Specifications

Unless otherwise specified, the conditions are that 23 °C ±5 °C, warming up for at least 30 minutes.

Measurement Modes

Measurement Modes	IMPD-3T (Default measurement mode) IMPD-2T (High-frequency measurement mode) IMPD-EXT (Expanded measurement mode) G-PH (Gain/phase measurement mode)

Measurement Value Display Ranges

IMPD-3T, IMPD-2T

Z		0 Ω to 999.999 GΩ, resolution 6 digits or 1 aΩ
R, X		±(1 a to 999.999 G) Ω and 0 Ω, resolution 6 digits or 1 aΩ
Y		0 S to 999.999 GS, resolution 6 digits or 1 aS
G, B		±(1 a to 999.999 G) S and 0 S, resolution 6 digits or 1 aS
Ls, Lp		±(1 a to 999.999 G) H and 0 H, resolution 6 digits or 1 aH
Cs, Cp		±(1 a to 999.999 G) F and 0 F, resolution 6 digits or 1 aF
Rs, Rp		±(1 a to 999.999 G) Ω and 0 Ω, resolution 6 digits or 1 aΩ
θz, θy	±180°	−180.000° to 179.999°, resolution 0.001°
	0 to 360°	0.000° to 359.999°, resolution 0.001°
	−360 to 0°	−360.000° to −0.001°, resolution 0.001°
	UNWRAP	−9999.999° to +9999.999°, resolution 0.001°
D, Dε, Dμ		±(0.00001 to 99999.9) and 0 (unitless number), resolution 6 digits or 0.00001
Qc, QL		±(0.00001 to 99999.9) and 0 (unitless number) resolution 6 digits or 0.00001
V		0 to 9.99999 Vrms, resolution 6 digits or 1 aVrms
I		0 to 99.9999 mArms, resolution 6 digits or 1 aArms
εs, εs′, εs″ μs, μs′, μs″		±(1 a to 999.999 G) and 0 (unitless number), resolution 6 digits or 1 a
FREQUENCY		10 μHz to 36.000 000 000 00 MHz, resolution 10 μHz This item is selectable when resonant frequency tracking measurement.

IMPD-EXT

Z		0 Ω to 999.999 GΩ, resolution 6 digits or 1 aΩ
R, X		±(1 a to 999.999 G) Ω and 0 Ω, resolution 6 digits or 1 aΩ
Y		0 S to 999.999 GS, resolution 6 digits or 1 aS
G, B		±(1 a to 999.999 G) S and 0 S, resolution 6 digits or 1 aS
Ls, Lp		±(1 a to 999.999 G) H and 0 H, resolution 6 digits or 1 aH
Cs, Cp		±(1 a to 999.999 G) F and 0 F, resolution 6 digits or 1 aF
Rs, Rp		±(1 a to 999.999 G) Ω and 0 Ω, resolution 6 digits or 1 aΩ
θz, θy	±180°	−180.000° to 179.999°, resolution 0.001°
	0 to 360°	0.000° to 359.999°, resolution 0.001°
	−360 to 0°	−360.000° to −0.001°, resolution 0.001°
	UNWRAP	−9999.999° to +9999.999°, resolution 0.001°
D, Dε, Dμ		±(0.00001 to 99999.9) and 0 (unitless number), resolution 6 digits or 0.00001
Qc, QL		±(0.00001 to 99999.9) and 0 (unitless number) resolution 6 digits or 0.00001
V1, V2		0 to 999.999 GVrms, resolution 6 digits or 1 aVrms V1 and V2 are the voltages resulting from the PORT1 measurement voltage and PORT2 measurement voltage being corrected (multiplied) by the respective input weighting factorsetting values.
εs, εs′, εs″ μs, μs′, μs″		±(1 a to 999.999 G) and 0 (unitless number), resolution 6 digits or 1 a
FREQUENCY		10 μHz to 36.000 000 000 00 MHz, resolution 10 μHz This item is selectable when resonant frequency tracking measurement.

G–PH

Gain		
dBR (gain dB)		−999.999 dB to +999.999 dB, resolution 0.001 dB
R (absolute gain)		0 to 999.999 G (unitless number), resolution 6 digits or 1 a
a (real part of gain)		±(1 a to 999.999 G) or 0 (unitless number), resolution 6 digits or 1 a
b (imaginary part of gain)		±(1 a to 999.999 G) or 0 (unitless number), resolution 6 digits or 1 a
θ (phase)	±180°	−180.000° to +179.999°, resolution 0.001°
	0 to 360°	0.000° to +359.999°, resolution 0.001°
	−360 to 0°	−360.000° to −0.001°, resolution 0.001°
	UNWRAP	−9999.999° to +9999.999°, resolution 0.001°
GD (group delay)		±(1 a to 999.999 G) s and 0 s, resolution 6 digits or 1 as
V1, V2		0 to 999.999 GVrms, resolution 6 digits or 1 aVrms V1 and V2 are the voltages resulting from the PORT1 measurement voltage and PORT2 measurement voltage being corrected (multiplied) by the respective input weighting factorsetting values.

Measurement Connectors

IMPD-3T

HCUR/OSC

Connector	BNC connector (front panel)
Frequency	10 μHz to 36 MHz (when HV DC bias is off) 1 kHz to 36 MHz (when HV DC bias is on) Setting resolution: 10 μHz Accuracy: ±10 ppm (when using internal reference clock)
Measurement signal amplitude	
Voltage	0 to 3.00 Vrms (Measurement signal amplitude setting [Vrms] × 1.42) + |Normal DC bias setting [V]| ≤ 5.0 (Measurement signal amplitude setting [Vrms] × 1.42) + |HV DC bias setting [V]| ≤ 42.0 Setting resolution: 3 digits or 10 μVrms, whichever is the largest Accuracy: ± 0.3 dB or less (1 kHz, 70 mVrms to 3.0 Vrms, no load)
Current	0 to 60 mArms (Measurement signal amplitude setting [Arms] × 71) + |Normal DC bias setting [A]× 50| ≤ 5.0 Setting resolution: 3 digits or 100 nArms, whichever is the largest Accuracy: nominal value
Frequency characteristics	±0.3 dB or less (100 kHz or less) ±0.5 dB or less (1 MHz or less) ±1.0 dB or less (15 MHz or less) ±3.0 dB or less (30 MHz or less) ±4.0 dB or less (36 MHz or less) 1 kHz reference, 70 mVrms to 3 Vrms, use normal DC bias, DC bias setting 0 V, 50 Ω load
Distortion	0.2% or less (no load, 100 kHz or less, BW500 kHz, and 3 Vrms output)
ALC	{CV (constant voltage) or CC (constant current)}/OFF
Output limit	Voltage: 10 μVrms to 3.00 Vrms Setting resolution: 3 digits or 10 μVrms, whichever is the largest Current 100 nArms to 60 mArms Setting resolution: 3 dights or 100 nArms, whichever is the largest
Normal DC bias (front panel or rear panel selectable)	
Voltage	−5.00 V to +5.00 V (Measurement signal amplitude setting [Vrms] × 1.42) + |Normal DC bias setting [V]| ≤ 5.0 Setting resolution: 10 mV Accuracy: ±(|1% of normal DC bias setting [V]| + 3% of measurement signal amplitude setting [Vrms] + 30 mV), When no load
Current	−100 mA to +100 mA (Measurement signal amplitude setting [Arms] × 71) + |Normal DC bias setting [A]× 50| ≤ 5.0 Setting resolution: 100 nA, accuracy: nominal value
HV DC bias	−40.0 V to +40.0 V (when no load) (Measurement signal amplitude setting [Vrms] × 1.42) + |HV DC bias setting [V]| ≤ 42.0 Setting resolution: 10 mV Accuracy: ±(|1% of HV DC bias setting [V]| + 3% of measurement signal amplitude setting [Vrms] + 30 mV), When no load Output Impedance: 1 kΩ (nominal value)
Output Impedance	50 Ω (nominal value)

HPOT/PORT1, LCUR/PORT2

Input connectors	BNC connectors (front panel)
Measurement range	10 Ω, 100 Ω, 1 kΩ, 10 kΩ, 100 kΩ, 1 MΩ, AUTO

● IMPD-2T

PORT3

Connector	N connector (front panel)
Frequency	10 µHz to 36 MHz (when HV DC bias is off) 1 kHz to 36 MHz (when HV DC bias is on) Setting resolution: 10 µHz, Accuracy: ±10 ppm (when using internal reference clock)
Measurement signal amplitude	
Voltage	0 to 3.00 Vrms (Measurement signal amplitude setting [Vrms] × 1.42) + |Normal DC bias setting [V]| ≤ 5.0 (Measurement signal amplitude setting [Vrms] × 1.42) + |HV DC bias setting [V]| ≤ 42.0 Setting resolution: 3 digits or 10 µVrms, whichever is the largest Accuracy: ± 0.3 dB or less (1 kHz, 70 mVrms to 3.0 Vrms, no load)
Current	0 to 60 mArms (Measurement signal amplitude setting [Arms] × 71) + |Normal DC bias setting [A] × 50| ≤ 5.0 Setting resolution: 3 digits or 100 nArms, whichever is the largest Accuracy: nominal value
Frequency characteristics	±0.3 dB or less (100 kHz or less) ±0.5 dB or less (1 MHz or less) ±1.0 dB or less (15 MHz or less) ±3.0 dB or less (30 MHz or less) ±4.0 dB or less (36 MHz or less) 1 kHz reference, 70 mVrms to 3 Vrms, use normal DC bias, DC bias setting 0 V, 50 Ω load
Distortion	0.2% or less (no load, 100 kHz or less, BW500 kHz, and 3 Vrms output)
ALC	{CV (constant voltage) or CC (constant current)}/OFF
Output limit	Voltage: 10 µVrms to 3.00 Vrms Setting resolution: 3 digits or 10 µVrms, whichever is the largest Current 100 nArms to 60 mArms Setting resolution: 3 dights or 100 nArms, whichever is the largest
Normal DC bias	
Voltage	−5.00 V to +5.00 V (Measurement signal amplitude setting [Vrms] × 1.42) + |Normal DC bias setting [V]| ≤ 5.0 Setting resolution: 10 mV Accuracy: ±(|1% of normal DC bias setting [V]| + 3% of measurement signal amplitude setting [Vrms] + 30 mV), When no load
Current	−100 mA to +100 mA (Measurement signal amplitude setting [Arms] × 71) + |Normal DC bias setting [A] × 50| ≤ 5.0 Setting resolution: 100 nA, accuracy: nominal value
HV DC bias	−40.0 V to +40.0 V (when no load) (Measurement signal amplitude setting [Vrms] × 1.42) + |HV DC bias setting [V]| ≤ 42.0 Setting resolution: 10 mV Accuracy: ±(|1% of HV DC bias setting [V]| + 3% of measurement signal amplitude setting [Vrms] + 30 mV), When no load Output Impedance: 1 kΩ (nominal value)
Measurement range	1 Ω, 10 Ω, 100 Ω, 1 kΩ, AUTO

● IMPD-EXT

HCUR/OSC

Unless otherwise specified, DUT drive amplifier gain setting K= +1.0 and ALC is OFF

Connector	BNC connector (front panel)
Frequency	10 µHz to 36 MHz Setting resolution: 10 µHz, Accuracy: ±10 ppm (when using internal reference clock)
Measurement signal amplitude	
Setting range	0 to 999 GVrms Limited to (0 to 3.0) × |K| Vrms by K (Measurement signal amplitude setting [Vrms] × 1.42) + |Normal DC bias setting [V]| ≤ 5.0 × |K| Setting resolution: 3 digits or 10 µVrms (K=1), whichever is the largest Accuracy: ± 0.3 dB or less (1 kHz, 70 mVrms to 3.0 Vrms, no load)
Frequency characteristics	±0.3 dB or less (100 kHz or less) ±0.5 dB or less (1 MHz or less) ±1.0 dB or less (15 MHz or less) ±3.0 dB or less (30 MHz or less) ±4.0 dB or less (36 MHz or less) 1 kHz reference, 70 mVrms to 3 Vrms, use normal DC bias, DC bias setting 0 V, 50 Ω load
Distortion	0.2% or less (no load, 100 kHz or less, BW500 kHz, and 3 Vrms output)
ALC	PORT1 / PORT2 / OFF
Output limit	Voltage: 1 aVrms to 999 GVrms Setting resolution: 3 digits or 1 aVrms, whichever is the largest
Normal DC bias	−999 GV to +999 GV Limited to −5.00 × K V to +5.00 × K V by K (Measurement signal amplitude setting [Vrms] × 1.42) + |Normal DC bias setting [V]| ≤ 5.0 × |K| Setting resolution: 3 digits or 10 mV (K= 1), whichever is the largest Accuracy: ±(|1% of normal DC bias setting [V]| + 3% of measurement signal amplitude setting [Vrms] + 30 mV), When no load
Output Impedance	50 Ω (nominal value)
DUT drive amplifier gain setting K	Set the gain of the amplifier or attenuator that supplies the measurement signal to the DUT. The measurement signal amplitude and normal DC bias applied to the DUT can be set directly. Setting range: ±(1E−12 to 1E+12) Setting resolution: 3 digits or 1E−12, whichever is the largest

HPOT/PORT1, LCUR/PORT2

Input connectors	BNC connectors (front panel)
Input Impedance	1 MΩ ±2%, 25 pF ±5 pF (HPOT) / 30 pF ±5 pF (LCUR) in parallel
Maximum non-destructive input voltage	±20 V
Measurement range	10 mVrms to 5 Vrms (1−2−5 sequence), 7 Vrms, and AUTO (PORT1 and PORT2 can be set individually.) • Measurement range and max. measurement input voltage

Measurement range [rms]	Maximum measurement input voltage	Measurement range [rms]	Maximum measurement input voltage
10 mV	±16 mV	500 mV	±780 mV
20 mV	±31 mV	1 V	±1.6 V
50 mV	±78 mV	2 V	±3.1 V
100 mV	±160 mV	5 V	±7.8 V
200 mV	±310 mV	7 V, AUTO	±11 V

Input weighting factor	This function corrects the conversion ratios of the voltage probe, current probe, shunt resistance, etc. for measurement. (PORT1 and PORT2 can be set individually) Setting range ±(1.00000E−15 to 999.999E+09) Setting resolution 6 digits or 1E−15
Over detection	Setting range: HPOT/PORT1 0 to 7 Vrms LCUR/PORT2 0 to 7 Vrms Setting resolution: 3 digits or 1 µVrms, whichever is the largest. Processing: Buzzer alarm sound, or stopping of measurement (can be turned on/off)

DC BIAS OUTPUT

Connector	BNC connector (rear panel)
Setting range	−999 GV to +999 GV Limited to −5.00 × K V to +5.00 × K V by K (Measurement signal amplitude setting [Vrms] × 1.42) + |Normal DC bias setting [V]| ≤ 5.0 × |K| Setting resolution: 3 digits or 10 mV (K=1), whichever is the largest Accuracy: ±(|1% of normal DC bias setting [V]| + 30 mV)
Output Impedance	600 Ω (nominal value)

● G-PH

HCUR/OSC

Connector	BNC connector (front panel)
Frequency	10 µHz to 36 MHz Setting resolution: 10 µHz Accuracy: ±10 ppm (when using internal reference clock)

(G-PH contunued)

Measurement signal amplitude	
Setting range	0 to 999 Gvrms Limited to (0 to 3.0) × |K| Vrms by K Resolution: 3 digits or 10 μVrms (K=1), whichever is the largest Accuracy: ± 0.3 dB or less (1 kHz, 70 mVrms to 3.0 Vrms, no load)
Frequency characteristics	±0.3 dB or less (100 kHz or less) ±0.5 dB or less (1 MHz or less) ±1.0 dB or less (15 MHz or less) ±3.0 dB or less (30 MHz or less) ±4.0 dB or less (36 MHz or less) 1 kHz reference, 70 mVrms to 3 Vrms, use normal DC bias, DC bias setting 0 V, 50 Ω load
Distortion	0.2% or less (no load when 100 kHz or less, BW500 kHz, and 3 Vrms output)
ALC	PORT1 / PORT2 / OFF
Output limit	Voltage: 1 aVrms to 999 GVrms Setting resolution: 3 digits or 1 aVrms, whichever is the largest
Normal DC bias	–999 GV to +999 GV Limited to –5.00 × K V to +5.00 × K V by K (Measurement signal amplitude setting [Vrms] × 1.42) + |Normal DC bias setting [V]| ≤ 5.0 × |K| Setting resolution: 3 digits or 10 mV (K=1), whichever is the largest Accuracy: ±(|1% of normal DC bias setting [V]| + 3% of measurement signal amplitude setting [Vrms] + 30 mV), When no load
Output Impedance	50 Ω (nominal value)
DUT drive amplifier gain setting K	Set the gain of the amplifier or attenuator that supplies the measurement signal to the DUT. The measurement signal amplitude and normal DC bias applied to the DUT can be set directly. Setting range: ±(1E–12 to 1E+12) Setting resolution: 3 digits or 1E–12, whichever is the largest

PORT1/HPOT, PORT2/LCUR

Input connectors	BNC connectors (front panel)
Input Impedance	1 MΩ ±2%, 25 pF ±5 pF (PORT1) / 30 pF ±5 pF (PORT2) in parallel
Maximum non-destructive input voltage	±20 V
Measurement range	10 mVrms to 5 Vrms (1–2–5 sequence), 7 Vrms, and AUTO (PORT1 and PORT2 can be set individually.) • Measurement range and max. measurement input voltage

Measurement range [rms]	Maximum measurement input voltage	Measurement range [rms]	Maximum measurement input voltage
10 mV	±16 mV	500 mV	±780 mV
20 mV	±31 mV	1 V	±1.6 V
50 mV	±78 mV	2 V	±3.1 V
100 mV	±160 mV	5 V	±7.8 V
200 mV	±310 mV	7 V, AUTO	±11 V

Input weighting factor	This function corrects the conversion ratios of the voltage probe, current probe, shunt resistance, etc. for measurement. (PORT1 and PORT2 can be set individually) Setting range: ±(1.00000E–15 to 999.999E+09) Setting resolution: 6 digits or 1E–15
Over detection	Setting range: HPOT/PORT1 0 to 7 Vrms LCUR/PORT2 0 to 7 Vrms Setting resolution: 3 digits or 1 μVrms, whichever is the largest. Processing: Buzzer alarm sound or, stopping of measurement (can be turned on/off)
Dynamic range	110 dB typ. (10 Hz to 1 MHz) 60 dB typ. (1 MHz to10 MHz) 50 dB typ. (10 MHz to 36 MHz) (The largest of the port inputs is 3 Vrms and measurement time setting 40 s or more)

DC BIAS OUTPUT

Connector	BNC connector (rear panel)
Setting range	–999 GV to +999 GV Limited to –5.00 × K V to +5.00 × K V by K (Measurement signal amplitude setting [Vrms] × 1.42) + |Normal DC bias setting [V]| ≤ 5.0 × |K| Setting resolution: 3 digits or 10 mV (K=1), whichever is the largest Accuracy: ±(|1% of normal DC bias setting [V]| + 30 mV)
Output Impedance	600 Ω (nominal value)

Measured Signal Control Section

Signal output control	
Measurement synchronous drive	SYNC (AC+DC): The measurement signal and DC bias are turned on at the start of measurement and turned off at the end of measurement. SYNC (AC): The measurement signal is turned on at the start of measurement and turned off at the end of measurement. The DC bias does not change. ASYNC: The measurement signal and DC bias are not changed at the start of measurement and end of measurement.
ON/OFF mode	QUICK: The measurement signal amplitude and DC bias changes immediately. SLOW: Output changes gradually over a period of approximately 10 seconds. 0° SYNC: This instrument waits until the measurement signal phase becomes 0° and then output turns off.
Frequency change mode	ASYNC: The frequency changes immediately. 0° SYNC: The frequency changes when the measurement signal phase becomes 0°.
Sweep	
Item	One of frequency, measurement signal amplitude, DC bias, and time (zero span)
Type	Either linear or log (frequency or amplitude only)
Control	SWEEP UP: Sweeps in the direction of lower limit to upper limit. SWEEP DOWN: Sweeps in the direction of upper limit to lower limit. SPOT: Measures with fixed frequency, measurement signal amplitude, and bias. REPEAT: Repeats SWEEP or SPOT when turns on.
Density	3 to 2,000 steps/sweep
Time	Frequency: From 0.5 ms/point, Measurement signal amplitude: From 2 ms/point DC bias: From 3 ms/point Zero span: From 0.5 ms/point

Measurement Accuracy

IMPD–3T

The conditions are that 0 to +40 °C, open and short correction was performed after warming up for at least 30 minutes.

Basic accuracy: ±0.08%

Measurement range Zr	Measurable range	Recommended range
1 MΩ	900 kΩ ≤	1 MΩ to 11 MΩ
100 kΩ	90 kΩ ≤	100 kΩ to 1.1 MΩ
10 kΩ	9 kΩ ≤	10 kΩ to 110 kΩ
1 kΩ	900 Ω ≤	1 kΩ to 11 kΩ
100 Ω	No limitation	9 Ω to 1.1 kΩ
10 Ω	≤ 10 Ω	1 Ω to 10 Ω

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

Recommended range: Operating range in which measurement accuracy is high.

Impedance measurement accuracy

Accuracy of \|Z\|: $\pm A_Z$ [%]

$$A_Z = \{(A+B\times U+K_{Z+}K_Y)\times K_V+K_B\}\times K_T$$

Accuracy of phase angle θ of impedance: $\pm P_Z$ [°]

when 10 kHz < f < 30 kHz and measurement range is 1 kΩ

$$P_Z = 0.573\times\{(1.5\times A+1.5\times B\times U+K_Z+K_Y)\times K_V+K_B\}\times K_T$$

when 10 kHz < f < 30 kHz and measurement range is 100 Ω

$$P_Z = 0.573\times\{(2\times A+2\times B\times U+K_Z+K_Y)\times K_V+K_B\}\times K_T$$

other than above $P_Z = 0.573\times A_Z$ f: Measurement frequency

Remark:

– The measurement accuracy when A_Z exceeds 10% is a supplementary value.

– Excluding the highest and lowest measurement ranges that can be used with that frequency, the measurement accuracy for a measured value smaller than half the lower limit of each recommended measurement range or larger than twice the upper limit is a supplementary value.

Each parameter value in the expression of A_Z and P_Z is listed below.

The meaning of the symbol used when calculating each parameter is shown below.

Zr: Measurement range [Ω]

Zx: Measurement value [Ω] of magnitude of impedance \|Z\|

U: Ratio coefficient

Zr	U
≥ 1 kΩ	|Zx / Zr – 1|
≤ 100 Ω	|Zr / Zx – 1|

A (upper row)**: Basic coefficient** [%]
B (lower row)**: Proportional coefficient** [%]
Measurement time setting is larger than (200 ms or (20/measurement frequency [Hz]) s) or more.

Measurement range Zr	Measurement frequency [Hz]			
	2 m < f ≤ 1 k	1 k < f < 30 k	30 k ≤ f ≤ 50 k	50 k < f ≤ 100 k
1 MΩ	1.50 2.00	0.80 0.60	— —	— —
100 kΩ	0.30 0.20	0.25 0.10	0.70 0.70	0.40 0.40
10 kΩ	0.15 0.03	0.14 0.02	0.15 0.06	0.20 0.03
1 kΩ	0.10 0.01	0.09 0.01	0.09 0.01	0.14 0.02
100 Ω	0.13 0.03	0.06 0.04	0.05 0.05	0.06 0.10
10 Ω	0.30 0.15	0.30 0.20	0.40 0.15	0.40 0.15

Measurement range Zr	Measurement frequency [Hz]			
	100 k < f ≤ 1 M	1 M < f ≤ 2 M	2 M < f ≤ 5 M	5 M < f ≤ 10 M
1 MΩ	— —	— —	— —	— —
100 kΩ	— —	— —	— —	— —
10 kΩ	0.20 0.03	0.80 0.30	— —	— —
1 kΩ	0.15 0.01	0.20 0.07	0.35 0.35	— —
100 Ω	0.15 0.03	0.15 0.05	0.20 0.20	0.30 0.40
10 Ω	0.40 1.20	0.50 2.00	1.50 5.00	— —

The measurement accuracy in the "—" column is not guaranteed.

Kz: Residual impedance coefficient [%]

Frequency range	Kz [%]
f ≤ 1 MHz	2/Zx [Ω]
1 MHz < f ≤ 10 MHz	f [kHz]×2×10^{-3}/Zx [Ω]

Kv: Residual admittancee coefficient [%]

Frequency range	Kv [%]
f < 30 kHz	Zx [Ω]/(1×10^{8})
30 kHz ≤ f ≤ 10 MHz	f [kHz]×Zx [Ω]/(3×10^{9})

Kv: Signal level coefficient
– When the measurement signal amplitude setting is less than 100 mVrms, the measurement accuracy is not guaranteed.
– When the signal level is set as a current, refer to Kv of the value calculated by measurement signal amplitude setting [Arms] × 71 as the signal level [Vrms].
Example) When the measurement signal amplitude setting is 2.1 mArms, refer to Kv of 2.1×10^{-3} × 71 = 149 m [Vrms].

Frequency ≤ 1 kHz

Measurement range Zr	Signal level [Vrms]					
	100 m ≤ V ≤ 300 m	300 m < V ≤ 500 m	500 m < V ≤ 800 m	800 m < V < 1.00	V = 1.00	1.00 < V ≤ 3.00
1 MΩ	5.0	2.5	2.0	1.0	1.0	1.0
100 kΩ	4.0	1.8	2.0	1.0	1.0	2.0
10 kΩ	3.0	1.5	1.5	1.0	1.0	2.5
1 kΩ	2.5	1.2	1.2	1.0	1.0	3.5
100 Ω	1.8	1.1	1.1	1.0	1.0	4.0
10 Ω	1.2	1.1	1.1	1.0	1.0	1.8

1 kHz < Frequency ≤ 30 kHz

Measurement range Zr	Signal level [Vrms]					
	100 m ≤ V ≤ 300 m	300 m < V ≤ 500 m	500 m < V ≤ 800 m	800 m < V < 1.00	V = 1.00	1.00 < V ≤ 3.00
1 MΩ	5.0	1.8	1.5	1.1	1.0	1.2
100 kΩ	3.5	1.5	1.5	1.1	1.0	2.0
10 kΩ	2.5	1.2	1.2	1.1	1.0	3.0
1 kΩ	2.0	1.2	1.1	1.1	1.0	4.5
100 Ω	2.5	1.2	1.5	1.1	1.0	6.5
10 Ω	1.1	1.1	1.1	1.1	1.0	2.0

30 kHz < Frequency ≤ 100 kHz

Measurement range Zr	Signal level [Vrms]					
	100 m ≤ V ≤ 300 m	300 m < V ≤ 500 m	500 m < V ≤ 800 m	800 m < V < 1.00	V = 1.00	1.00 < V ≤ 3.00
100 kΩ	8.0	2.5	1.8	1.1	1.0	2.0
10 kΩ	8.0	2.5	1.8	1.1	1.0	3.0
1 kΩ	6.5	2.0	1.5	1.1	1.0	5.0
100 Ω	6.0	2.0	2.0	1.1	1.0	7.0
10 Ω	1.2	1.1	1.2	1.1	1.0	1.8

100 kHz < Frequency ≤ 1 MHz

Measurement range Zr	Signal level [Vrms]					
	100 m ≤ V ≤ 300 m	300 m < V ≤ 500 m	500 m < V ≤ 800 m	800 m < V < 1.00	V = 1.00	1.00 < V ≤ 3.00
10 kΩ	5.0	1.8	1.5	1.0	1.0	3.0
1 kΩ	4.5	1.5	1.5	1.1	1.0	4.0
100 Ω	4.0	1.2	1.5	1.0	1.0	4.0
10 Ω	1.0	1.0	1.0	1.0	1.0	1.8

1 MHz < Frequency ≤ 2 MHz

Measurement range Zr	Signal level [Vrms]					
	100 m ≤ V ≤ 300 m	300 m < V ≤ 500 m	500 m < V ≤ 800 m	800 m < V < 1.00	V = 1.00	1.00 < V ≤ 3.00
10 kΩ	1.5	1.0	1.0	1.0	1.0	1.2
1 kΩ	1.5	1.0	1.0	1.0	1.0	3.0
100 Ω	2.0	1.0	1.2	1.0	1.0	4.0
10 Ω	1.0	1.0	1.0	1.0	1.0	1.2

2 MHz < Frequency ≤ 10 MHz

Measurement range Zr	Signal level [Vrms]					
	100 m ≤ V ≤ 300 m	300 m < V ≤ 500 m	500 m < V ≤ 800 m	800 m < V < 1.00	V = 1.00	1.00 < V ≤ 3.00
1 kΩ	1.0	1.0	1.0	1.0	1.0	2.0
100 Ω	1.5	1.0	1.0	1.0	1.0	2.0
10 Ω	1.0	1.0	1.0	1.0	1.0	1.0

KB: DC bias coefficient [%]
– When the normal DC bias setting is 0.00 V, KB = 0%.
– The KB [%] when the normal DC bias is output from the front panel HCUR/OSC is as shown in the table below. This is common for the voltage setting and current setting.

Measurement range Zr	Measurement frequency [Hz]		
	f ≤ 1 k	1 k < f ≤ 30 k	30 k < f ≤ 10 M
1 MΩ	5.0	2.0	—
100 kΩ	1.0	0.2	2.0
10 kΩ	0.2	0.1	0.2
1 kΩ	0.1	0.1	0.1
100 Ω	0.3	0.3	0.3
10 Ω	0.5	0.5	0.5

– The KB [%] when the HV DC bias is enabled is as shown in the table below.

Measurement range Zr	Measurement frequency [Hz]	
	1 k ≤ f < 30 k	30 k < f ≤ 10 M
1 MΩ	2.0	—
100 kΩ	0.5	2.0
10 kΩ	0.2	0.2
1 kΩ	0.2	0.2
100 Ω	0.5	0.5
10 Ω	0.5	0.5

KT: Temperature-dependent coefficient

Ambient temperature T[°C]	KT
0 to +18	1+k×(18–T)
+18 to +28	1
+28 to +40	1+k×(T–28)

k: Temperature coefficient

Measurement range Zr	Measurement frequency [Hz]			
	f < 30 k	30 k ≤ f ≤ 1 M	1 M < f ≤ 5 M	5 M < f ≤ 10 M
1 MΩ	0.04	—	—	—
100 kΩ	0.05	0.04	—	—
10 kΩ	0.05	0.04	0.04	—
1 kΩ	0.06	0.04	0.06	—
100 Ω	0.08	0.05	0.04	0.08
10 Ω	0.03	0.02	0.02	—

IMPD–2T

The conditions are that 23 ±5 °C, open and short correction was performed after warming up for at least 30 minutes.

Basic accuracy: ±0.32%

Measurement range Zr	Measurable range	Recommended range
1 kΩ	No limitation	90 Ω to 10 kΩ
100 Ω	≤ 110 Ω	9 Ω to 100 Ω
10 Ω	≤ 11 Ω	0.9 Ω to 10 Ω
1 Ω	≤ 1.1 Ω	0.09 Ω to 1 Ω

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

Recommended range: Operating range in which measurement accuracy is high.

Impedance measurement accuracy

Accuracy of |Z|: $\pm A_Z[\%]$ $A_Z = \{(A+B\times U+K_Z+K_Y)\times K_V+K_B\}\times K_T$

Accuracy of phase angle θ of impedance: $\pm P_Z$ [°] $P_Z = 0.573\times A_Z$

Remark: The measurement accuracy when A_Z exceeds 10% is a supplementary value.

Each parameter value in the expression of A_Z and P_Z is listed below.

The meaning of the symbol used when calculating each parameter is shown below.

Z_r: Measurement range [Ω] Z_X: Measurement value [Ω] of magnitude of impedance |Z|

U: Ratio coefficient

Zr	U
1 kΩ	Zx/Zr (however, 0.1 when Zx/Zr < 0.1)
Other than 1 kΩ	Zr/Zx (however, 1 when Zr/Zx < 1)

A (upper row)**: Basic coefficient** [%]
B (lower row)**: Proportional coefficient** [%]

Measurement time setting is larger than (200 ms or (20/measurement frequency [Hz]) s) or more.

Measurement range Zr	Measurement frequency [Hz]					
	2 m < f ≤ 1 k	1 k < f < 30 k	30 k ≤ f ≤ 100 k	100 k < f ≤ 1 M	1 M < f ≤ 10 M	10 M < f ≤ 36 M
1 kΩ	0.20 0.15	0.30 0.35	0.30 0.15	0.30 0.60	1.00 2.00	— —
100 Ω	0.30 0.03	0.30 0.02	0.30 0.02	0.30 0.02	1.00 0.15	3.00 0.30
10 Ω	0.20 0.40	0.20 0.30	0.20 0.20	0.20 0.30	1.50 1.00	— —
1 Ω	0.40 3.00	0.20 3.00	0.20 2.00	0.40 2.50	— —	— —

The measurement accuracy in the "—" column is not guaranteed.

K_Z: Residual impedance coefficient [%]

Frequency range	K_Z [%]
f ≤ 100 kHz	0.02/Zx [Ω]
100 kHz < f ≤ 36 MHz	f [kHz]×2×10⁻⁴/Zx [Ω]

K_Y: Residual admittancee coefficient [%]

Frequency range	K_Y [%]
f < 30 kHz	Zx [Ω]/(1×10⁶)
30 kHz ≤ f ≤ 1 MHz	f [kHz]×Zx [Ω]/(3×10⁶)
1 MHz < f ≤ 36 MHz	f [kHz]×Zx [Ω]/(2×10⁶)

K_V: Signal level coefficient

– When the signal level is less than 100 mV, the measurement accuracy is not guaranteed.
– When the signal level is set as a current, refer to Kv of the value calculated by measurement signal amplitude setting [Arms] × 50 as the signal level [Vrms].

Frequency < 30 kHz

Measurement range Zr	Signal level [Vrms]		
	100 m ≤ V ≤ 300 m	300 m < V ≤ 1.00	1.00 < V ≤ 3.00
1 kΩ	1.2	1.0	3.0
100 Ω	1.3	1.0	2.2
10 Ω	1.0	1.0	1.5
1 Ω	1.0	1.0	1.2

30 kHz ≤ Frequency ≤ 1 MHz

Measurement range Zr	Signal level [Vrms]				
	100 m ≤ V ≤ 300 m	300 m < V ≤ 500 m	500 m < V ≤ 800 m	800 m < V ≤ 1.00	1.00 < V ≤ 3.00
1 kΩ	1.5	1.0	1.1	1.0	2.5
100 Ω	1.6	1.0	1.1	1.0	2.2
10 Ω	1.5	1.0	1.0	1.0	2.0
1 Ω	1.2	1.0	1.0	1.0	1.2

1 MHz < Frequency

Measurement range Zr	Signal level [Vrms]				
	100 m ≤ V ≤ 300 m	300 m < V ≤ 500 m	500 m < V ≤ 800 m	800 m < V ≤ 1.00	1.00 < V ≤ 3.00
1 kΩ	1.5	1.0	1.1	1.0	1.1
100 Ω	1.6	1.0	1.1	1.0	1.2
10 Ω	1.5	1.0	1.0	1.0	1.0

K_B: DC bias coefficient [%]

– When the HV DC bias is enabled, K_B = 0.1%.
– The K_B [%] when the normal DC bias is output from the front panel PORT3 is as shown in the table below. This is common for the voltage setting and current setting.

Frequency range	normal DC bias	
	0 V	≠ 0 V
f ≤ 1 kHz	0.0	1.00
1 kHz < f	0.0	0.05

K_T: Temperature-dependent coefficient

Ambient temperature T[°C]	K_T	
	f ≤ 10 MHz	10 MHz < f
0 to +18	1+0.03×(18–T)	1+0.04×(18–T)
+18 to +28	1	1
+28 to +40	1+0.03×(T–28)	1+0.04×(T–28)

IMPD–EXT/G–PH

The conditions are that ambient temperature of 0 to +40 °C, within 12 hours since self-calibration was performed after warming up for at least 30 minutes, and ambient temperature variations are within ±5 °C after self-calibration. DUT drive amplifier gain setting K = +1.0 and input weighting factor is 1.0 for both PORT1 and PORT2.

Measurement accuracy: Relative accuracy + Calibration accuracy

Relative accuracy: ±(basic accuracy + dynamic accuracy + inter-range accuracy)

Calibration accuracy: Accuracy of external equipment connected to this instrument, such as a shunt resistance, probe, or calibration standard

Upper: Impedance Z (IMPD–EXT); Middle: Gain (G–PH); Lower: Phase

Basic accuracy

Measurement range [rms]	Measurement frequency [Hz]		
	f ≤ 1 M	1 M < f ≤ 10 M	10 M < f ≤ 36 M
7 V : 100 mV	0.12% 0.01 dB 0.06°	0.35% 0.03 dB 0.18°	1.20 % 0.10 dB 0.60°
50 mV : 10 mV	0.24% 0.02 dB 0.12°		

Conditions:
- Largest or more of measurement time setting 100 ms and (10 ÷ measurement frequency [Hz]) s
- Measurement range of 10 mVrms to 7 Vrms
- Both ports have the same measurement range.
- The Z, gain and phase errors when full-scale signal (max. 3 Vrms) input of themeasurement range.

Dynamic accuracy

Measurement range [rms]	Measurement frequency [Hz]		
	f ≤ 1 M	1 M < f ≤ 10 M	10 M < f ≤ 36 M
7 V : 100 mV	0.24% 0.02 dB 0.12°	0.35% 0.03 dB 0.18°	1.20% 0.10 dB 0.60°
50 mV : 10 mV	1.20% 0.10 dB 0.60°		

Conditions:
- Largest or more of measurement time setting 100 ms and (10 ÷ measurement frequency [Hz]) s
- Measurement range of 10 mVrms to 7 Vrms
- Both ports have the same measurement range.
- The Z, gain and phase variation for when the signal level changes from full-scale (max. 3 Vrms) of measurement range to 3/10. The input signal is 1:1 or 1:0.3 between port.

Inter-range accuracy

Measurement range [rms]	Measurement frequency [Hz]		
	f ≤ 1 M	1 M < f ≤ 10 M	10 M < f ≤ 36 M
7 V	0.24% 0.02 dB 0.12°	0.35% 0.03 dB 0.18°	1.40% 0.12 dB 0.72°
5 V			
2 V			
1 V			1.20% 0.10 dB 0.60°
500 mV			
200 mV			
100 mV			
50 mV			
20 mV			
10 mV	0.35% 0.03 dB 0.18°		

Conditions:
- Largest or more of measurement time setting 100 ms and (10 ÷ measurement frequency [Hz]) s
- Measurement range of 10 mVrms to 7 Vrms
- Z, gain and phase errors when difference of the measurement ranges of both port is one and the input signal levels are the same for both ports (full scale level of smallest measurement range, max. 3 Vrms).

Measurement Accuracy of Measurement Parameters Other Than Z and θ

Measurement Modes: IMPD–EXT, IMPD–3T and IMPD–2T

Calculate the measurement accuracy from the impedance measurement accuracy as follows.
Here, Q_X is the measurement value of Q, D_X is the measurement value of D, and θ_X is the measurement value of θ. It is also acceptable to calculate the θ_X used for the accuracy calculation by either $(90° - \tan^{-1}|1/Q_X|)$ or $(90° - \tan^{-1}|D_X|)$.

Parameter	Measurement accuracy (supplementary value)
|Y|, εs, μs	±Az [%]
Lp, Ls, X, εs′, μs′	±Az [%] (|Qx| ≥ 10), ±Az/sinθx [%] (|Qx| < 10)
Cp, Cs, B	±Az [%] (|Dx| ≤ 0.1), ±Az/sinθx [%] (|Dx| > 0.1)
Rp, Rs, G, εs″ μs″	±Az [%] (|Qx| ≤ 0.1), ±Az/cosθx [%] (|Qx| > 0.1)
Q	±Q_x^2 × Pe / (1–|Qx| × Pe) (|Qx| ≥ 10 or |Qx| × Pe ≤ 0.1) Here, phase angle error Pe [rad] = Pz [°] / 57.3. The measurement accuracy of Q is the actual value and not the % value.
D	±(Pz [°] / 57.3) (|Dx| ≤ 0.1) The measurement accuracy of D is the actual value and not the % value.

Measurement Accuracy of Measurement Parameters Other Than Gain and θ

Measurement Modes: G–PH

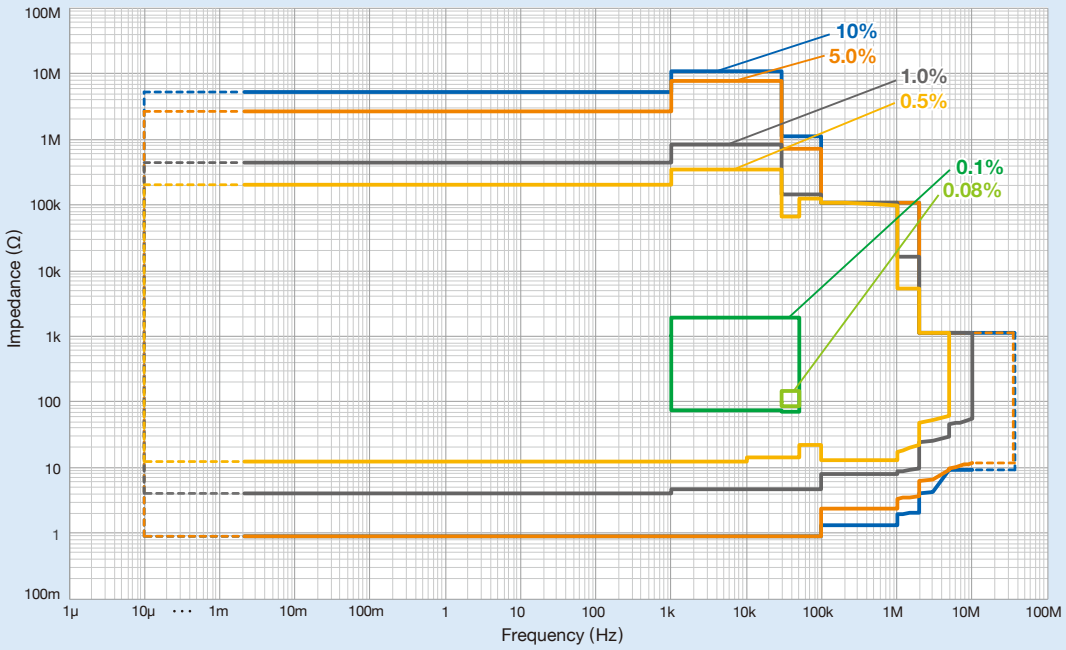
Calculate the measurement accuracy from the phase measurement accuracy as follows.
Here, P_G is the measurement accuracy [°] of θ.

Parameter	Measurement accuracy (supplementary value)
GD	$\pm\frac{P_G}{360 \times APT}$ [s] Here, APT is the aperture frequency (Δf [Hz]), and is aperture setting*1 × sweep measurement frequency interval.

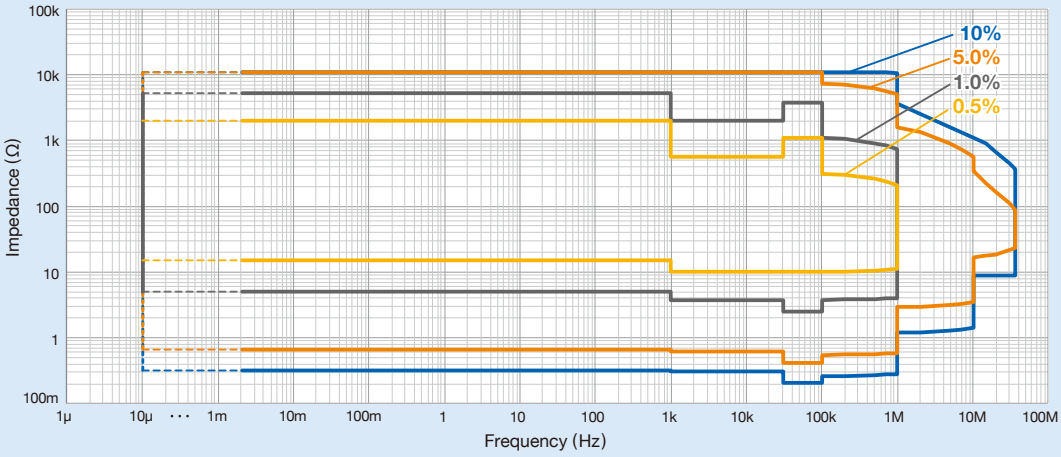
*1: "Aperture setting" is a parameter that is set in this instrument for group delay (GD) measurement.

Measurement accuracy

IMPD-3T
(Reference values below 2 mHz and above 10MHz)



IMPD-2T
(Reference values below 2 mHz)



Measurement Processing Section

Measurement time setting	Setting of time required for one measurement (in the case of sweep measurement, the setting of the measurement time of not the entire sweep but of each point). Measurement results are averaged within the range not exceeding the set time and the influence of noise isv reduced. Setting range; 0 ms to 9,990 s Setting resolution: 3 digits or 0.1 ms, whichever is the largest
Measurement delay function	This function delays the start of measurement after the sweep parameters are changed. Setting range: 0 to 9,990 s Setting resolution: 3 digits or 0.1 ms, whichever is the largest
Measurement start delay function	This function delays the start of measurement only when sweeping starts. Setting range 0 to 9,990 s or MANual Setting resolution: 3 digits or 0.1 ms, whichever is the largest
Automatic high density sweep (slow sweep)	When there is a sudden change in the measurement data during frequency sweep measurement, this function performs measurement by automatically increasing the frequency sweep density in the regions before and after that point. <IMPD–EXT, IMPD–3T and IMPD–2T> Z: 1 a to 999 GΩ, setting resolution 3 digits or 1 aΩ, whichever is the largest Y: 1 a to 999 GS, setting resolution 3 digits or 1 aS, whichever is the largest θ: 0.001 to 179.999°, setting resolution 0.001° <G–PH> Gain: Linear 1 a to 999 G, setting resolution 3 digits or 1 a, whichever is the largest Log 0.001 to 999.999 dB, setting resolution 0.001 dB θ: 0.001 to 179.999°, setting resolution 0.001°
Sequence measurement function	This function performs measurements according to the contents of setting memory (condition file). UP SWEEP: The first up sweep is performed over the sweep range set in condition file number 1, the next up sweep is performed over the range set in condition file number 2, and so on continuously up to the upper limit condition file number. DOWN SWEEP: The first down sweep is performed over the range set in the upper limit condition file number, the next down sweep is performed over the range set in the next condition file number down (upper limit condition file number minus 1), and so on continuously down to condition file number 1. Upper limit condition file number: 1 to 32 Setting resolution: 1
Resonant frequency tracking function	This function automatically keeps the measurement frequency tracked to the resonance frequency of the DUT.
Equivalent circuit estimation function	Estimate each constant of the equivalent circuits from the frequency sweep measurement results. (IMPD–EXT, IMPD–3T and IMPD–2T)
Piezoelectric constant calculation function	Calculates the piezoelectric related constants from the frequency sweep measurement results. Piezoelectric constant calculation: Calculates the piezoelectric constants,piezoelectric parameters, resonant frequency, etc. Simulation: Calculates and displays the admittance characteristics from the piezoelectric parameters. (IMPD–EXT, IMPD–3T and IMPD–2T)
Comparator	SPOT: measurement results Max. 14 bins SWEEP: measurement results upper limit and lower limit comparison Number of comparison settings: 1 to 20
Discharge protection	Protection tolerance: 2 J or less (voltage is 100 V or less)
Error correction function	<IMPD–EXT, IMPD–3T and IMPD–2T> Open correction: Corrects the stray admittance. Short correction: Corrects the residual impedance. Load correction: Corrects the voltage-current conversion coefficient of the measurement system. Load standard value: Standard values can be entered for up to 30 frequency points. Port extension: Corrects the error due to phase delay in cables for 2-terminal measurements. Characteristic impedance: 1.00 to 999 Ω, setting resolution 3 digits Electrical length: 0.000 to 999.999 m, setting resolution 0.001 m
(Error correction function contunued)	Slope compensation: <IMPD–EXT> This function performs analysis that is unaffected by the DC level for signals that have a composited DC level that varies linearly over time. It is used when measuring the impedance of batteries during charging and discharging. Equalizing: <G–PH> This function acquires the characteristics of only the EUT by measuring the frequency characteristics of the measurement system (sensors, cables, etc.) in advance and then eliminating the error components of the measurement system when actual measurements are taken later. Self-calibration: <IMPD–EXT and G–PH> This function measures and corrects the measurement errors that arise within this instrument itself.

Display Section

Display unit	8.4-inch color TFT-LCD (SVGA) with touch panel
Graphs	Bode plot, Nyquist plot, Cole-cole plot
Graph display styles	SINGLE: One graph is displayed on the LCD. SPLIT: Two graphs are displayed, one above the other.
Graph axis setting	The X, Y1, and Y2 axis can each be set to Lin/Log individually.
Graph traces	9 traces of measurement data (MEAS) and reference data (REF 1 to 8)
Auto scaling	This function automatically optimizes the graph display scale.(on or off)
Marker display	Markers are displayed on a graph, and the data at a marker position is displayed as a numerical value.
Marker search function Search items	Max, Min: Search for the maximum and minimum values. Peak, Bottom: Search for the peak (maximal) and bottom (minimal) values. Next Peak: Search for the next peak. Next Bottom: Search for the next bottom. Prev Peak: Search for the previous peak. Prev Bottom: Search for the previous bottom. Value: Search for the marker value. Δ Value: Search for the difference between the reference marker and search marker values. X Value: Search for the sweep parameter. BW1: Display the passband gain and cutoff frequency. BW2: Display the center frequency and pass bandwidth. BW3: Display the notch frequency and notch bandwidth. *A search can be performed automatically at the end of sweep measurement.

Memory

Measurement conditions	32 sets (per measurement mode)
Measurement data (MEAS)	Data from sweep measurement Up to 32 sets of data can be saved to the internal storage of this instrument.
Reference data (REF)	Data (up to 8 sets) that can be displayed on a graph together with measurement data (MEAS) This can be measurement data or data copied from a USB memory device. The display can be turned on or off.
Error correction data	Open correction, short correction, load correction, open correction at port extension tip, short correction at port extension tip, load correction at port extension tip, equalizing (each 32 sets)

External Memory

Media	USB memory device
Connector	Front panel, USB-A connector
File system	FAT
Saved items	Setting conditions, measurement data (MEAS) and reference data (REF 1 to 8), equivalent circuit estimation results, piezoelectric constant calculation results, and marker information
File format	CSV format
Screen capture function	A screen capture of the LCD screen can be saved to a USB memory device.

External Input/Output Function

Interface	GPIB: Standards conformance; IEEE488.1 and IEEE488.2 USB: USB 2.0 High Speed LAN: 10/100 Base-T RS–232: Baud rate 4800 to 230400 bps
External monitor	For connecting a projector or external monitor, etc. Connector: VGA connector (mini D-sub 15-pin, female) Signal: 800×600 dot (SVGA), analog RGB component video signal
Reference clock input	Frequency: Within 10 MHz ±100 ppm Input waveform: Sinusoidal or square Input voltage: 0.5 V_{p-p} to 5 V_{p-p} Input impedance: 300 Ω (nominal value), AC coupling
Reference clock output	Frequency: 10 MHz ±10 ppm (when using internal reference clock) Output waveform: 1 V_{p-p}/50 Ω, square waveform Output impedance: 50 Ω (nominal value), AC coupling
Handler interface	(This can be used in Measurement modes IMPD-EXT, IMPD-3T and IMPD-2T.) All I/O signals are optically isolated (withstand voltage ±42 V) Input signal: Trigger, setting condition file number Output signal: Sorting results BIN1 to BIN14
Expansion connector	AUX connector

Miscellaneous Specifications

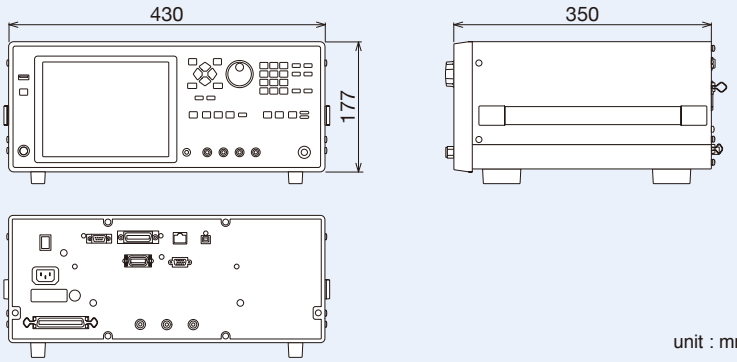
Power input	Voltage: AC 100 V to 230 V ±10 %, however 250 V or less Frequency: 50 Hz/60 Hz ±2 Hz, Power consumption: Max. 100 VA Overvoltage category II
Environmental conditions	Operation 0 to +40 °C, 5 to 85% RH (However, absolute humidity 1 to 25 g/m^3, no condensation)
External dimensions	430 (W) × 177 (H) × 350 (D) mm (excluding protruding parts)
Weight	Approx. 7.0 kg
Safety, EMC	EN61010-1, EN61010-2-030 EN61326-1 (Group1, ClassA), EN61326-2-1
RoHS Directive	Directive 2011/65/EU
Warm-up time	At least 30 minutes
Calibration cycle	1 year
Accessories	Instruction Manual (Basics, Advanced and Remote Control), Power cord set (with 3-pin plug, 2 m) × 1, CALIBRATION BOX × 1, 100 Ω RESISTOR × 1

CALIBRATION BOX

100 Ω RESISTOR

Note: available as option

Dimensions



unit : mm

Note: The contents of this catalog are current as of Dec. 20th, 2019
- Products appearance and specificaitons are subject to change without notice.
- Before purchase contact us to confirm the latest specifications, price and delivery date.

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