APPENDIX A
Model 3321 Specifications

A.1 MEASUREMENT PARAMETERS

Kinds of Parameters

- Main Parameters

  AUTO: Selects the main parameters, sub-parameters and equivalent circuits automatically.

  L: Self-inductance (unit: H, henry)

  C: Capacitance (unit: F, farad)

  |Z|: Magnitude of impedance (unit: Ω)

  There are series and parallel measuring modes for each of L, C and R.

- Sub-parameters

  Q: *Quality factor (quality of circuit)*

  D: Dissipation factor (= tan δ = 1/Q)

  ESR: Equivalent series resistance (unit: Ω)

  G: Parallel conductance (unit: S, siemens; 1/Ω; Mho)

  θ: Phase angle of impedance (unit: degree)

- Equivalent Circuits

  AUTO: Automatic selection

  SER: Series

  PAR: Parallel

- Automatic Parameter Selection

  Parameters can be automatically selected by the phase angle of impedance.

  θ ≈ +90° ± 45° → L - Q

  θ ≈ -90° ± 45° → C - D

  θ ≈ Other than the above → |Z| - θ

- Automatic Selection of Equivalent Circuits

  Equivalent circuits can be automatically selected by the value and phase angle of impedance, and the combination of parameters.

Conditions for Selection of Series Mode		Conditions for Selection of Parallel Mode	
L, C	- ESR	L, C	- G
L, C (|Z| ≤1kΩ)	- Q, D	L, C (|Z| > 1kΩ)	- Q, D
|Z|	- θ		

Displayed Resolution

4-1/2 digits (19999 max)

D and Q Resolution: 0.0001 min

θ Resolution: 0.01°

Measuring (display) Range

|Z|, ESR: 0.1mΩ to 19.999MΩ

C: 0.001pF to 199.99mF

L: 0.1nH to 19.999kH

Q, D: 0.0001 to 19999

G: 0.001μS to 199.99S

θ: -180.00° to +179.99°

These ranges are dependent on the frequency, measuring range, and phase angle of impedance.

Accuracy

Accuracy Guarantee Conditions

- Warm-up time: 30 minutes.
- Ambient temperature and humidity: 23° ±5°C, ≤90% RH.
- Zero correction: Performed under the above conditions.
- Calibration period: 12 months.

Accuracy of |Z| and θ

For 0.2Ω ≤ |Z| ≤ 20MΩ, see Table A-1.

For |Z| < 0.2Ω, see Table A-2.

For |Z| >20MΩ, see Table A-3.

Notes:

1. When a measurement is made at twice line frequency, the measured value may deviate beyond the accuracy range due to interaction with line frequency.
2. When the operating temperature is 5°-40°C, add the value shown in Table A-4 to that in Table A-1. Double the values shown in Table A-2 and A-3.
3. Tables A-1 through A-3 show the worst case value in each impedance range. Obtain the correct accuracy in the following ranges by linear interpolation:

- |Z| = 1M to 20MΩ

  In this range, as impedance increases, accuracy decreases.

  acc1: Accuracy shown in one range below the range including a Z in Table A-1.

  acc2: Accuracy (worst case value) shown in the range including a Z in Table A-1.

- |Z| = 0.2 to 2Ω

  In this range, as impedance decreases, accuracy decreases.

  acc1: Accuracy (worst case value) shown in the range including a Z in Table A-1.

Notes Cont.:

acc2: Accuracy shown in one range above the range including a Z in Table A-1.

$$acc = [acc1\ (Z2 - Z) + acc2\ (Z - Z1)] / (Z2 - Z1)$$

Z: Magnitude of measured impedance (measured value)

Z1: Lower limit value of each impedance range in Table A-1.

Z2: Upper limit value of each impedance range in Table A-1.

acc: Measuring accuracy of impedance Z ($|Z|$ is displayed by %, and θ by degree.)

acc1: Measuring accuracy of impedance Z1

acc2: Measuring accuracy of impedance of Z2

When obtaining the accuracy in the ambient temperature ranging from 5°-40°C, add each corresponding value in Table A-4 to acc1 and acc2 in advance.

- When level = 50mV rms, accuracy is not guaranteed in the following ranges.

  $|Z| \geq 20M\Omega$

  $|Z| \geq 2M\Omega$ and frequency = 100kHz

  $|Z| < 0.2\Omega$

Accuracy of ESR and G

In the case of $Q < 0.1$ ($D > 10$), use the accuracy of $|Z|$:

$|ESR| = |Z|$

$|G| = 1/|Z|$

Accuracy of L and C

In the case of $Q > 10$ ($D < 0.1$), use the accuracy of $|Z|$:

$$L = \frac{|Z|}{2\pi f}$$

$$C = \frac{1}{2\pi f\,|Z|}$$

where f is the test frequency in Hz.

Refer to Figure A-1, Conversion from LC to $|Z|$.

Accuracy of D and Q

In case $D<<1$ ($Q>>1$), use the following equations:

Accuracy of $D = \pm(0.0175 \times \theta$ accuracy (deg))

Accuracy of $Q = \pm(0.0175 \times \theta$ accuracy (deg) $\times Q^2)$

In any parameter, add the $\pm 1/2$ count, i.e., half of the resolution to the displayed value as actual accuracy.