7. SPECIFICATION

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Supplementary value: These values show the guideline data for reference and do not guarantee the performance.

7.1 Specification

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Measurement parameters

• Primary parameters	Z , Y , L, C, R, G
	For equivalent circuit of L, C, and R, Parallel / Series / Auto Selection are
	selectable.
 Secondary parameters 	Q, D, θ , X, B, Rs, Rp, G, Lp, Rdc (direct-current resistance)
• Auto parameter	Primary parameters (including equivalent circuit) and secondary parameters
selection	can be selected automatically.

Measured value display range

• Z	$0.000 \mathrm{m}\Omega$ to $999.999 \mathrm{M}\Omega$
• R (Rs, Rp, Rdc), X	$0 \Omega, \pm (0.001 \mathrm{m}\Omega \text{ to } 999.999 \mathrm{M}\Omega)$
• Y	0.00nS to 9.999999kS
• G, B	0 S, ±(0.01nS to 9.999999kS)
• C (Cp, Cs)	0 F, ±(0.0001pF to 99.9999kF)
• L (Ls, Lp)	0 H, ±(0.00001nH to 9.999999GH)
• Q, D	0, ±(0.00001 to 99999.9)
• θ	$\pm 180.000^{\circ}$
	Actual measurement and display ranges of respective parameters are
	restricted by the measurement range or frequency.

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Measurement condit	ions	
• Measurement frequency	1mHz to 5.5	5MHz, Resolution 6 digits (1mHz when < 100Hz),
	Accuracy ±	0.01%
 Measurement signal 		
Level Setting range	10mV to 5	V, Resolution 3 digits (1mV when < 100mV)
Level accuracy	$\pm (8\% + 5n)$	$NV \le 1MHz$ (typical value when $< 1Hz$)
	$\pm (10\% + 5)$	(mV) > 1MHz
	RMS value	s at open output.
• ALC	Constant vo	ltage drive / Constant current drive / Disabled
	Voltage set	tting range 10mV to 5V, Resolution 3 digits (1mV when <
	100mV)	
	Current sett	ting range 1µA to 200mA, Resolution 3 digits (0.1µA when <
	10µA)	
	The constar	nt control range will be narrower than the above specifications
	depending of	on the product dispersion or DUT's impedance.
	The current	range is restricted depending on the measurement range.
 Output impedance 	6Ω / 25Ω /	100Ω (supplementary value).
	The minimu	im output impedance can be selected from the above three values.
	However, it	t is limited by the measurement range, the signal level, and the
	frequency.	
 Internal DC bias 	Setting rang	ge 0V to $+5V$, Resolution 1mV,
	Accuracy \pm	$(2\% + 5mV)$ [Level $\leq 2V$]
	±	(2% + 10mV) [Level > 2V]
	at	signal frequency of 1 MHz or less, $23 \pm 10^{\circ}$ C (Environmental
	te	mperature), and open output.
	It can be tu	rned on / off.
Trigger source	INT	Internal (automatic continuous trigger)
	MAN	Manual
	EXT	Handler interface
	BUS	Remote control
 Trigger delay time 	Setting rang	ge 0s to 999.9999s, Resolution 0.0001s
	(Time after	input of trigger until start of signal acquisition)
 Triggered drive 	Drive only a	at measurement / Continuous drive selectable
	(Measureme	ent signal can be output only during the time from trigger to
	completion	of signal acquisition)

• Measurement speed

RAPid / FAST / MEDium / SLOW / VerySLOw

Typical measurement time

(Typical value. Time from input of trigger to output of measurement end signal EOM)

Measurement frequency	RAP	FAST	MED	SLOW	VSLO
120Hz	10ms	10ms	26ms	126ms	501ms
1kHz	2ms	5ms	25ms	121ms	501ms
10kHz	2ms	5ms	25ms	121ms	501ms
100kHz	2ms	5ms	25ms	121ms	501ms
1MHz	2ms	5ms	25ms	121ms	501ms

Conditions: Measurement range hold, Trigger delay time = 0,

Averaging count = 1, Secondary parameter \neq Rdc.

Signal acquisition time is the value subtracted by about 1ms from the above value.

DUT can be replaced immediately after the completion of signal acquisition.

After replacement of DUT, the signal settling time is required additionally. It should be an appropriate trigger delay time and not zero.

Additional time when measuring direct-current resistance Rdc (supplementary value)

	RAP	FAST	MED	SLOW	VSLO
(DC)	150ms	150ms	150ms	218ms	616ms

Conditions: DC resistance measurement range fixed, Trigger delay time = 0,

Averaging count = 1.

• Measurement range

Measurement range	Recommended range	Measureable range	Output impedance
1MΩ	1MΩ to 11MΩ	≥900kΩ	100Ω
100kΩ	$100k\Omega$ to $1.1M\Omega$	≥90kΩ	100Ω
10kΩ	10kΩ to 110kΩ	≥9kΩ	100Ω
1kΩ	1kΩ to 11kΩ	≥0.9kΩ	100Ω
100Ω	9Ω to 1.1kΩ	No limitation	100Ω (*1)
10Ω	0.9Ω to 10Ω	≤11Ω	100Ω (*1)
1Ω	90mΩ to 1Ω	≤1.1Ω	25Ω / 6Ω
100mΩ	$9m\Omega$ to $100m\Omega$	≤110mΩ	25Ω / 6Ω

Measureable range: Approximate range in which measurement and display are possible (supplementary value).

*1 For the 10Ω and 100Ω ranges, the output impedance may become 25Ω or 6Ω depending on the minimum output impedance setting. In this case, the recommended range and the measureable range for the 10Ω and 100Ω ranges change as follows:

Measurement	Recommended	Measureable
range	range	range
100Ω	100Ω to1.1kΩ	≥90Ω
10Ω	0.9Ω to110Ω	Not limited

Recommended range: Recommended operating range for high accuracy measurement.

Limitations: When frequency > 20kHz, the $1M\Omega$ range cannot be used.

When frequency > 1MHz, the measureable range is limited to between 1Ω and $10k\Omega$ ranges.

When frequency > 2MHz, the measureable range is limited to between 10Ω and $1k\Omega$ ranges.

The output impedance may be restricted depending on the frequency and signal level.

When cable length = 4m and frequency > 200kHz, the measureable range is limited to between 10Ω and $10k\Omega$ ranges.

• Measurement range selection

Auto / Manual

- Measurement accuracy
- Basic accuracy 0.08%

• Impedance measurement accuracy

Zr: Measurement range (100m Ω to 1M Ω)

Zx: Measured value of impedance magnitude |Z|

With the above definitions, the impedance measurement accuracy is obtained as follows:

Accuracy of impedance magnitude $|Z| \pm Az[\%]$

 $Az = (A + B \times U + Kz + Ky) \times K_T + (Kv + K_B) \times U \text{ (Level } \leq 1 \text{V)}$

$$Az = (A + B \times U + Kz + Ky) \times K_T + Kv + K_B \times U \text{ (Level > 1V)}$$

Accuracy of phase angle θ of impedance $\pm Pz[^\circ]$

 $Pz = 0.573 \times Az$

The measurement accuracy when Az exceeds 10[%] is a supplementary value. Excluding the highest and the lowest ranges available for each frequency, the measurement accuracy for the measured value smaller than half the lower limit of each recommended measurement range or larger than twice the upper limit is a typical value.

Each parameter value in the expression is listed below.

• U: Ratio coefficient

Zx	U
> 100Ω	Zx / Zr (however, 1 when Zx / Zr < 1)
≤ 100Ω	Zr / Zx (however, 1 when Zr / Zx < 1)

If the measureable range for the 10Ω range becomes unlimited depending on the minimum output impedance setting, the following values should be used.

Zx	U
> 10Ω	Zx / Zr (however, 1 when Zx / Zr < 1)
≤ 10Ω	Zr / Zx (however, 1 when Zr / Zx < 1)

• A (upper row): Basic coefficient[%]

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• **B** (lower row): Proportional coefficient[%]

For the measurement speeds, MED, SLOW, and VSLO, the coefficient is as shown in the table below.

For the measurement speeds, RAP and FAST, the coefficient is 1.1 times of the value shown below.

		Measurement frequency Hz					
range Zr	0 (DC)	999.999 ↑ 1m	1k	20k ↑ 1.00001k	50k ↑ 20.0001k	100k ↑ 50.0001k	200k ↑ 100.001k
1MΩ	0.20 0.15	0.15 0.10	0.12 0.15	0.30 0.30			
100kΩ	0.06	0.06	0.06	0.06	0.08	0.20	0.20
	0.03	0.03	0.03	0.06	0.08	0.08	0.08
10kΩ	0.06	0.06	0.06	0.06	0.07	0.10	0.15
	0.03	0.03	0.03	0.03	0.03	0.04	0.04
1kΩ	0.06	0.06	0.05	0.05	0.06	0.10	0.12
	0.03	0.03	0.03	0.03	0.03	0.04	0.04
100Ω	0.09	0.12	0.05	0.06	0.06	0.06	0.12
	0.03	0.02	0.03	0.03	0.03	0.03	0.03
10Ω	0.08	0.12	0.10	0.12	0.12	0.12	0.12
	0.04	0.06	0.06	0.08	0.08	0.10	0.10
1Ω	0.20	0.20	0.20	0.30	0.30	0.30	0.30
	0.05	0.05	0.03	0.08	0.08	0.08	0.08
100mΩ	0.30	0.30	0.20	0.30	0.30	0.40	0.40
	0.40	0.30	0.20	0.40	0.40	0.40	0.40

Management	Measurement frequency Hz						
range Zr	500k ↑ 200.001k	1M ↑ 500.001k	2M ↑ 1.00001M	3M ↑ 2.00001M	4M ↑ 3.00001M	5.5M ↑ 4.00001M	
1MΩ							
100kΩ	0.30 0.10	1.00 0.30					
10kΩ	0.20 0.05	0.80 0.10	1.50 0.80	1.50 1.00	1.50 1.20	2.00 2.00	
1kΩ	0.15 0.05	0.30 0.06	0.50 0.20	0.60 0.30	0.60 0.30	1.50 0.30	
100Ω	0.14 0.03	0.15 0.04	0.30 0.05	0.40 0.08	0.40 0.08	1.50 0.08	
10Ω	0.12 0.20	0.12 0.20	0.12 0.60	0.12 0.80	0.15 0.80	0.20 2.00	
1Ω	0.30 0.50	0.30 0.50	0.60 0.60				
100mΩ	0.50 1.00	0.50 1.00					

The measurement accuracy is not guaranteed for "---".

The basic coefficient A of the 100Ω range is increased 1.5 times, when the output impedance is 25Ω or 6Ω below 1MHz.

• Kc: Cable length coefficient

Frequency range	Kc [%]
DC, Frequency ≤ 1kHz	0.01 x (Cable length[m])
1kHz < Frequency ≤ 100kHz	0.2 x (Cable length[m])
100kHz < Frequency ≤ 1MHz	0.5 x (Cable length[m]) ²
1MHz < Frequency	20 x (Cable length[m]) ²

Restriction on measurement frequency and signal level depending on cable length

Cable length	Applicable frequency range	Applicable signal level
0m	All ranges including DC	All range
1m	DC, Frequency ≤ 2MHz	All range
2m	DC, Frequency ≤ 2MHz	All range
4m	DC, Frequency ≤ 1MHz	All range for DC and frequency ≤ 500kHz ≤ 2V for frequency > 500kHz

The measurement accuracy is not guaranteed for frequencies and signal levels out of these ranges.

• Kz: Residual impedance coefficient

Frequency range	Kz [%]
DC, Frequency ≤ 20kHz	(0.02 + Kc) / Zx[Ω]
20kHz < Frequency ≤ 100kHz	(0.05 + Kc) / Zx[Ω]
100kHz < Frequency	(0.5 + Kc) / Zx[Ω]

• Ky: Residual admittance coefficient

When the cable length is 0m, the coefficient is as shown in the table below.

When an extension cable (1m, 2m, or 4m) is used on the frequency of more 20kHz, the coefficient is 10 times of the value shown below.

Frequency range	Ky [%]
DC, Frequency ≤ 50kHz	$Zx[\Omega] / (2 \times 10^7)$
50kHz < Frequency ≤ 500kHz	$Zx[\Omega] \times (Frequency[kHz])^2 / (2 \times 10^{10})$
500kHz < Frequency	Zx[Ω] / (1× 10 ⁵)

• Kv: Signal level coefficient

For the DC resistance Rdc, V = 0.

The measurement accuracy is not guaranteed for signal levels < 100mV.

The measurement accuracy is not guaranteed for frequency > 2MHz, range = $10k\Omega$, and signal level > 2V.

For other measurement parameters, the coefficient is as shown in the table below.

Frequency \leq 120Hz

	Signal level[Vrms]					
Measurement range Zr	200m ↑ 100m	500m ↑ 201m	999m ↑ 501m	1	2 ↑ 1.01	5 ↑ 2.01
1MΩ	0.40	0.10	0.10	0	0.10	0.15
100kΩ	0.10	0.02	0.02	0	0.03	0.10
10kΩ	0.10	0.02	0.02	0	0.03	0.10
1kΩ	0.10	0.01	0.01	0	0.03	0.10
100Ω	0.10	0.03	0.03	0	0.03	0.15
10Ω	0.20	0.03	0.01	0	0.04	0.04
1Ω	0.40	0.10	0.02	0	0.03	0.03
100mΩ	3.5	0.80	0.50	0	0.03	0.03

120Hz < Frequency \leq 100kHz

			Signal lev	evel[Vrms]		
Measurement range Zr	200m ↑ 100m	500m ↑ 201m	999m ↑ 501m	1	2 ↑ 1.01	5 ↑ 2.01
1MΩ	0.40	0.10	0.10	0	0.10	0.20
100kΩ	0.20	0.05	0.05	0	0.02	0.10
10kΩ	0.10	0.02	0.02	0	0.03	0.20
1kΩ	0.10	0.02	0.02	0	0.03	0.20
100Ω	0.15	0.05	0.05	0	0.10	0.20
10Ω	0.15	0.05	0.05	0	0.10	0.10
1Ω	0.10	0.01	0.01	0	0.01	0.01
100mΩ	1.5	0.20	0.10	0	0.01	0.01

100kHz < Frequency

	Signal level[Vrms]					
Measurement range Zr	200m ↑ 100m	500m ↑ 201m	999m ↑ 501m	1	2 ↑ 1.01	5 ↑ 2.01
100kΩ	4.00	1.00	0.10	0	0.10	0.15
10kΩ	4.00	1.00	0.10	0	0.10	0.15
1kΩ	0.80	0.10	0.10	0	0.30	1.5
100Ω	0.20	0.05	0.05	0	0.50	3.0
10Ω	0.20	0.05	0.05	0	0.10	1.0
1Ω	0.10	0.01	0.01	0	0.01	0.20
100mΩ	1.5	0.20	0.10	0	0.01	0.01

• **KT**: Temperature-dependent coefficient

Ambient temperature	KT			
(T °C)	Frequency ≤ 20kHz	Frequency > 20kHz		
0 to +18	1 + 0.1 × (18-T)	1 + 0.15 × (18-T)		
+18 to +28	1	1		
+28 to +40	1 + 0.1 × (T-28)	1 + 0.15 × (T-28)		

• KB: DC bias coefficient

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For the DC resistance Rdc, $K_B = 0$ [%].

When the internal DC bias is disabled, KB = 0 [%].

When the internal DC bias is enabled, KB [%] is as shown in the table below.

	Frequency Hz					
Measurement range Zr	0 (DC)	120 ↑ 1m	20k ↑ 120.001	100k ↑ 20.0001k	1M ↑ 100.001k	5.5M ↑ 1.00001M
1MΩ	0	0.02	0.02			
100kΩ	0	0.01	0.01	0.01	0.01	
10kΩ	0	0.01	0.01	0.01	0.01	0.20
1kΩ	0	0.01	0.01	0.01	0.01	0.20
100Ω	0	0.01	0.01	0.01	0.01	0.30
10Ω	0	0.05	0.05	0.05	0.20	0.50
1Ω	0		0.20	0.20	0.50	0.50
100mΩ	0					

The measurement accuracy is not guaranteed for "---".

Other conditions

Warm-up	30 min or more
Zero correction	Execute OPEN correction and SHORT correction.
Cable Length Correction	Execute according to the connection cable length.
Calibration cycle	1 year

- Measurement accuracy of measurement parameters except Z and $\boldsymbol{\theta}$

From the measurement accuracy of impedance, obtain as follows.

Here, Qx is a measured value of Q, Dx is a measured value of D, and θx is a measured value of θ . θx used for accuracy calculation may be obtained from (90° - tan⁻¹|1/Qx|) or (90° - tan⁻¹|Dx|).

Parameter	Measurement accuracy
Y	±Az [%]
Lp, Ls, X	±Az [%] (Qx ≥10), ±Az / sinθx [%] (Qx < 10)
Cp, Cs, B	±Az [%] (Dx ≤0.1), ±Az / sinθx [%] (Dx > 0.1)
Rp, Rs, G	±Az [%] (Qx ≤0.1), ±Az / cosθx [%] (Qx > 0.1)
Rdc	±Az [%]
Q	$\pm Qx^2 \times Pe / (1 - Qx \times Pe)$ ($ Qx \ge 10$, $ Qx \times Pe \le 0.1$) Here, the phase angle error Pe[rad] = 0.01 × Az[%]. It differs from Pz[°]. Measurement accuracy of Q is absolute value. It is not a % value.
D	±(0.01 × Az) (Dx ≤0.1) Measurement accuracy of D is absolute value. It is not a % value.

In general, a range of each measurement parameter (maximum value and minimum value) can be calculated based on an error circle of the impedance.





Figure 7-1 Range of error

Pure L[H] and C[F] can be converted into $|Z|[\Omega]$ by the following expression:

 $|Z|[\Omega] = 2 \times \pi \times Frequency[Hz] \times L[H]$

 $|Z|[\Omega] = 1 / (2 \times \pi \times Frequency[Hz] \times C[F])$

Approximate value can be read from the following graph.





Figure 7-2 LC - Z conversion graph

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 Other measurement 	measurement related functions				
 Zero correction 	OPEN correction and	d SHORT correction provided. Both can be turned on or			
	off.				
 LOAD correction 	Provided. It can be turned on or off.				
Cable length correction	0m / 1m / 2m / 4m				
Contact check	Provided.				
	Based on detection	n of an abnormally low capacitance or abnormal			
	voltage/current.				
• Averaging	1 to 256 times				
• Deviation measurement	Primary parameters:	Deviation and deviation % from reference value can be displayed.			
	Secondary parameters:	Deviation and deviation % from reference value can be			
	V 1	displayed.			
Comparator	Primary parameters:	Max. 14 bins			
1	5 1	Original measured value / Deviation / Deviation % can			
		be sorted.			
	Secondary parameters:	Upper limit and lower limit comparison			
	V 1	Original measured value / Deviation / Deviation % can			
		be sorted.			
	Beeper:	Sounds according to comparison result			
		(Pass / Fail / Off)			
• Handler interface	Signal isolation:	All I/O signals are optically isolated			
		(withstand voltage ± 42 V)			
	Input signal:	Trigger, Key lock, Settings/correction value memory			
		designation.			
		High speed recalling with only spot correction value is			
		possible.			
	Output signal:	Comparison result BIN1 to BIN11, NC / BIN12, PHI /			
		BIN13, PLO / BIN14, OUT OF BINS, S-NG, ERR,			
		INDEX, EOM (when BIN10 - BIN14 are used, NC,			
		PHI, and PLO cannot be used).			
	Rated power voltage:	: External +5V to +24V, Internal +5V (non-isolated)			
 Multi-measurement 	Execute measurement	nt and limit comparison under multiple conditions for			
	the total comparison.				
	Maximum number of	f steps: 32			
	Selectable measurem	nent conditions: Measurement frequency, measurement			
	signal level, internal DC bias voltage, measurement parameters, etc.				

• Monitor display	Voltage: Voltage value applied to the DUT		
	Voltage Monitor Accuracy		
		±(2%+2mVrms) from 10Hz to 50kHz	
		±(3.5%+2mVrms) over 50kHz to 100kHz	
		±(5%+5mVrms) over 100kHz to 1MHz	
		±(10%+10mVrms) over 1MHz to 5.5MHz	
	Current:	Current value flowing in the DUT	
		Current monitor accuracy (supplementary value)	
		Voltage monitor accuracy + Measurement accuracy of impedance Z	
Discharge protection	4J or less	when voltage is below 250V, or 0.5J or less when below 1kV.	
	(All are su	pplementary values)	
	For voltag	e V[V], the energy stored in capacitance C[F] is $(1/2) \times C \times V^2[J]$.	
Remote control integration	erface		
• USB	USBTMC	, USB 1.1 Full-speed	
• RS-232	Data rate	-	
	4800 / 9600 / 19200 / 38400 / 57600 / 115200 / 230400bps		
	For the data rate exceeding 19200bps, communication may fail		
	deper	nding on the characteristics of cable or controller.	
	Flow cont	rol	
	None	, Software (X-ON/X-OFF), Hardware (RTS/CTS)	
• GPIB	Conforms	to IEEE 488.1 and IEEE 488.2 Standards	
• LAN (optional)	10BASE-7	Γ / 100BASE-TX, RJ-45 connector	

General specifications

•	Power	Supply
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- Voltage: Frequency:
 - Power consumption:

AC 100V to 230V ±10%, but 250V or less 50Hz/60Hz ±2Hz 75VA or less

Overvoltage category II • Environmental conditions

Operation	Temperature:	0 to +40°C
	Humidity:	5 to 85%RH. Absolute humidity 1 to 25g/m ³ , non-condensing
	Altitude:	2000m or less
Storage	Temperature:	-10 to +50°C
	Humidity:	5 to 95%RH. Absolute humidity 1 to 29g/m ³ , non-condensing



- Pollution 2 (indoor use) Degree
- Safety EN 61010-1:2010 • EMC EN 61326-1:2013(Group 1, Class A) EN61000-3-2:2006+A1:2009+A2:2009 EN61000-3-3:2008 • RoHS Directive 2011/65/EU • Warm-up Time 30 minutes • Settings/correction value memory 32 sets. Settings and correction values can be saved and restore individually or together. • Resume Last setting and correction value are restore at power-on. • External dimensions Approx. 260 (W) \times 88 (H) \times 280 (D) mm, not including protuberances • Weight Approx. 2.4kg (without accessories)