Q value  
 $D_e$  Relative D accuracy

## $\theta$ accuracy

$\theta$  accuracy  $\theta_e$  is given as:

**Equation 11.** 
$$\theta_e = \frac{180 \times A_e}{\pi \times 100} \text{ (deg)}$$

$A_e$  Relative accuracies of  $|Z|$ ,  $|Y|$ , L, C, R, X, G, and B

1. When  $Q_x \times D_e \geq 1$ ,  $Q_e = \pm \infty$

## G accuracy (when $D_x \leq 0.1$ )

G accuracy  $G_e$  is given as:

**Equation 12.**  $G_e = B_x \times D_e$  (S)

$$B_x = 2\pi f C_x = \frac{1}{2\pi f L_x}$$

|       |                      |
|-------|----------------------|
| $G_e$ | Relative G accuracy  |
| $D_x$ | Measured D value     |
| $B_x$ | Measured B value     |
| $D_e$ | Relative D accuracy  |
| $f$   | Test frequency (Hz)  |
| $C_x$ | Measured C value (F) |
| $L_x$ | Measured L value (H) |

## Rp accuracy (when $D_x \leq 0.1$ and $D_x > D_e$ )<sup>1</sup>

Rp accuracy  $R_{pe}$  is given as:

**Equation 13.**  $R_{pe} = \pm \frac{R_{px} \times D_e}{D_x \mp D_e}$  ( $\Omega$ )

|          |                                |
|----------|--------------------------------|
| $R_{pe}$ | Relative Rp accuracy           |
| $R_{px}$ | Measured Rp value ( $\Omega$ ) |
| $D_x$    | Measured D value               |
| $D_e$    | Relative D accuracy            |

## Rs accuracy (when $D_x \leq 0.1$ )

Rs accuracy  $R_{se}$  is given as:

**Equation 14.**  $R_{se} = X_x \times D_e$  ( $\Omega$ )

$$X_x = \frac{1}{2\pi f C_x} = 2\pi f L_x$$

|          |                               |
|----------|-------------------------------|
| $R_{se}$ | Relative Rs accuracy          |
| $D_x$    | Measured D value              |
| $X_x$    | Measured X value ( $\Omega$ ) |
| $D_e$    | Relative D accuracy           |
| $f$      | Test frequency (Hz)           |
| $C_x$    | Measured C value (F)          |
| $L_x$    | Measured L value (H)          |

1. When  $D_x \leq D_e$ ,  $R_{pe} = \pm \infty$

## Example of C-D accuracy calculation

### Measurement conditions

**Test frequency:** 1 kHz  
**Measured C value:** 100 nF  
**Test signal voltage:** 1 Vrms  
**Measurement time mode:** Medium  
**Measurement temperature:** 23°C

$$A_b = 0.05\%$$

$$|Z_m| = 1 / (2\pi \times 1 \times 10^3 \times 100 \times 10^{-9}) = 1590 \Omega$$

$$Z_s = 0.6 \text{ m}\Omega \times (1 + 0.400/1) \times (1 + \sqrt{(1000/1000)}) = 1.68 \text{ m}\Omega$$

$$Y_o = 0.5 \text{ nS} \times (1 + 0.100/1) \times (1 + \sqrt{(100/1000)}) = 0.72 \text{ nS}$$

$$C \text{ accuracy: } A_e = [0.05 + 1.68 \text{ m}/1590 \times 100 + 0.72 \text{ n} \times 1590 \times 100] \times 1 = 0.05\%$$

$$D \text{ accuracy: } D_e = 0.05/100 = 0.0005$$

### Basic accuracy

Basic accuracy  $A_b$  is given from Table 12, 13, 14 and 15.

**Table 12. Measurement time mode = SHORT**

| Test frequency [Hz] | Test signal voltage       |                            |                          |                         |                          |
|---------------------|---------------------------|----------------------------|--------------------------|-------------------------|--------------------------|
|                     | 5 mVrms<br>≤ - < 50 mVrms | 50 mVrms<br>≤ - < 0.3 Vrms | 0.3 Vrms<br>≤ - ≤ 1 Vrms | 1 Vrms<br>< - ≤ 10 Vrms | 10 Vrms<br>< - ≤ 20 Vrms |
| 20 ≤ - < 125        | (0.6%) ×<br>(50 mVrms/Vs) | 0.60%                      | 0.30%                    | 0.30%                   | 0.30%                    |
| 125 ≤ - ≤ 1 M       | (0.2%) ×<br>(50 mVrms/Vs) | 0.20%                      | 0.10%                    | 0.15%                   | 0.15%                    |
| 1 M < - ≤ 2 M       | (0.4%) ×<br>(50 mVrms/Vs) | 0.40%                      | 0.20%                    | 0.30%                   | 0.30%                    |

**Table 13. Measurement time mode = MED, LONG**

| Test frequency [Hz] | Test signal voltage        |                            |                          |                         |                          |
|---------------------|----------------------------|----------------------------|--------------------------|-------------------------|--------------------------|
|                     | 5 mVrms<br>≤ - < 30 mVrms  | 30 mVrms<br>≤ - < 0.3 Vrms | 0.3 Vrms<br>≤ - ≤ 1 Vrms | 1 Vrms<br>< - ≤ 10 Vrms | 10 Vrms<br>< - ≤ 20 Vrms |
| 20 ≤ - < 100        | (0.25%) ×<br>(30 mVrms/Vs) | 0.25%                      | 0.10%                    | 0.15%                   | 0.15%                    |
| 100 ≤ - ≤ 1 M       | (0.1%) ×<br>(30 mVrms/Vs)  | 0.10%                      | 0.05%                    | 0.10%                   | 0.15%                    |
| 1 M < - ≤ 2 M       | (0.2%) ×<br>(30 mVrms/Vs)  | 0.20%                      | 0.10%                    | 0.20%                   | 0.30%                    |

Vs [Vrms]      Test signal voltage

### Effect by impedance of DUT

**Table 14. For impedance of DUT below 30 Ω, the following value is added.**

| Test frequency [Hz] | Impedance of DUT     |              |
|---------------------|----------------------|--------------|
|                     | 1.08 Ω <  Zx  < 30 Ω | Zx  ≤ 1.08 Ω |
| 20 ≤ - ≤ 1 M        | 0.05%                | 0.10%        |
| 1 M < - ≤ 2 M       | 0.10%                | 0.20%        |

**Table 15. For impedance of DUT over 9.2 k Ω, the following value is added.**

| Test frequency [Hz] | Impedance of DUT      |             |
|---------------------|-----------------------|-------------|
|                     | 9.2 kΩ <  Zx  < 92 kΩ | 92 kΩ ≤  Zx |
| 10 k ≤ - ≤ 100 k    | 0%                    | 0.05%       |
| 100 k < - ≤ 1 M     | 0.05%                 | 0.05%       |
| 1 M < - ≤ 2 M       | 0.10%                 | 0.10%       |

### Effect of cable extension

When the cable is extended, the following element is added per one meter.

$$0.015 \% \times (F_m/1 \text{ MHz})^2 \times (L_{\text{cable}})^2$$

Fm [Hz]      Test frequency

L\_cable [m]      Cable length

## Short offset Zs

**Table 16. Impedance of DUT > 1.08 Ω**

| Test frequency [Hz] | Measurement time mode   |   |
|---------------------|---|---|
|                     | SHORT   | MED, LONG   |
| 20 - 2 M            | $2.5 \text{ m}\Omega \times (1 + 0.400/V_s) \times (1 + \sqrt{(1000/F_m)})$ | $0.6 \text{ m}\Omega \times (1 + 0.400/V_s) \times (1 + \sqrt{(1000/F_m)})$ |

**Table 17. Impedance of DUT ≤ 1.08 Ω**

| Test frequency [Hz] | Measurement time mode   |   |
|---------------------|---|---|
|                     | SHORT   | MED, LONG   |
| 20 - 2 M            | $1 \text{ m}\Omega \times (1 + 1/V_s) \times (1 + \sqrt{(1000/F_m)})$ | $0.2 \text{ m}\Omega \times (1 + 1/V_s) \times (1 + \sqrt{(1000/F_m)})$ |

Vs [Vrms] Test signal voltage

Fm [Hz] Test frequency

## Effect of cable extension (Short offset)

**Table 18. When the cable is extended, the following value is added to Zs (independent of the measurement time mode).**

| Test frequency [Hz] | Cable length |         |        |      |
|---------------------|--------------|---------|--------|------|
|                     | 0 m          | 1 m     | 2 m    | 4 m  |
| 20 ≤ - ≤ 1 M        | 0            | 0.25 mΩ | 0.5 mΩ | 1 mΩ |
| 1 M < - ≤ 2 M       | 0            | 1 mΩ    | 2 mΩ   | 4 mΩ |

## Open offset $Y_o$

**Table 19. Test signal voltage  $\leq 2.0$  Vrms**

| Test frequency [Hz]               | Measurement time mode   |   |
|-----------------------------------|---|---|
|                                   | SHORT   | MED, LONG   |
| $20 \leq f < 100 \text{ k}$       | $2 \text{ nS} \times (1 + 0.100/V_s) \times (1 + \sqrt{(100/F_m)})$ | $0.5 \text{ nS} \times (1 + 0.100/V_s) \times (1 + \sqrt{(100/F_m)})$ |
| $100 \text{ k} < f < 1 \text{ M}$ | $20 \text{ nS} \times (1 + 0.100/V_s)$                              | $5 \text{ nS} \times (1 + 0.100/V_s)$                                 |
| $1 \text{ M} < f < 2 \text{ M}$   | $40 \text{ nS} \times (1 + 0.100/V_s)$                              | $10 \text{ nS} \times (1 + 0.100/V_s)$                                |

**Table 20. Test signal voltage  $> 2.0$  Vrms**

| Test frequency [Hz]               | Measurement time mode   |   |
|-----------------------------------|---|---|
|                                   | SHORT   | MED, LONG   |
| $20 \leq f < 100 \text{ k}$       | $2 \text{ nS} \times (1 + 2/V_s) \times (1 + \sqrt{(100/F_m)})$ | $0.5 \text{ nS} \times (1 + 2/V_s) \times (1 + \sqrt{(100/F_m)})$ |
| $100 \text{ k} < f < 1 \text{ M}$ | $20 \text{ nS} \times (1 + 2/V_s)$                              | $5 \text{ nS} \times (1 + 2/V_s)$                                 |
| $1 \text{ M} < f < 2 \text{ M}$   | $40 \text{ nS} \times (1 + 2/V_s)$                              | $10 \text{ nS} \times (1 + 2/V_s)$                                |

$V_s$  [Vrms]      Test signal voltage

$F_m$  [Hz]        Test frequency

Note

The Open Offset may become three times greater in the ranges of 40 to 70 kHz and 80 to 100 kHz due to residual response.

## Effect of cable length

**Table 21. When the cable is extended, multiply  $Y_o$  by the following factor.**

| Test frequency [Hz]               | Cable length |                                    |                                   |                                   |
|-----------------------------------|--------------|------------------------------------|-----------------------------------|-----------------------------------|
|                                   | 0 m          | 1 m                                | 2 m                               | 4 m                               |
| $100 \leq f < 100 \text{ k}$      | 1            | $1 + 5 \times F_m/1 \text{ MHz}$   | $1 + 10 \times F_m/1 \text{ MHz}$ | $1 + 20 \times F_m/1 \text{ MHz}$ |
| $100 \text{ k} < f < 1 \text{ M}$ | 1            | $1 + 0.5 \times F_m/1 \text{ MHz}$ | $1 + 1 \times F_m/1 \text{ MHz}$  | $1 + 2 \times F_m/1 \text{ MHz}$  |
| $1 \text{ M} < f < 2 \text{ M}$   | 1            | $1 + 1 \times F_m/1 \text{ MHz}$   | $1 + 2 \times F_m/1 \text{ MHz}$  | $1 + 4 \times F_m/1 \text{ MHz}$  |

$F_m$  [Hz]        Test frequency



## Temperature factor Kt

Table 22. Temperature factor Kt.

| Temperature [°C]    | Kt |
|---------------------|----|
| $0 \leq - < 18$     | 4  |
| $18 \leq - \leq 28$ | 1  |
| $28 < - \leq 55$    | 4  |

## Calibration accuracy Acal

Calibration accuracy Acal is given below.

For impedance of DUT or test frequency on the boundary line, apply the smaller value.

Table 23. Impedance range = 0.1, 1, 10  $\Omega$

|                   | Test frequency [Hz] |                    |                    |   |   |   |
|-------------------|---------------------|--------------------|--------------------|---|---|---|
|                   | 20 – 1 k            | 1 k – 10 k         | 10 k – 100 k       | 100 k – 300 k                             | 300 k – 1 M                               | 1 M – 2 M                                 |
| Z  [%]            | 0.03                | 0.05               | 0.05               | $0.05 + 5 \times 10^{-5} F_m$             | $0.05 + 5 \times 10^{-5} F_m$             | $0.1 + 1 \times 10^{-4} F_m$              |
| $\theta$ [radian] | $1 \times 10^{-4}$  | $2 \times 10^{-4}$ | $3 \times 10^{-4}$ | $3 \times 10^{-4} + 2 \times 10^{-7} F_m$ | $3 \times 10^{-4} + 2 \times 10^{-7} F_m$ | $6 \times 10^{-4} + 4 \times 10^{-7} F_m$ |

Table 24. Impedance range = 100  $\Omega$

|                   | Test frequency [Hz] |                    |                    |                               |                               |                              |
|-------------------|---------------------|--------------------|--------------------|-------------------------------|-------------------------------|------------------------------|
|                   | 20 – 1 k            | 1 k – 10 k         | 10 k – 100 k       | 100 k – 300 k                 | 300 k – 1 M                   | 1 M – 2 M                    |
| Z  [%]            | 0.03                | 0.05               | 0.05               | $0.05 + 5 \times 10^{-5} F_m$ | $0.05 + 5 \times 10^{-5} F_m$ | $0.1 + 1 \times 10^{-4} F_m$ |
| $\theta$ [radian] | $1 \times 10^{-4}$  | $2 \times 10^{-4}$ | $3 \times 10^{-4}$ | $3 \times 10^{-4}$            | $3 \times 10^{-4}$            | $6 \times 10^{-4}$           |

Table 25. Impedance range = 300, 1 k $\Omega$

|                   | Test frequency [Hz] |                    |                    |                    |                    |                    |
|-------------------|---------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
|                   | 20 – 1 k            | 1 k – 10 k         | 10 k – 100 k       | 100 k – 300 k      | 300 k – 1 M        | 1 M – 2 M          |
| Z  [%]            | 0.03                | 0.03               | 0.05               | 0.05               | 0.05               | 0.1                |
| $\theta$ [radian] | $1 \times 10^{-4}$  | $1 \times 10^{-4}$ | $3 \times 10^{-4}$ | $3 \times 10^{-4}$ | $3 \times 10^{-4}$ | $6 \times 10^{-4}$ |

**Table 26. Impedance range = 3 k, 10 kΩ**

|            | Test frequency [Hz]              |                                  |                                  |                                  |                                  |                                  |
|------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|
|            | 20 – 1 k                         | 1 k – 10 k                       | 10 k – 100 k                     | 100 k – 300 k                    | 300 k – 1 M                      | 1 M – 2 M                        |
| Z  [%]     | 0.03 +<br>$1 \times 10^{-4} F_m$ | 0.03 +<br>$1 \times 10^{-4} F_m$ | 0.03 +<br>$1 \times 10^{-4} F_m$ | 0.03 +<br>$1 \times 10^{-4} F_m$ | 0.03 +<br>$1 \times 10^{-4} F_m$ | 0.06 +<br>$2 \times 10^{-4} F_m$ |
| θ [radian] | $(100 + 2.5 F_m) \times 10^{-6}$ | $(100 + 2.5 F_m) \times 10^{-6}$ | $(100 + 2.5 F_m) \times 10^{-6}$ | $(100 + 2.5 F_m) \times 10^{-6}$ | $(100 + 2.5 F_m) \times 10^{-6}$ | $(200 + 5 F_m) \times 10^{-6}$   |

**Table 27. Impedance range = 30 k, 100 kΩ**

|            | Test frequency [Hz]              |                                  |                                  |                                  |                                  |                                  |
|------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|
|            | 20 – 1 k                         | 1 k – 10 k                       | 10 k – 100 k                     | 100 k – 300 k                    | 300 k – 1 M                      | 1 M – 2 M                        |
| Z  [%]     | 0.03 +<br>$1 \times 10^{-3} F_m$ | 0.03 +<br>$1 \times 10^{-3} F_m$ | 0.03 +<br>$1 \times 10^{-3} F_m$ | 0.03 +<br>$1 \times 10^{-3} F_m$ | 0.03 +<br>$1 \times 10^{-4} F_m$ | 0.06 +<br>$2 \times 10^{-4} F_m$ |
| θ [radian] | $(100 + 20 F_m) \times 10^{-6}$  | $(100 + 20 F_m) \times 10^{-6}$  | $(100 + 20 F_m) \times 10^{-6}$  | $(100 + 20 F_m) \times 10^{-6}$  | $(100 + 2.5 F_m) \times 10^{-6}$ | $(200 + 5 F_m) \times 10^{-6}$   |

Fm[kHz]      Test frequency

## Measurement accuracy

The impedance measurement calculation example below is the result of absolute measurement accuracy.

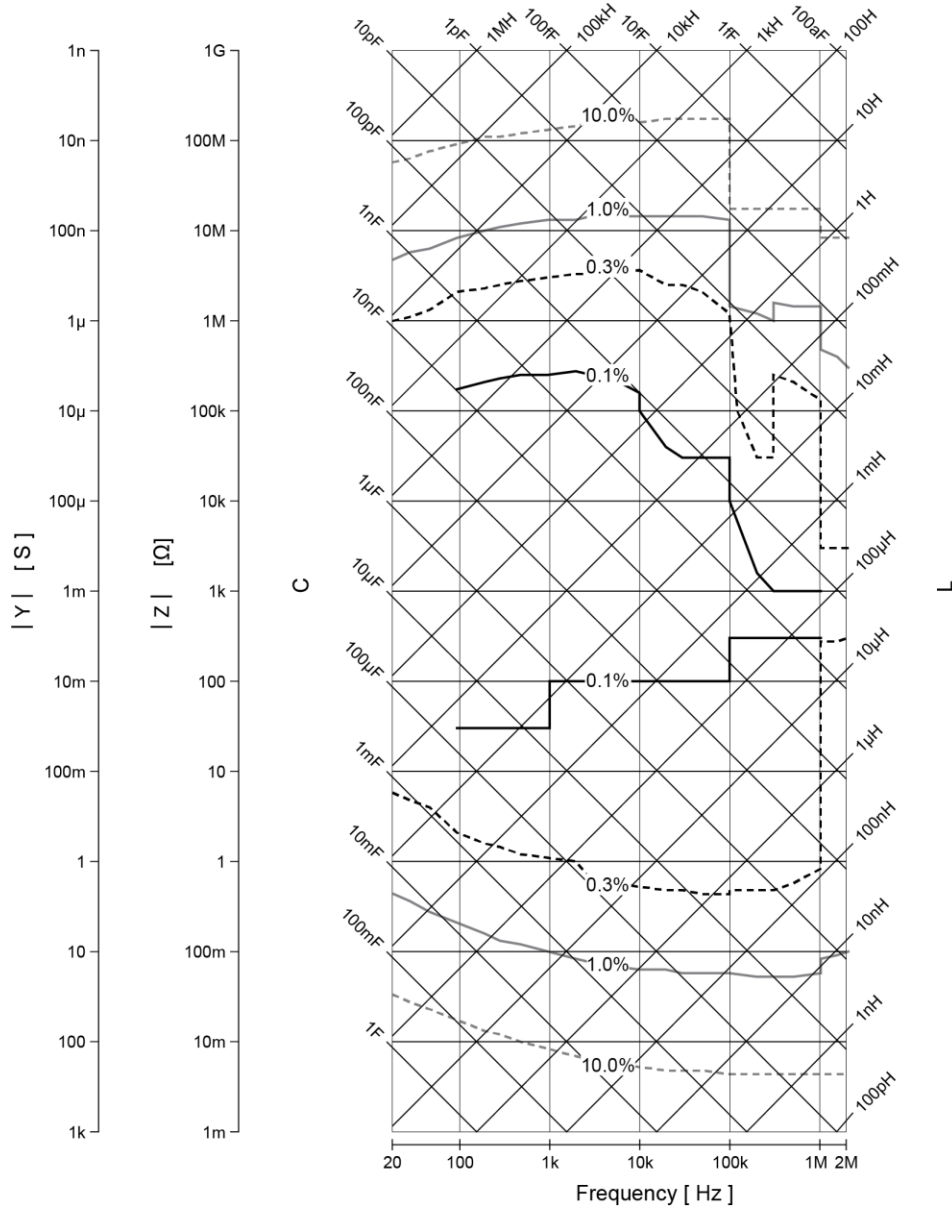


Figure 1. Impedance measurement accuracy (Test signal voltage = 1 Vrms, cable length = 0 m, measurement time mode = MED)

## Compensation function

**Table 28. The E4980A/E4980AL provides three types of compensation functions: OPEN compensation, SHORT compensation, and LOAD compensation.**

| Type of compensation | Description   |
|----------------------|---|
| OPEN compensation    | Compensates errors caused by the stray admittance (C, G) of the test fixture.   |
| SHORT compensation   | Compensates errors caused by the residual impedance (L, R) of the test fixture.   |
| LOAD compensation    | Compensates errors between the actual measured value and a known standard value under the measurement conditions desired by the user. |

### List sweep

**Points:** There is a maximum of 201 points.

**First sweep parameter (primary parameter):** Test frequency, test signal voltage, test signal current, test signal voltage of DC bias signal, test signal current of DC bias signal, DC source voltage.

**Second sweep parameter (secondary parameter):** None, impedance range, test frequency, test signal voltage, test signal current, test signal voltage of DC bias signal, test signal current of DC bias signal, DC source voltage

#### Note

A parameter selected for one of the two parameters cannot be selected for the other parameter. It is not possible to set up a combination of test signal voltage and test signal current or one of test signal voltage of DC bias signal and test signal current of DC bias. The secondary parameter can be set only with SCPI commands.

### Trigger mode

**Sequential mode:** When the E4980A/E4980AL is triggered once, the device is measured at all sweep points. /EOM/INDEX is output only once.

**Step mode:** The sweep point is incremented each time the E4980A/E4980AL is triggered. /EOM/INDEX is output at each point, but the result of the comparator function of the list sweep is available only after the last /EOM is output.

**Comparator function of list sweep:** The comparator function enables setting one pair of lower and upper limits for each measurement point.

You can select from: Judge with the first sweep parameter/Judge with the second parameter/Not used for each pair of limits.

**Time stamp function:** In the sequential mode, it is possible to record the measurement starting time at each measurement point by defining the time when FW detects a trigger as 0 and obtain it later with the SCPI command.

## 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. The sequential mode and tolerance mode can be selected as the sorting mode.

**Limit setup:** Absolute value, deviation value, and % deviation value can be used for setup.

**BIN count:** Countable from 0 to 999999.

## DC bias signal

**Table 29. Test signal voltage**

|            |   |
|------------|---|
| Range      | 0 V to +2 V   |
| Resolution | 0 V / 1.5 V / 2 V only  |
| Accuracy   | 0.1% + 2 mV (23°C ± 5°C)<br>(0.1% + 2 mV) × 4 (0 to 18°C or 28 to 55°C) |

**Output impedance:** 100 Ω (nominal)

## Measurement assistance functions

**Data buffer function:** Up to 201 measurement results can be read out in a batch.

### Save/Recall function:

- Up to 10 setup conditions can be written to/read from the built-in non-volatile memory.
- Up to 10 setup conditions can be written to/read from the USB memory.
- Auto recall function can be performed when the setting conditions are written to Register 10 of the USB memory.

**Key lock function:** The front panel keys can be locked.

**GPIB:** 24-pin D-Sub (Type D-24), female; complies with IEEE488.1, 2 and SCPI

**USB host port:** Universal serial bus jack, type-A (4 contact positions, contact 1 is on your left), female (for connection to USB memory only).

**USB interface port:** Universal serial bus jack, type mini-B (4 contact positions); complies with USBTMC-USB488 and USB 2.0; female; for connection to the external controller.

**USBTMC:** Abbreviation for USB Test & Measurement Class

**LAN:** 10/100 BaseT Ethernet, 8 pins (two speed options)

**LXI Compliance:** Class C (only applies to units with firmware revision A.02.00 or later)

## Options

### Frequency options

|             |                  |
|-------------|------------------|
| E4980A      | 20 Hz to 2 MHz   |
| E4980AL-032 | 20 Hz to 300 kHz |
| E4980AL-052 | 20 Hz to 500 kHz |
| E4980AL-102 | 20 Hz to 1 MHz   |

Note  
Option xxx is described as E4980A-xxx in the order information

**Table 30. Installable options**

| Options                             | E4980A                   | E4980AL                      |
|-------------------------------------|--------------------------|------------------------------|
| Power and DC bias enhancement (001) | Installable              | Not installable              |
| DCR measurement (200)               | Installable <sup>1</sup> | Not installable <sup>2</sup> |
| Handler interface (201)             | Installable              | Installable                  |
| Scanner interface (301)             | Installable              | Installable                  |

1. Mandatory option
2. DCR measurement function is equipped by default.

## Interface options

### Option 201 (Handler interface)

Adds handler interface.

### Option 301 (Scanner interface)

Adds scanner interface.

### Option 710 (No interface)

An option with no interface.

Up to 2 interface options can be installed in the interface connector on the rear panel.

When no interface is installed, two of the option 710 are installed. When one interface is installed, the option number of its interface and one option 710 are installed.

## Other options

### Option 001 (Power and DC Bias enhancement)

Increases test signal voltage and adds the variable DC bias voltage.

### Option 007 (Standard model)

Upgrades the entry model to the standard (only available in E4980AU).

Note

Option 007 can be installed only in the E4980A with option 005.

### Option 200 (DCR measurement)

Adds DCR measurement

Note

E4980A-200/001 and E4980AL-032/052/102 supports DCR measurement function.

## Power and DC bias enhancement specification

Increases test signal voltage and adds the variable DC bias voltage function. The Vdc-Idc measurement function is available when the option 001 is installed.

## Measurement parameters

The following parameters can be used.

- Lp-Rdc
- Ls-Rdc
- Vdc-Idc

where

|     |                                 |
|-----|---------------------------------|
| Rdc | Direct-current resistance (DCR) |
| Vdc | Direct-current voltage          |
| Idc | Direct-current electricity      |

## Test signal

### Signal level

**Table 31. Test signal voltage**

|                |                       |  |
|----------------|-----------------------|--|
| Range          |                       | 0 Vrms to 20 Vrms (test frequency $\leq$ 1 MHz)<br>0 Vrms to 15 Vrms (test frequency $>$ 1 MHz)  |
| Resolution     |                       | 100 $\mu$ Vrms (0 Vrms $\leq$ $- \leq$ 0.2 Vrms)<br>200 $\mu$ Vrms (0.2 Vrms $< - \leq$ 0.5 Vrms)<br>500 $\mu$ Vrms (0.5 Vrms $< - \leq$ 1 Vrms)<br>1 mVrms (1 Vrms $< - \leq$ 2 Vrms)<br>2 mVrms (2 Vrms $< - \leq$ 5 Vrms)<br>5 mVrms (5 Vrms $< - \leq$ 10 Vrms)<br>10 mVrms (10 Vrms $< - \leq$ 20 Vrms) |
| Setup accuracy | Normal                | $\pm$ (10% + 1 mVrms) (test signal voltage $\leq$ 2 Vrms)<br>(test frequency $\leq$ 1 MHz: spec., test frequency $>$ 1 MHz: typ.)  |
|                |                       | $\pm$ (10% + 10 mVrms) (Test frequency $\leq$ 300 kHz,<br>test signal voltage $>$ 2 Vrms) (spec.)  |
|                |                       | $\pm$ (15% + 20 mVrms) (test frequency $>$ 300 kHz,<br>test signal voltage $>$ 2 Vrms) (test frequency $\leq$ 1 MHz: spec.,<br>test frequency $>$ 1 MHz: typ.)   |
|                | Constant <sup>1</sup> | $\pm$ (6% + 1 mVrms) (test signal voltage $\leq$ 2 Vrms)<br>(test frequency $\leq$ 1 MHz: spec., test frequency $>$ 1 MHz: typ.)   |
|                |                       | $\pm$ (6% + 10 mVrms) (test frequency $\leq$ 300 kHz,<br>test signal voltage $>$ 2 Vrms) (spec.)   |
|                |                       | $\pm$ (12% + 20 mVrms) (test frequency $>$ 300 kHz,<br>test signal voltage $>$ 2 Vrms) (test frequency $\leq$ 1 MHz: spec.,<br>test frequency $>$ 1 MHz: typ.)   |

1. When auto level control function is on.



**Table 32. Test signal current**

|                |                       |   |
|----------------|-----------------------|---|
| Range          |                       | 0 Arms - 100 mArms  |
| Resolution     |                       | 1 $\mu$ Arms (0 Arms $\leq$ - $\leq$ 2 mArms)<br>2 $\mu$ Arms (2 mArms < - $\leq$ 5 mArms)<br>5 $\mu$ Arms (5 mArms < - $\leq$ 10 mArms)<br>10 $\mu$ Arms (10 mArms < - $\leq$ 20 mArms)<br>20 $\mu$ Arms (20 mArms < - $\leq$ 50 mArms)<br>50 $\mu$ Arms (50 mArms < - $\leq$ 100 mArms) |
| Setup accuracy | Normal                | $\pm$ (10% + 10 $\mu$ Arms) (test signal voltage $\leq$ 20 mArms)<br>(test frequency $\leq$ 1 MHz: spec., test frequency > 1 MHz: typ.)   |
|                |                       | $\pm$ (10% + 100 $\mu$ Arms) (test frequency $\leq$ 300 kHz,<br>test signal current > 20 mArms) (spec.)   |
|                |                       | $\pm$ (15% + 200 $\mu$ Arms) (test frequency > 300 kHz,<br>test signal voltage > 20 mArms) (test frequency $\leq$ 1 MHz: spec., test<br>frequency > 1 MHz: typ.)  |
|                | Constant <sup>1</sup> | $\pm$ (6% + 10 $\mu$ Arms) (test signal voltage $\leq$ 20 mArms)<br>(test frequency $\leq$ 1 MHz: spec., test frequency > 1 MHz: typ.)  |
|                |                       | $\pm$ (6% + 100 $\mu$ Arms) (test frequency $\leq$ 300 kHz,<br>test signal voltage > 20 mArms) (spec.)  |
|                |                       | $\pm$ (12% + 200 $\mu$ Arms) (test frequency > 300 kHz,<br>test signal voltage > 20 mArms) (test frequency $\leq$ 1 MHz: spec., test<br>frequency > 1 MHz: typ.)  |

### Test signal level monitor function

- Test signal voltage and test signal current can be monitored.
- Level monitor accuracy:

**Table 33. Test signal voltage monitor accuracy (Vac)**

| Test signal voltage <sup>2</sup> | Test frequency | Specification                                       |
|----------------------------------|----------------|---|
| 5 mVrms to 2 Vrms                | $\leq$ 1 MHz   | $\pm$ (3% of reading value + 0.5 mVrms)             |
|                                  | > 1MHz         | $\pm$ (6% of reading value + 1 mVrms)               |
| > 2 Vrms                         | $\leq$ 300 kHz | $\pm$ (3% of reading value + 5 mVrms)               |
|                                  | > 300 kHz      | $\pm$ (6% of reading value + 10 mVrms) <sup>3</sup> |

1. When auto level control function is on.
2. This is not an output value but a displayed test signal level
3. Typ. when test frequency is > 1 MHz with test signal voltage > 10 Vrms.

**Table 34. Test signal current monitor accuracy (Iac)**

| Test signal current <sup>2</sup> | Test frequency | Specification                                |
|----------------------------------|----------------|--|
| 50 $\mu$ Arms to 20 mArms        | $\leq 1$ MHz   | $\pm$ (3% of reading value + 5 $\mu$ Arms)   |
|                                  | $> 1$ MHz      | $\pm$ (6% of reading value + 10 $\mu$ Arms)  |
| $> 20$ mArms                     | $\leq 300$ kHz | $\pm$ (3% of reading value + 50 $\mu$ Arms)  |
|                                  | $> 300$ kHz    | $\pm$ (6% of reading value + 100 $\mu$ Arms) |

**DC bias signal****Table 35. Test signal voltage**

|            |                                   |   |
|------------|-----------------------------------|---|
| Range      |                                   | -40 V to +40 V  |
| Resolution |                                   | Setup resolution: 100 $\mu$ V, effective resolution:<br>330 $\mu$ V $\pm$ (0 V $\leq - \leq 5$ V)<br>1 mV $\pm$ (5 V $< - \leq 10$ V)<br>2 mV $\pm$ (10 V $< - \leq 20$ V)<br>5 mV $\pm$ (20 V $< - \leq 40$ V) |
| Accuracy   | test signal voltage $\leq 2$ Vrms | 0.1% + 2 mV (23°C $\pm 5^\circ$ C)<br>(0.1% + 2 mV) $\times 4$ (0 to 18°C or 28 to 55°C)  |
|            | test signal voltage $> 2$ Vrms    | 0.1 % + 4 mV (23°C $\pm 5^\circ$ C)<br>(0.1% + 4 mV) $\times 4$ (0 to 18°C or 28 to 55°C)   |

**Table 36. Test signal current**

|            |  |   |
|------------|--|---|
| Range      |  | -100 mA - 100 mA  |
| Resolution |  | Setup resolution: 1 $\mu$ A, effective resolution:<br>3.3 $\mu$ A $\pm$ (0 A $\leq - \leq 50$ mA)<br>10 $\mu$ A $\pm$ (50 mA $< - \leq 100$ mA) |

**DC bias voltage level monitor Vdc**

(0.5% of reading value + 60 mV)  $\times$  Kt

When using Vdc-I<sub>dc</sub> measurement: (spec.)

When using level monitor: (typ.)

Kt      Temperature coefficient

2. This is not an output value but a displayed test signal level

## DC bias current level monitor $I_{dc}$

$(A [\%] \text{ of the measurement value} + B [A]) \times K_t$

When using Vdc-I<sub>dc</sub> measurement: (spec.)

When using level monitor: (typ.)

A [%] When the measurement time mode is SHORT: 2%  
When the measurement time mode is MED or LONG: 1%

B [A] given below

K<sub>t</sub> Temperature coefficient

When the measurement mode is SHORT, double the following value.

**Table 37. Test signal voltage  $\leq 0.2 V_{rms}$  (measurement time mode = MED, LONG)**

| DC bias current range | Impedance range [ $\Omega$ ] |             |             |             |             |
|-----------------------|------------------------------|-------------|-------------|-------------|-------------|
|                       | < 100                        | 100         | 300, 1 k    | 3 k, 10 k   | 30k, 100 k  |
| 20 $\mu A$            | 150 $\mu A$                  | 30 $\mu A$  | 3 $\mu A$   | 300 nA      | 45 nA       |
| 200 $\mu A$           | 150 $\mu A$                  | 30 $\mu A$  | 3 $\mu A$   | 300 nA      | 300 nA      |
| 2 mA                  | 150 $\mu A$                  | 30 $\mu A$  | 3 $\mu A$   | 3 $\mu A$   | 3 $\mu A$   |
| 20 mA                 | 150 $\mu A$                  | 30 $\mu A$  | 30 $\mu A$  | 30 $\mu A$  | 30 $\mu A$  |
| 100 mA                | 150 $\mu A$                  | 150 $\mu A$ | 150 $\mu A$ | 150 $\mu A$ | 150 $\mu A$ |

**Table 38.  $0.2 V_{rms} < \text{test signal voltage} \leq 2 V_{rms}$  (measurement time mode = MED, LONG)**

| DC bias current range | Impedance range [ $\Omega$ ] |             |             |             |             |
|-----------------------|------------------------------|-------------|-------------|-------------|-------------|
|                       | < 100                        | 100, 300    | 1k, 3 k     | 10k, 30 k   | 100 k       |
| 20 $\mu A$            | 150 $\mu A$                  | 30 $\mu A$  | 3 $\mu A$   | 300 nA      | 45 nA       |
| 200 $\mu A$           | 150 $\mu A$                  | 30 $\mu A$  | 3 $\mu A$   | 300 nA      | 300 nA      |
| 2 mA                  | 150 $\mu A$                  | 30 $\mu A$  | 3 $\mu A$   | 3 $\mu A$   | 3 $\mu A$   |
| 20 mA                 | 150 $\mu A$                  | 30 $\mu A$  | 30 $\mu A$  | 30 $\mu A$  | 30 $\mu A$  |
| 100 mA                | 150 $\mu A$                  | 150 $\mu A$ | 150 $\mu A$ | 150 $\mu A$ | 150 $\mu A$ |

**Table 39. Test signal voltage > 2 Vrms (measurement time mode = MED, LONG)**

| DC bias current range | Impedance range [ $\Omega$ ] |             |             |             |
|-----------------------|------------------------------|-------------|-------------|-------------|
|                       | $\leq 300$                   | 1 k, 3 k    | 10k, 30 k   | 100 k       |
| 20 $\mu$ A            | 150 $\mu$ A                  | 30 $\mu$ A  | 3 $\mu$ A   | 300 nA      |
| 200 $\mu$ A           | 150 $\mu$ A                  | 30 $\mu$ A  | 3 $\mu$ A   | 300 nA      |
| 2 mA                  | 150 $\mu$ A                  | 30 $\mu$ A  | 3 $\mu$ A   | 3 $\mu$ A   |
| 20 mA                 | 150 $\mu$ A                  | 30 $\mu$ A  | 30 $\mu$ A  | 30 $\mu$ A  |
| 100 mA                | 150 $\mu$ A                  | 150 $\mu$ A | 150 $\mu$ A | 150 $\mu$ A |

**Table 40. Input impedance (nominal)**

| Input impedance | Conditions  |
|-----------------|---|
| 0 $\Omega$      | Other than conditions below.  |
| 20 $\Omega$     | Test signal voltage $\leq 0.2$ Vrms, Impedance range $\geq 3$ k $\Omega$ , DC bias current range $\leq 200$ $\mu$ A |
|                 | Test signal voltage $\leq 2$ Vrms, Impedance range $\geq 10$ k $\Omega$ , DC bias current range $\leq 200$ $\mu$ A  |
|                 | Test signal voltage > 2 Vrms, Impedance range = 100 k $\Omega$ , DC bias current range $\leq 200$ $\mu$ A           |

## DC source signal

**Table 41. Test signal voltage**

|            |   |
|------------|---|
| Range      | -10 V to 10 V   |
| Resolution | 1 mV  |
| Accuracy   | 0.1% + 3 mV (23°C $\pm$ 5°C)<br>(0.1% + 3 mV) x 4 (0 to 18°C or 28 to 55°C) |

**Table 42. Test signal current**

|       |                           |
|-------|---------------------------|
| Range | -45 mA to 45 mA (nominal) |
|-------|---------------------------|

**Output impedance:** 100  $\Omega$  (nominal)

## DCR measurement specification

DC resistance (Rdc) measurement function is available when either E4980A-001/200 or E4980AL-032/052/102 is installed.

### DC resistance (Rdc) accuracy

Absolute measurement accuracy Aa

Absolute measurement accuracy Aa is given as

**Equation 15.**  $Aa = Ae + Acal$

Aa Absolute accuracy (% of reading value)

Ae Relative accuracy (% of reading value)

Acal Calibration accuracy

Relative measurement accuracy Ae

Relative measurement accuracy Ae is given as

**Equation 16.**  $Ae = [Ab + (Rs / |Rm| + Go \times |Rm|) \times 100] \times Kt$

Rm Measurement value

Ab Basic accuracy

Rs Short offset [ $\Omega$ ]

Go Open offset [S]

Kt Temperature coefficient

### Calibration accuracy Acal

Calibration accuracy Acal is 0.03%.

### Basic accuracy Ab

Table 43. Basic accuracy Ab.

| Measurement time mode | Test signal voltage |            |
|-----------------------|---------------------|------------|
|                       | $\leq 2$ Vrms       | $> 2$ Vrms |
| SHORT                 | 1.00%               | 2.00%      |
| MED                   | 0.30%               | 0.60%      |

## Open offset Go

**Table 44. Open offset Go.**

| Measurement time mode | Test signal voltage   |                    |
|-----------------------|-----------------------|--------------------|
|                       | $\leq 2 \text{ Vrms}$ | $> 2 \text{ Vrms}$ |
| SHORT                 | 50 nS                 | 500 nS             |
| MED                   | 10 nS                 | 100 nS             |

## Short offset Rs

**Table 45. Short offset Rs.**

| Measurement time mode | Test signal voltage   |                    |
|-----------------------|-----------------------|--------------------|
|                       | $\leq 2 \text{ Vrms}$ | $> 2 \text{ Vrms}$ |
| SHORT                 | 25 m $\Omega$         | 250 m $\Omega$     |
| MED                   | 5 m $\Omega$          | 50 m $\Omega$      |

## Effect of cable length (Short offset)

**Table 46. Values added to Rs when the cable is extended.**

| Cable length    |                |              |
|-----------------|----------------|--------------|
| 1 m             | 2 m            | 4 m          |
| 0.25 m $\Omega$ | 0.5 m $\Omega$ | 1 m $\Omega$ |

## Temperature coefficient Kt

**Table 47. Temperature coefficient Kt.**

| Temperature [ $^{\circ}\text{C}$ ] | Kt |
|------------------------------------|----|
| $0 \leq - < 18$                    | 4  |
| $18 \leq - \leq 28$                | 1  |
| $28 < - \leq 55$                   | 4  |

## General Specifications

**Table 48. Power source**

|                   |               |
|-------------------|---------------|
| Rated voltage     | 100 – 240 VAC |
| Voltage range     | 90 – 264 VAC  |
| Rated frequency   | 50 / 60 Hz    |
| Frequency range   | 47 – 63 Hz    |
| Power consumption | Max. 150 VA   |

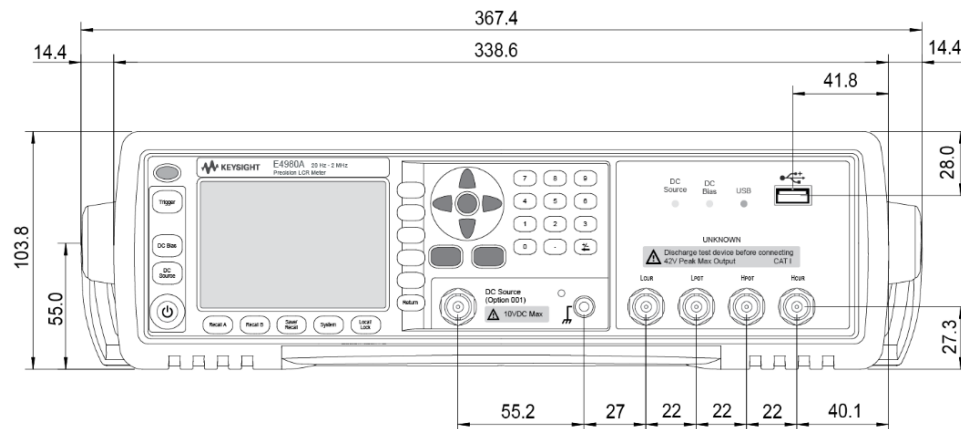
**Table 49. Operating environment**

|   |              |
|---|--------------|
| Temperature   | 0 – 55°C     |
| Humidity ( $\leq 40^\circ\text{C}$ , no condensation) | 15% – 85% RH |
| Altitude  | 0 m – 2000 m |

**Table 50. Storage environment**

|   |              |
|---|--------------|
| Temperature   | -20 – 70°C   |
| Humidity ( $\leq 60^\circ\text{C}$ , no condensation) | 0% – 90% RH  |
| Altitude  | 0 m – 4572 m |

**Outer dimensions:** 375 (width) x 105 (height) x 390 (depth) mm (nominal)



**Figure 2. Dimensions (front view, with handle and bumper, in millimeters, nominal)**

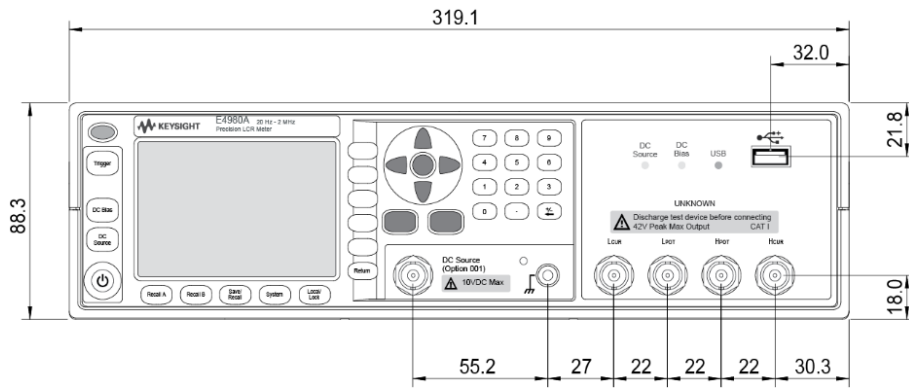


Figure 3. Dimensions (front view, without handle and bumper, in millimeters, nominal)

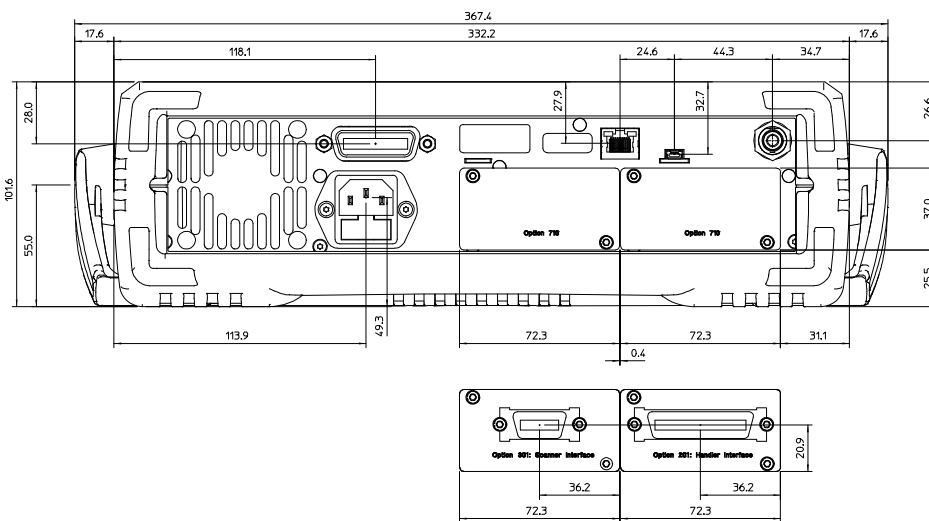


Figure 4. Dimensions (rear view, with handle and bumper, in millimeters, nominal)

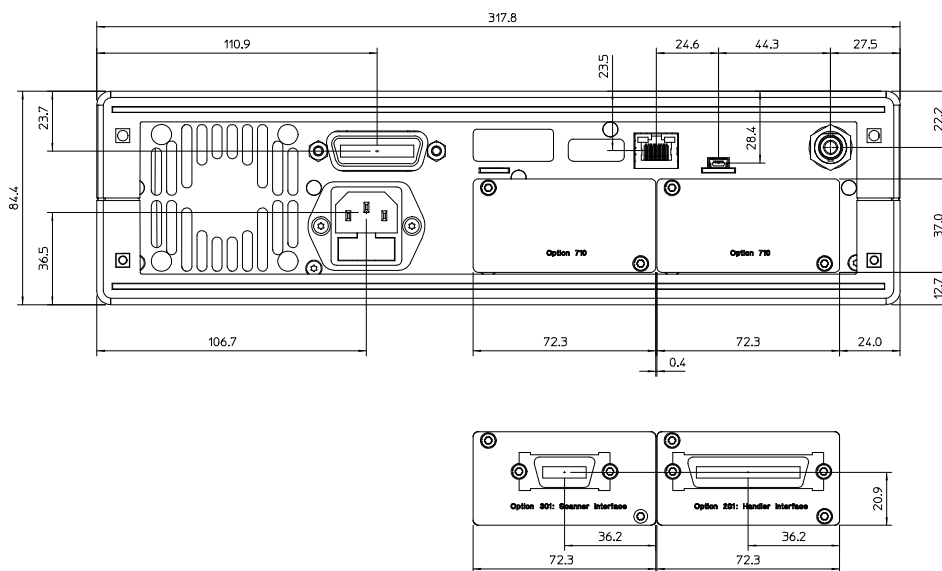
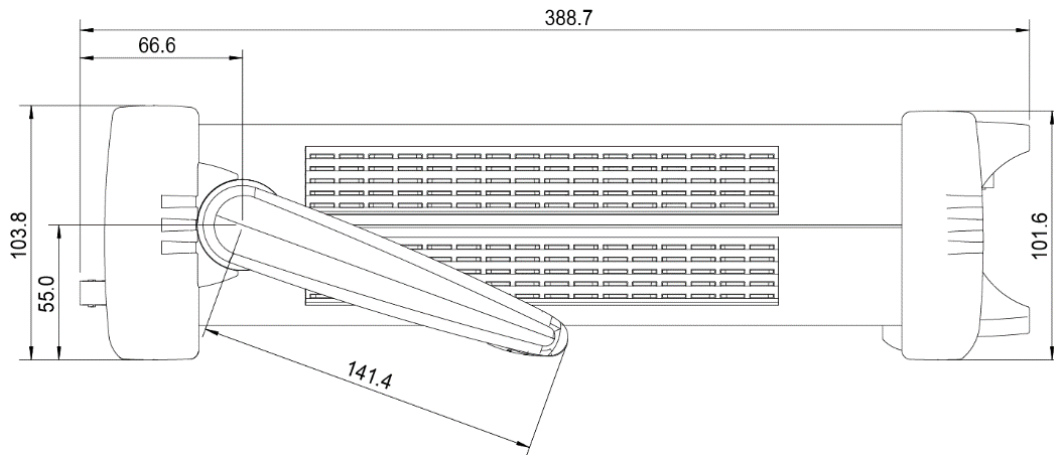
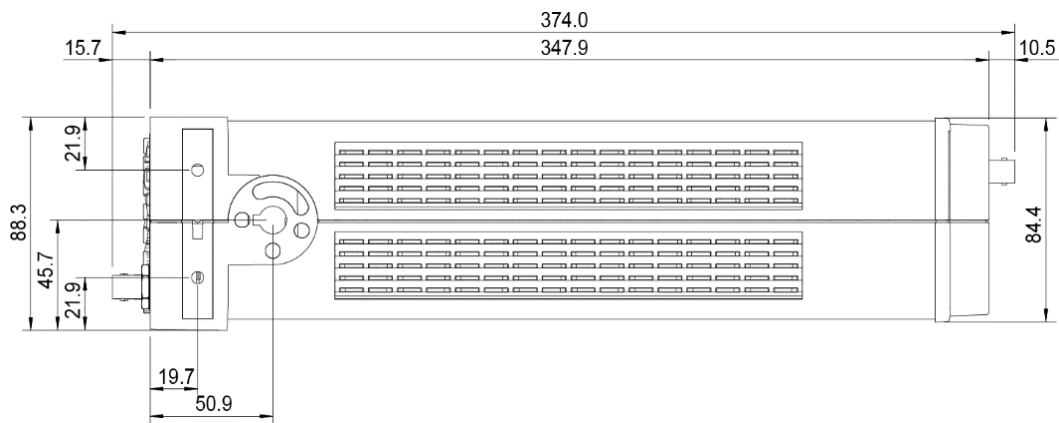


Figure 5. Dimensions (rear view, with handle and bumper, in millimeters, nominal)





**Figure 6. Dimensions (side view, with handle and bumper, in millimeters, nominal)**



**Figure 7. Dimensions (side view, without handle and bumper, in millimeters, nominal)**

**Weight:** 5.3 kg (nominal)





**Display:** LCD, 320 × 240 (pixels), RGB color

**Note**

Effective pixels are more than 99.99%. There may be 0.01% (approx. 7 pixels) or smaller missing pixels or constantly lit pixels, but this is not a malfunction.

The following items can be displayed:

- Measurement value
- Measurement conditions
- Limit value and judgment result of comparator
- List sweep table
- Self-test message

| EMC <sup>1</sup>   |   |
|--|---|
| Complies with the essential requirements of the European EMC Directive as well as current editions of the following standards (dates and editions are cited in the Declaration of Conformity). |   |
|   | <p>The CE mark is a registered trademark of the European Community (if accompanied by a year, it is the year when the design was proven). This product complies with all relevant directives.</p> <ul style="list-style-type: none"> <li>• IEC 61326-1</li> <li>• CISPR 11 Group 1, Class A</li> </ul>  |
|   | UK conformity mark is a UK government owned mark. When affixed to the product is declaring all applicable Directives and Regulations have been met in full.   |
| CAN ICES/NMB-001(A)  | This ISM device complies with Canadian ICES-001.<br>Cet appareil ISM est conforme a la norme NMB du Canada.   |
|   | <p>The RCM mark is a registered trademark of the Australian Communications and Media Authority.</p> <ul style="list-style-type: none"> <li>• AS/NZS CISPR 11</li> </ul>   |
|   | <p>South Korean Certification (KC) mark; includes the marking's identifier code: R-R-Kst-xxxxxxx</p> <p>South Korean Class A EMC declaration:<br/>Information to the user:<br/>This equipment has been conformity assessed for use in business environments. In a residential environment this equipment may cause radio interference.<br/>※ This EMC statement applies to the equipment only for use in business environment.</p> <div style="border: 1px solid black; padding: 5px; margin-top: 10px;"> <p style="text-align: center; background-color: #e1eef6;">사 용 자 안 내 문</p> <p style="text-align: center; color: #0070c0;">이 기기는 업무용 환경에서 사용할 목적으로 적합성평가를 받은 기기로서 가정용 환경에서 사용하는 경우 전파간섭의 우려가 있습니다.</p> </div> <p>※ 사용자 안내문은 “업무용 방송통신기자재”에만 적용한다.</p> |

| Safety <sup>1</sup>  |   |
|--|---|
| Complies with the essential requirements of the European Low Voltage Directive as well as current editions of the following standards (dates and editions are cited in the Declaration of Conformity). This product is designed for use in INSTALLATION CATEGORY II and POLLUTION DEGREE 2 and MEASUREMENT CATEGORY NONE per IEC standards. This product is intended for indoor use. |   |
|   | <ul style="list-style-type: none"> <li>• IEC/EN 61010-1</li> </ul>  |
|   | <p>The CSA mark is a registered trademark of the CSA International.</p> <ul style="list-style-type: none"> <li>• Canada: CSA C22.2 No. 610610-1</li> <li>• USA: UL std no. 61010-1</li> </ul> |

1. To find a current Declaration of Conformity for a specific Keysight product, go to: <http://www.keysight.com/go/conformity>.

## Environment



This product complies with the WEEE Directive (2002/96/EC) marking requirements. The affixed label indicates that you must not discard this electrical/electronic product in domestic household waste.

Product Category: With reference to the equipment types in the WEEE Directive Annex I, this product is classed as a “Monitoring and Control instrumentation” product.

## Supplemental Information

### Settling time

**Table 51. Test frequency setting time**

| Test frequency setting time | Test frequency (Fm)                       |
|-----------------------------|---|
| 5 ms                        | $F_m \geq 1 \text{ kHz}$                  |
| 12 ms                       | $1 \text{ kHz} > F_m \geq 250 \text{ Hz}$ |
| 22 ms                       | $250 \text{ Hz} > F_m \geq 60 \text{ Hz}$ |
| 42 ms                       | $60 \text{ Hz} > F_m$                     |

**Table 52. Test signal voltage setting time**

| Test signal voltage setting time | Test frequency (Fm)                       |
|----------------------------------|---|
| 11 ms                            | $F_m \geq 1 \text{ kHz}$                  |
| 18 ms                            | $1 \text{ kHz} > F_m \geq 250 \text{ Hz}$ |
| 26 ms                            | $250 \text{ Hz} > F_m \geq 60 \text{ Hz}$ |
| 48 ms                            | $60 \text{ Hz} > F_m$                     |

Switching of the impedance range is as follows:  $\leq 5 \text{ ms/}$  range switching

## Measurement circuit protection

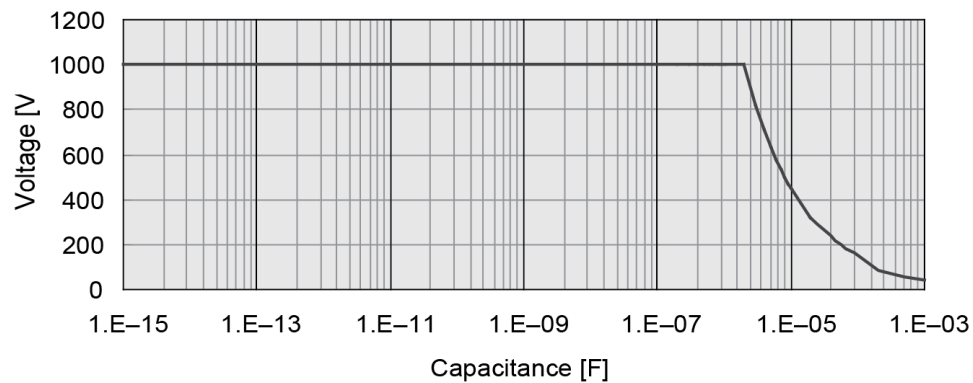
The maximum discharge withstand voltage, where the internal circuit remains protected if a charged capacitor is connected to the UNKNOWN terminal, is given below.

**Table 53. Maximum discharge withstand voltage**

| Maximum discharge withstand voltage | Range of capacitance value C of DUT |
|-------------------------------------|-------------------------------------|
| 1000 V                              | $C < 2 \mu\text{F}$                 |
| $\sqrt{2/CV}$                       | $2 \mu\text{F} \leq C$              |

Note

Discharge capacitors before connecting them to the UNKNOWN terminal or a test fixture to avoid damages to the instrument.



**Figure 8. Maximum discharge withstand voltage**

## Measurement time

### Definition

This is the time between the trigger and the end of measurement (EOM) output on the handler interface.

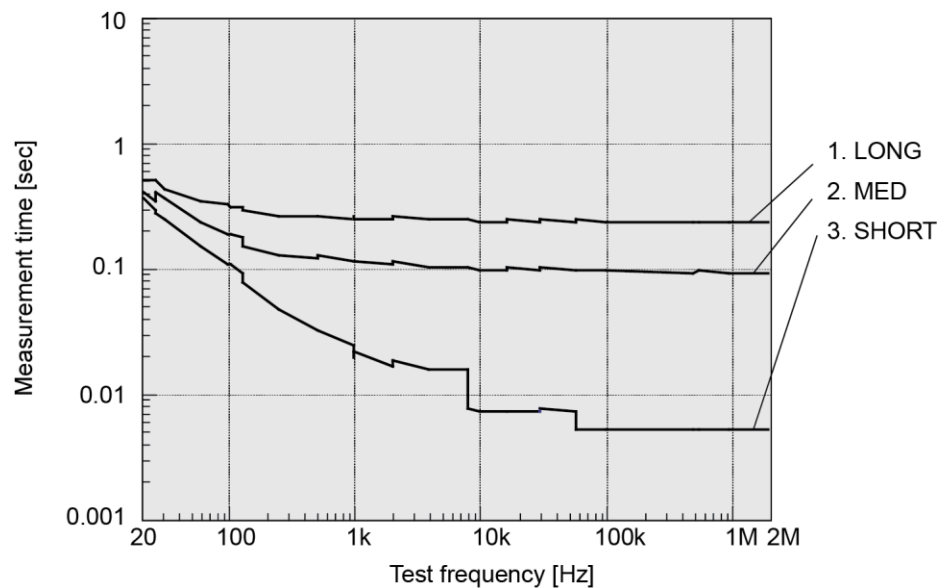
## Conditions

Tables 54 and 55 show the measurement time when the following conditions are satisfied:

- Normal impedance measurement other than Ls-Rdc, Lp-Rdc, Vdc-Idc
- Impedance range mode: hold range mode
- DC bias voltage level monitor: OFF
- DC bias current level monitor: OFF
- Trigger delay: 0 s
- Step delay: 0 s
- Calibration data: OFF
- Display mode: blank

**Table 54. E4980A measurement time [ms] (DC bias: OFF)**

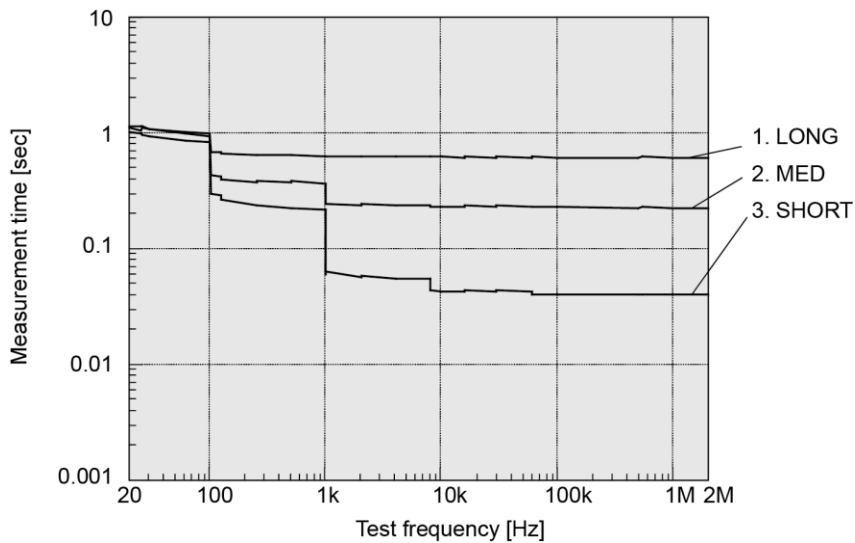
| Measurement time mode |       | Test frequency |        |       |        |         |       |       |
|-----------------------|-------|----------------|--------|-------|--------|---------|-------|-------|
|                       |       | 20 Hz          | 100 Hz | 1 kHz | 10 kHz | 100 kHz | 1 MHz | 2 MHz |
| 1                     | LONG  | 480            | 300    | 240   | 230    | 220     | 220   | 220   |
| 2                     | MED   | 380            | 180    | 110   | 92     | 89      | 88    | 88    |
| 3                     | SHORT | 330            | 100    | 20    | 7.7    | 5.7     | 5.6   | 5.6   |



**Figure 9. Measurement time (E4980A, DC bias: OFF)**

**Table 55. E4980AL measurement time [ms] (DC bias: OFF)**

| Measurement time mode |       | Test frequency |        |       |        |         |       |
|-----------------------|-------|----------------|--------|-------|--------|---------|-------|
|                       |       | 20 Hz          | 100 Hz | 1 kHz | 10 kHz | 100 kHz | 1 MHz |
| 1                     | LONG  | 729            | 423    | 363   | 353    | 343     | 343   |
| 2                     | MED   | 650            | 250    | 140   | 122    | 119     | 118   |
| 3                     | SHORT | 579            | 149    | 26    | 14     | 12      | 12    |



**Figure 10. Measurement time (E4980AL)**

When DC bias is ON, the following time is added:

**Table 56. Additional time when DC bias is ON [ms]**

| Test frequency |        |       |        |         |       |       |
|----------------|--------|-------|--------|---------|-------|-------|
| 20 Hz          | 100 Hz | 1 kHz | 10 kHz | 100 kHz | 1 MHz | 2 MHz |
| 30             | 30     | 10    | 13     | 2       | 0.5   | 0.5   |

When the number of averaging increases, the measurement time is given as

**Equation 17.  $MeasTime + (Ave - 1) \times AveTime$**

- MeasTime      Measurement time calculated based on Table 54, 55 and 56
- Ave            Number of averaging
- AveTime      Refer to Table 57

**Table 57. Additional time per averaging [ms]**

| Measurement time mode | Test frequency |        |       |        |         |       |       |
|-----------------------|----------------|--------|-------|--------|---------|-------|-------|
|                       | 20 Hz          | 100 Hz | 1 kHz | 10 kHz | 100 kHz | 1 MHz | 2 MHz |
| SHORT                 | 51             | 11     | 2.4   | 2.3    | 2.3     | 2.2   | 2.2   |
| MED                   | 110            | 81     | 88    | 87     | 85      | 84    | 84    |
| LONG                  | 210            | 210    | 220   | 220    | 220     | 210   | 210   |

**Table 58. Measurement time when Vdc-Idc is selected [ms]**

| Measurement time mode | Test frequency |        |       |        |         |       |       |
|-----------------------|----------------|--------|-------|--------|---------|-------|-------|
|                       | 20 Hz          | 100 Hz | 1 kHz | 10 kHz | 100 kHz | 1 MHz | 2 MHz |
| SHORT                 | 210            | 46     | 14    | 14     | 14      | 14    | 14    |
| MED                   | 210            | 170    | 170   | 170    | 170     | 170   | 170   |
| LONG                  | 410            | 410    | 410   | 410    | 410     | 410   | 410   |

Add the same measurement time per 1 additional average.

Additional Measurement time when the Vdc and Idc monitor function is ON. Add SHORT mode of Table 58. When using only Vdc or Idc, add a half of SHORT mode of Table 58.

**Table 59. Measurement time when Ls-Rdc or Lp-Rdc is selected [ms]**

| Measurement time mode | Test frequency |        |       |        |         |       |       |
|-----------------------|----------------|--------|-------|--------|---------|-------|-------|
|                       | 20 Hz          | 100 Hz | 1 kHz | 10 kHz | 100 kHz | 1 MHz | 2 MHz |
| SHORT                 | 910            | 230    | 43    | 24     | 22      | 22    | 22    |
| MED                   | 1100           | 450    | 300   | 280    | 270     | 270   | 270   |
| LONG                  | 1400           | 820    | 700   | 670    | 660     | 650   | 650   |

Add the three times of Table 57 Additional Time per 1 additional average number.

## Display time

Except for the case of the DISPLAY BLANK page, the time required to update the display on each page (display time) is as follows. When a screen is changed, drawing time and switching time are added. The measurement display is updated about every 100 ms.

**Table 60. Display time**

| Item                                   | When Vdc, Idc monitor is OFF | When Vdc, Idc monitor is ON |
|--|------------------------------|-----------------------------|
| MEAS DISPLAY page drawing time         | 10 ms                        | 13 ms                       |
| MEAS DISPLAY page (large) drawing time | 10 ms                        | 13 ms                       |
| BIN No. DISPLAY page drawing time      | 10 ms                        | 13 ms                       |
| BIN COUNT DISPLAY page drawing time    | 10 ms                        | 13 ms                       |
| LIST SWEEP DISPLAY page drawing time   | 40 ms                        | —                           |
| Measurement display switching time     | 35 ms                        | —                           |

### Measurement data transfer time

This table shows the measurement data transfer time under the following conditions. The measurement data transfer time varies depending on measurement conditions and computers.

**Table 61. Measurement transfer time under the following conditions**

|                               |   |
|-------------------------------|---|
| Host computer:                | HP Z420 Workstation, Xeon CPU ES-1620 0 @3.60 GHz |
| Display:                      | OFF   |
| Impedance range mode:         | AUTO (The overload has not been generated.)       |
| OPEN/SHORT/LOAD compensation: | OFF   |
| Test signal voltage monitor:  | OFF   |

**Table 62. Measurement data transfer time [ms]**

| Interface | Data transfer format | Using: FETC? command (one point measurement) |                | Using data buffer memory (list sweep measurement) |           |            |            |
|-----------|----------------------|--|----------------|---|-----------|------------|------------|
|           |                      | Comparator ON                                | Comparator OFF | 10 points   | 51 points | 128 points | 201 points |
| GPIB      | ASCII                | 2  | 2              | 4   | 13        | 28         | 43         |
|           | ASCII Long           | 2  | 2              | 5   | 15        | 34         | 53         |
|           | Binary               | 2  | 2              | 4   | 10        | 21         | 36         |
| USB       | ASCII                | 2  | 2              | 3   | 8         | 16         | 23         |
|           | ASCII Long           | 2  | 2              | 4   | 9         | 19         | 28         |
|           | Binary               | 2  | 2              | 3   | 5         | 9          | 13         |
| LAN       | ASCII                | 3  | 4              | 5   | 12        | 24         | 36         |
|           | ASCII Long           | 3  | 3              | 5   | 13        | 29         | 44         |
|           | Binary               | 3  | 3              | 5   | 9         | 18         | 26         |

DC bias test signal current (1.5 V/2.0 V): Output current: Max. 20 mA



**Option 001 (Power and DC Bias enhance):**

DC bias voltage: DC bias voltage applied to DUT is given as:

**Equation 18.**  $V_{dut} = V_b - 100 \times I_b$

$V_{dut}$  [V]      DC bias voltage  
 $V_b$  [V]        DC bias setting voltage  
 $I_b$  [A]         DC bias current

**DC bias current:** DC bias current applied to DUT is given as:

**Equation 19.**  $I_{dut} = V_b / (100 + R_{dc})$

$I_{dut}$  [A]        DC bias current  
 $V_b$  [V]        DC bias setting voltage  
 $R_{dc}$  [ $\Omega$ ]       DUT's DC resistance

**Maximum DC bias current**

**Table 63. Maximum DC bias current when the normal measurement can be performed.**

| Impedance range [ $\Omega$ ] | Bias current isolation   |                                   |                                |
|------------------------------|--|-----------------------------------|--------------------------------|
|                              | ON   | OFF                               |                                |
|                              |  | Test signal voltage $\leq 2$ Vrms | Test signal voltage $> 2$ Vrms |
| 0.1                          | Auto range mode:<br>100 mA<br>Hold range mode:<br>its values for<br>the range. | 20 mA                             | 100 mA                         |
| 1                            |  | 20 mA                             | 100 mA                         |
| 10                           |  | 20 mA                             | 100 mA                         |
| 100                          |  | 20 mA                             | 100 mA                         |
| 300                          |  | 2 mA                              | 100 mA                         |
| 1 k                          |  | 2 mA                              | 20 mA                          |
| 3 k                          |  | 200 $\mu$ A                       | 20 mA                          |
| 10 k                         |  | 200 $\mu$ A                       | 2 mA                           |
| 30 k                         |  | 20 $\mu$ A                        | 2 mA                           |
| 100 k                        |  | 20 $\mu$ A                        | 200 $\mu$ A                    |

When DC bias is applied to the DUT, add the following value to the absolute accuracy  $Ab$ .

**Table 64. Only when Fm < 10 kHz and |Vdc| > 5 V**

| SHORT  | MED, LONG  |
|--|--|
| $0.05\% \times (100 \text{ mV/Vs}) \times (1 + \sqrt{(100/Fm)})$ | $0.01\% \times (100 \text{ mV/Vs}) \times (1 + \sqrt{(100/Fm)})$ |

Fm [Hz]      Test frequency  
Vs [V]        Test signal voltage

**Relative measurement accuracy with bias current isolation**

When DC bias Isolation is set to ON, add the following value to the open offset Yo.

**Equation 20.**  $Yo\_DCI1 \times (1 + 1/(Vs)) \times (1 + \sqrt{(500/Fm)}) + Yo\_DCI2$

Zm [Ω]        Impedance of DUT  
Fm [Hz]        Test frequency  
Vs [V]        Test signal voltage  
Yo\_DC1,2 [S] Calculate this by using Table 65 and 66  
Idc [A]        DC bias isolation current

**Table 65. Yo\_DC11 value**

| DC bias current range | Measurement time mode |           |
|-----------------------|-----------------------|-----------|
|                       | SHORT                 | MED, LONG |
| 20 μA                 | 0 S                   | 0 S       |
| 200 μA                | 0.25 nS               | 0.05 nS   |
| 2 mA                  | 2.5 nS                | 0.5 nS    |
| 20 mA                 | 25 nS                 | 5 nS      |
| 100 mA                | 250 nS                | 50 nS     |

**Table 66. Yo\_DC12 value**

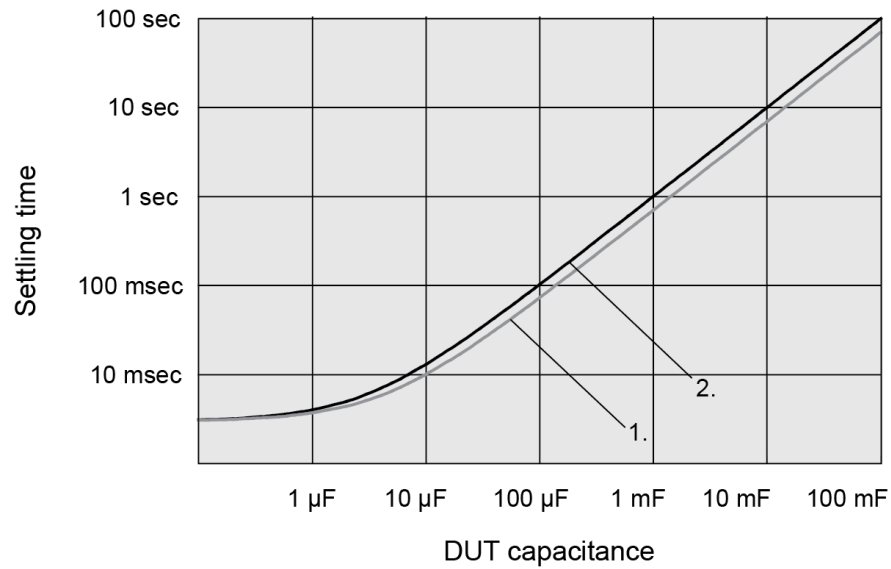
| DC bias current range | Measurement time mode |              |               |                 |
|-----------------------|-----------------------|--------------|---------------|-----------------|
|                       | ≤ 100 Ω               | 300 Ω, 1 k Ω | 3 k Ω, 10 k Ω | 30 k Ω, 100 k Ω |
| 20 μA                 | 0 S                   | 0 S          | 0 S           | 0 S             |
| 200 μA                | 0 S                   | 0 S          | 0 S           | 0 S             |
| 2 mA                  | 0 S                   | 0 S          | 0 S           | 3 nS            |
| 20 mA                 | 0 S                   | 0 S          | 30 nS         | 30 nS           |
| 100 mA                | 0 S                   | 300 nS       | 300 nS        | 300 nS          |

## DC bias settling time

When DC bias is set to ON, add the following value to the settling time:

**Table 67. DC bias settling time**

|   | Bias       | Settling time                                    |
|---|------------|--|
| 1 | Standard   | Capacitance of DUT × 100 × loge (2/1.8 m) + 3 m  |
| 2 | Option 001 | Capacitance of DUT × 100 × loge (40/1.8 m) + 3 m |



**Figure 11. DC bias settling time**

## Web Resources

Visit our Web sites for additional product information and literature.

E4980A Precision LCR Meter  
[www.keysight.com/find/e4980a](http://www.keysight.com/find/e4980a)

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