LS3300 AC power calibrator
Technical Information

Contents

1. Introduction

This document mainly provides the characteristic data about items that are not specified in the specifications of the LS3300.
From the nature of the data, please consider the measurement results described in this document to be reference values.
For the specifications guaranteed by the LS3300, please refer to the specifications described in the catalog and the user's manual.
The data included in this document is measured at the reference temperature (23 ℃ ± 3 ℃) unless otherwise noted. The measurement instruments used for creation of this document are as follows:

Measurement instrument	Model	Manufacturer
AC Power Calibrator	LS3300	YOKOGAWA
Precision Power Analyzer	WT3000E	YOKOGAWA
AC/DC Current Sensor	CT200	YOKOGAWA
AC/DC Current Sensor	CT1000	YOKOGAWA
Mixed Signal Oscilloscope	DLM2054	YOKOGAWA
Universal Counter	TC110	YOKOGAWA
Reference Multi Meter	8508A	FLUKE
Phase Meter	6000A	Clarke-Hess

The current transformation ratio of the CT200 and the CT1000 is 1000:1 and 1500:1, respectively.
The LS3300 is set as follows unless otherwise noted:
Wiring = 1P2W
Oscillation = INT
Lo to Earth = ON

2-1-1. Stability of voltage and current

Overview

This is the fluctuation of the output error of a representative range when the LS3300 is connected to the power meter WT3000E.
The period of the plotted data is one hour from one minute after the output is turned on.

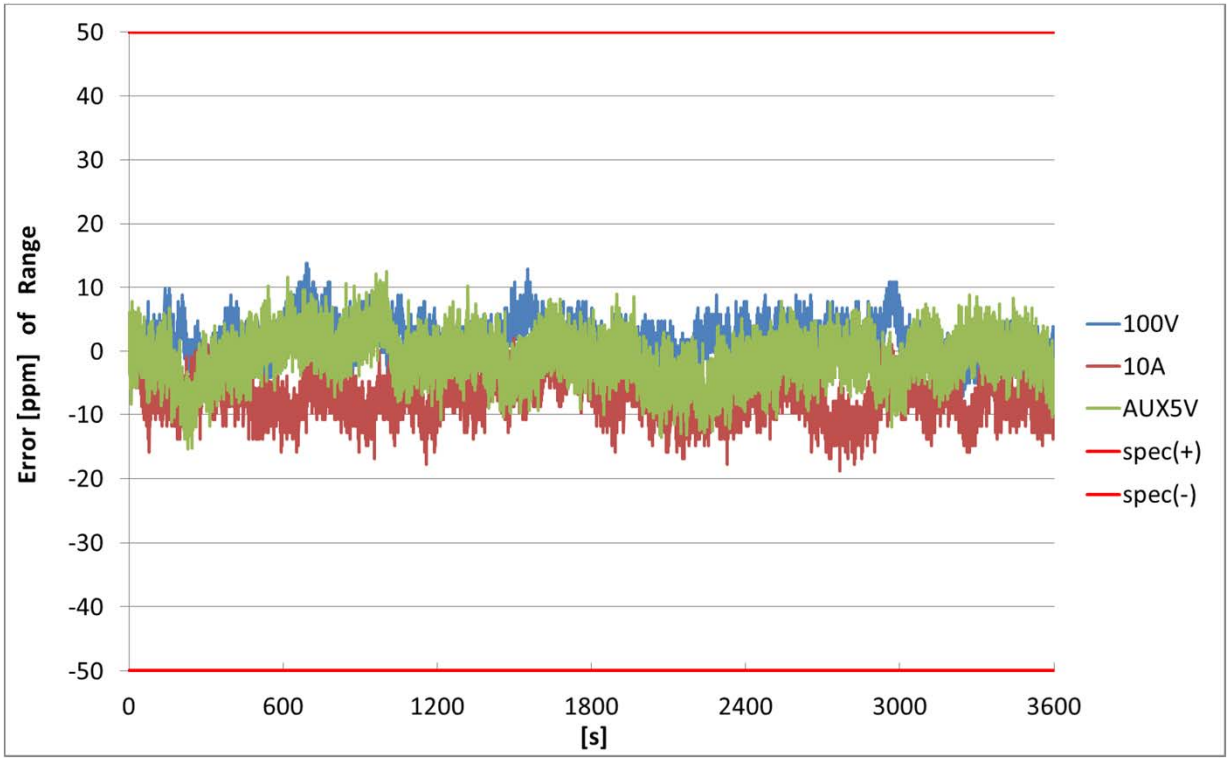
Used device

Power Meter WT3000E

Device settings

WT3000E Update rate = 500 ms
LS3300 Range = 100 V, 10 A, AUX 5 V
Output setting value = 100% of each range
Frequency = 60 Hz

Measurement result



2-1-2. Stability of large current output

Overview

This is the fluctuation of the output error of the 50 A range when the LS3300 is connected to the power meter WT3000E through the CT200. The period of the plotted data is one hour from one minute after the output is turned on.

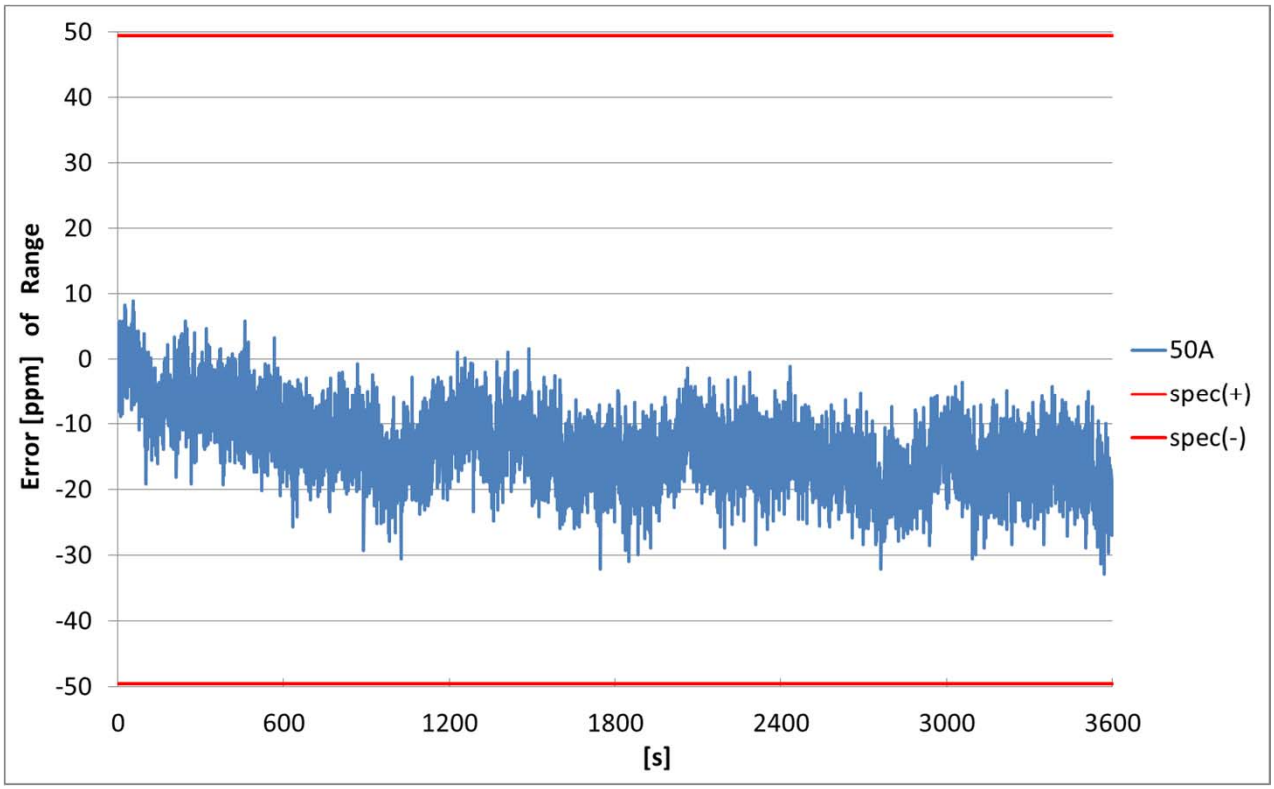
Used device

Power Meter WT3000E
Current Sensor CT200

Device settings

WT3000E Update rate = 500 ms
LS3300 Range = 50 A
Output setting value = 100% of each range
Frequency = 60Hz

Measurement result



2-1-3. Power stability (1)

Overview

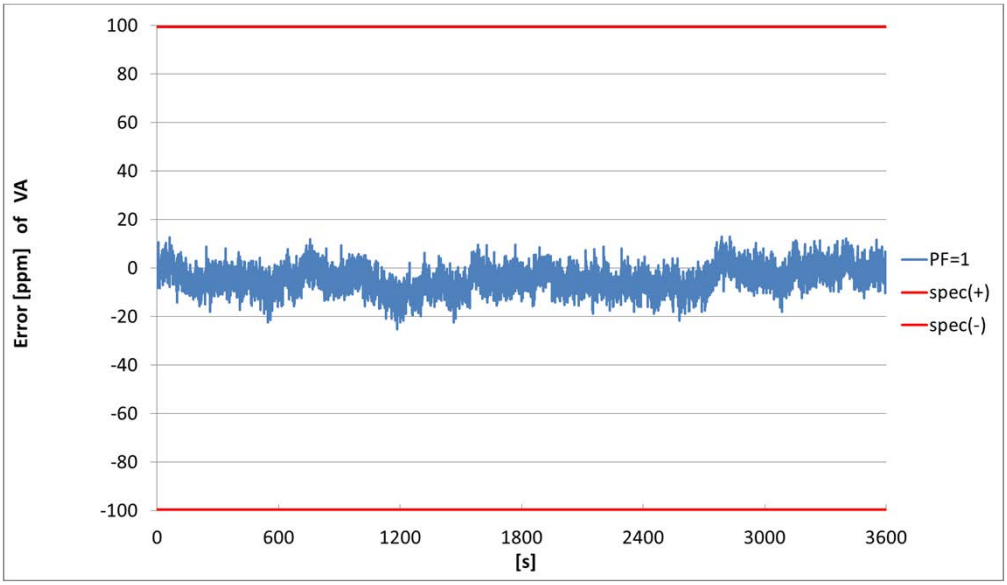
This is the fluctuation of the output error at the phase angle setting of power factor(λ)=0 or 1 when the LS3300 is connected to the power meter WT3000E and outputs 500 VA.
The period of the plotted data is one hour from one minute after the output is turned on.

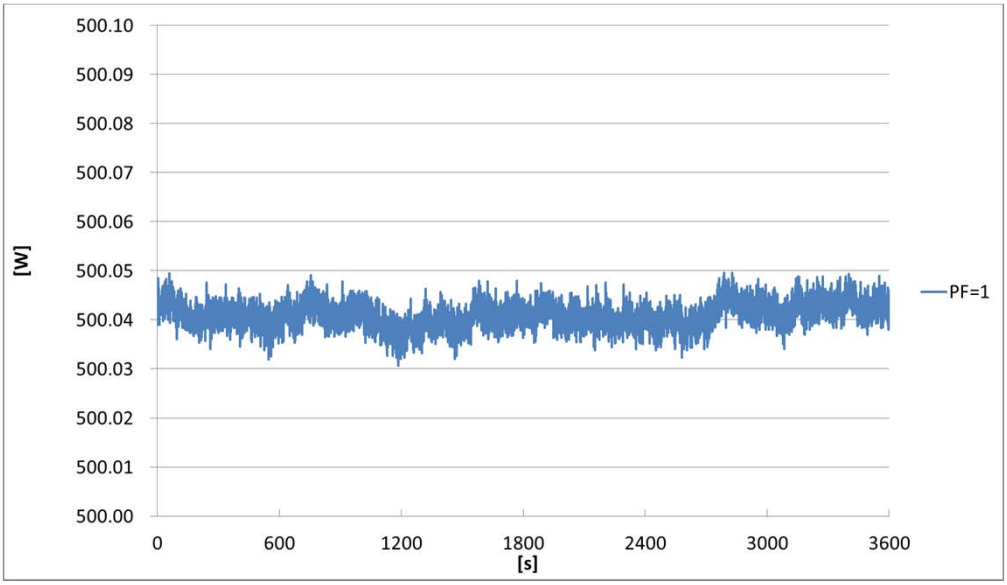
Used device

Power Meter WT3000E

2-1-3. Power stability (2)

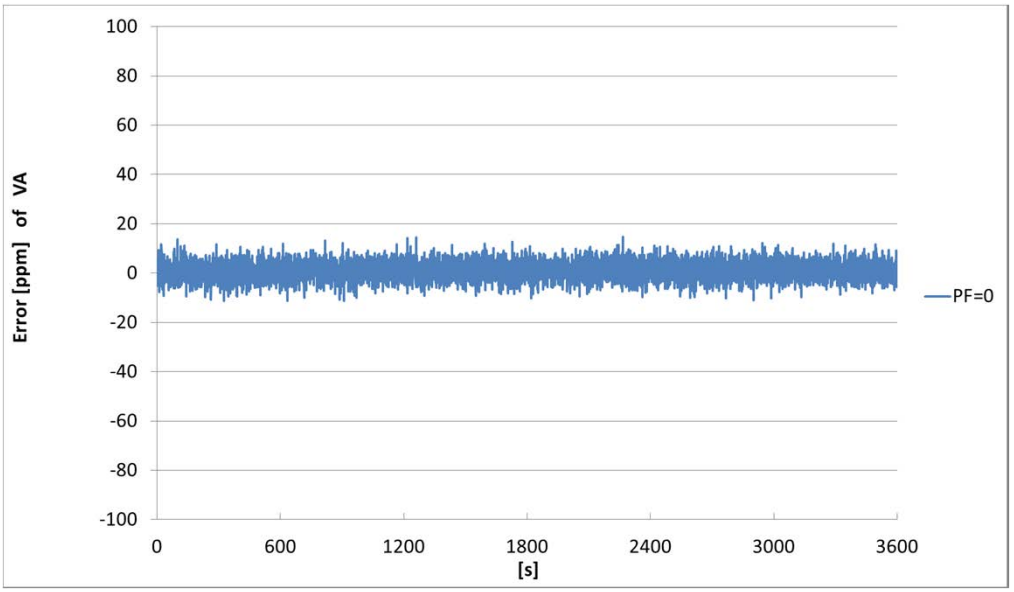
- **Device settings**
  - **WT3000E Voltage range = 100 V, Current range = 5 A**
    Update rate = 500 ms
  - **LS3300 Range = 100 V, 10 A**
    Output setting value = 100 V, 5 A
    Frequency = 60 Hz
- **Measurement result**
  - **PF= 1**

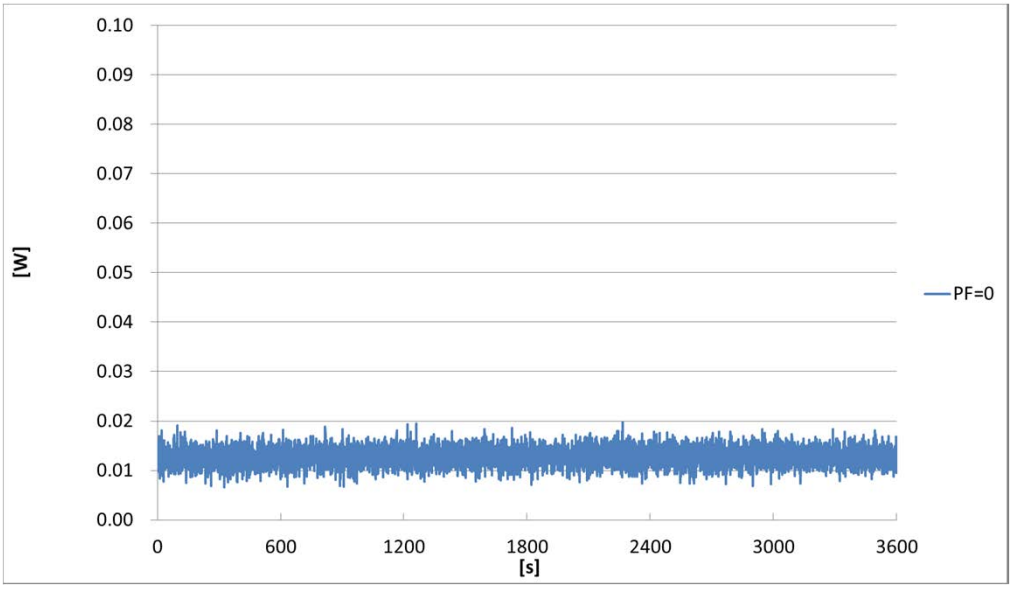




2-1-3. Power stability (3)

- **Device settings**
  - **WT3000E Voltage range = 100 V, Current range = 5 A**
    Update rate = 500 ms
  - **LS3300 Range = 100 V, 10 A**
    Output setting value = 100 V, 5A
    Frequency = 60 Hz
- **Measurement result**
  - **PF= 0**





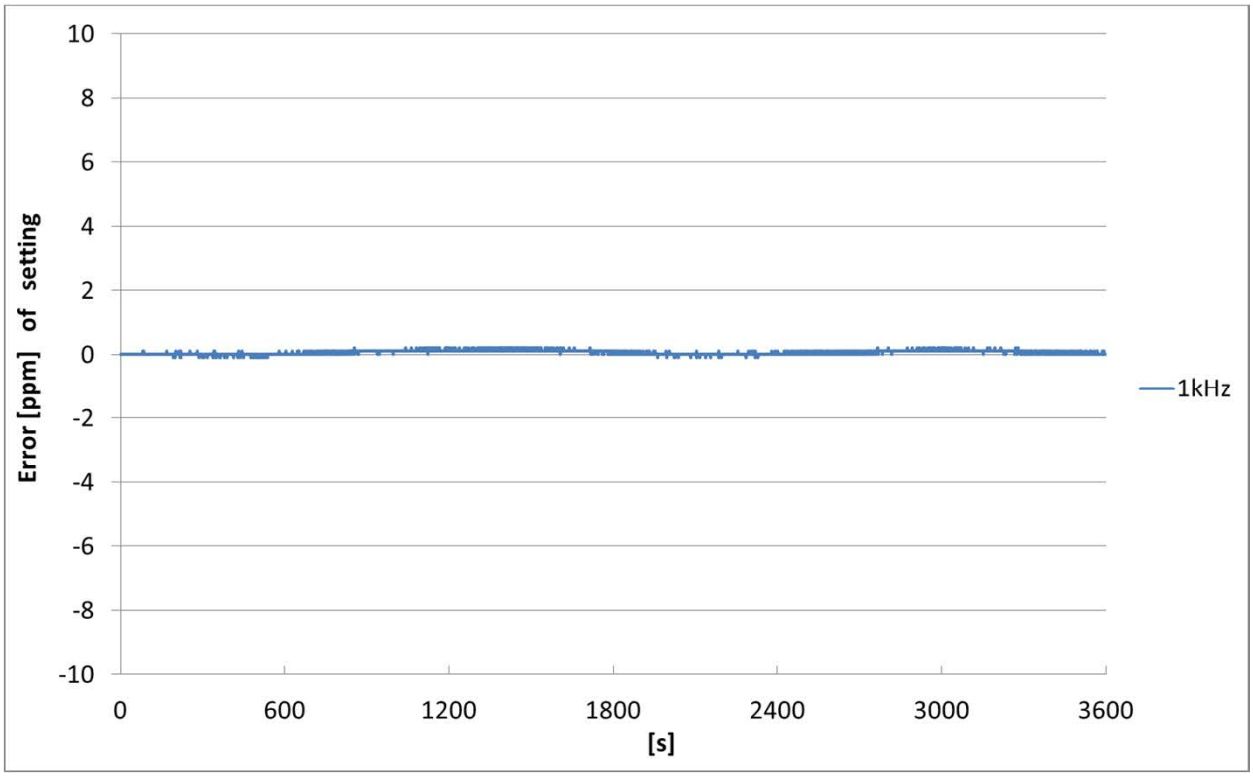
2-1-4. Frequency stability

- **Overview**
  This is the fluctuation of the frequency error of a representative range when the LS3300 is connected to the TC110.
  The period of the plotted data is one hour from one minute after the output is turned on.

- **Used device**
  Universal Counter TC110

- **Device settings**
  TC110 CH = A
  FILT ON
  LS3300 Range = 10 V
  Output setting value = 100% of each range
  Frequency = 1 kHz

- **Measurement result**



2-1-5. Phase stability (1)

Overview

This is the fluctuation of the phase at the phase angle setting of power factor(λ)=0 when the LS3300 is connected to the power meter WT3000E and outputs 100 V/10 A and 100 V/AUX 5 V.
The period of the plotted data is one hour from one minute after the output is turned on.

Used device

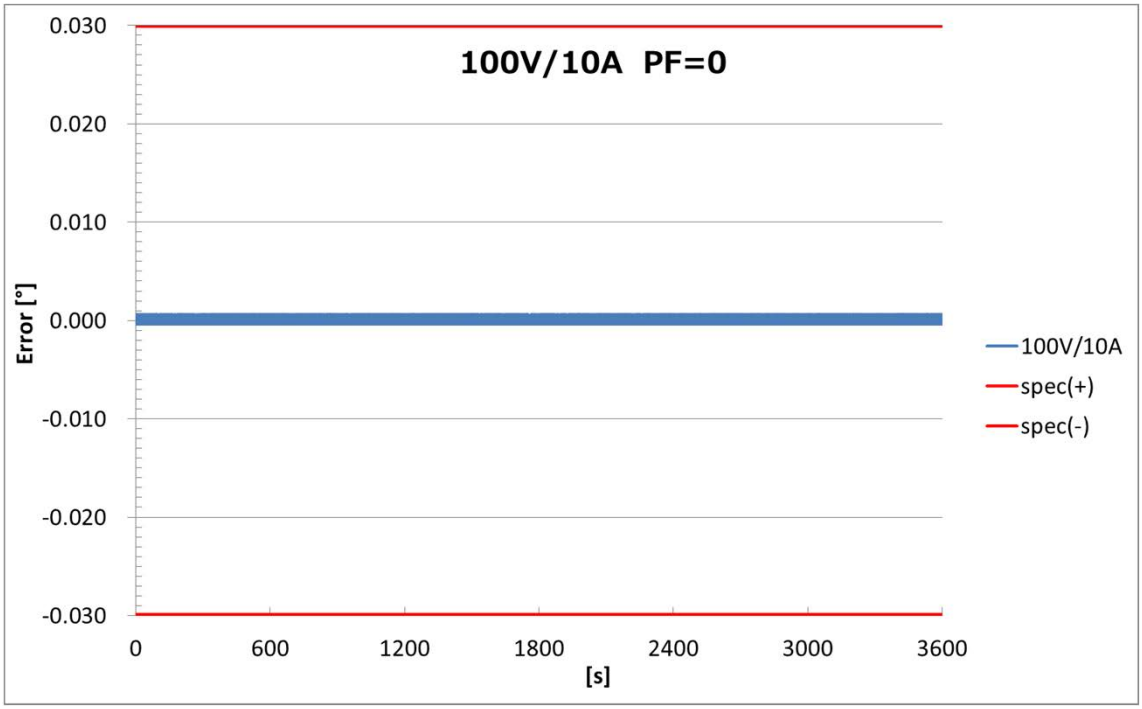
Power Meter WT3000E

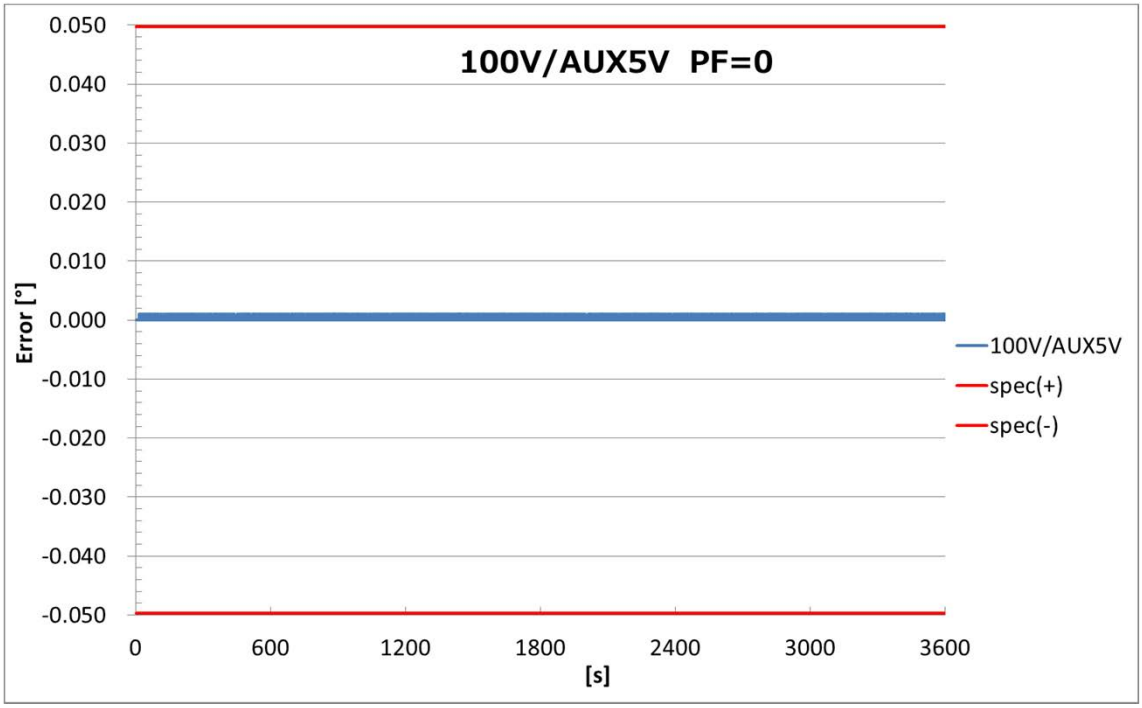
Device settings

WT3000E Voltage range = 100 V, Current range = 10 A, EXT 5 V
Update rate = 500ms
LS3300 Range = 100 V, 10 A, AUX 5 V
Output setting value = 100 V, 10 A, AUX 5 V
Frequency = 60Hz
Power factor = 0

2-1-5. Phase stability (2)

- **Measurement result**





2-1-5. Phase stability (3)

Overview

This is the fluctuation of the phase between the devices when two LS3300s are connected to the 6000A and output 100V.
The period of the plotted data is one hour from one minute after the output is turned on.

Used device

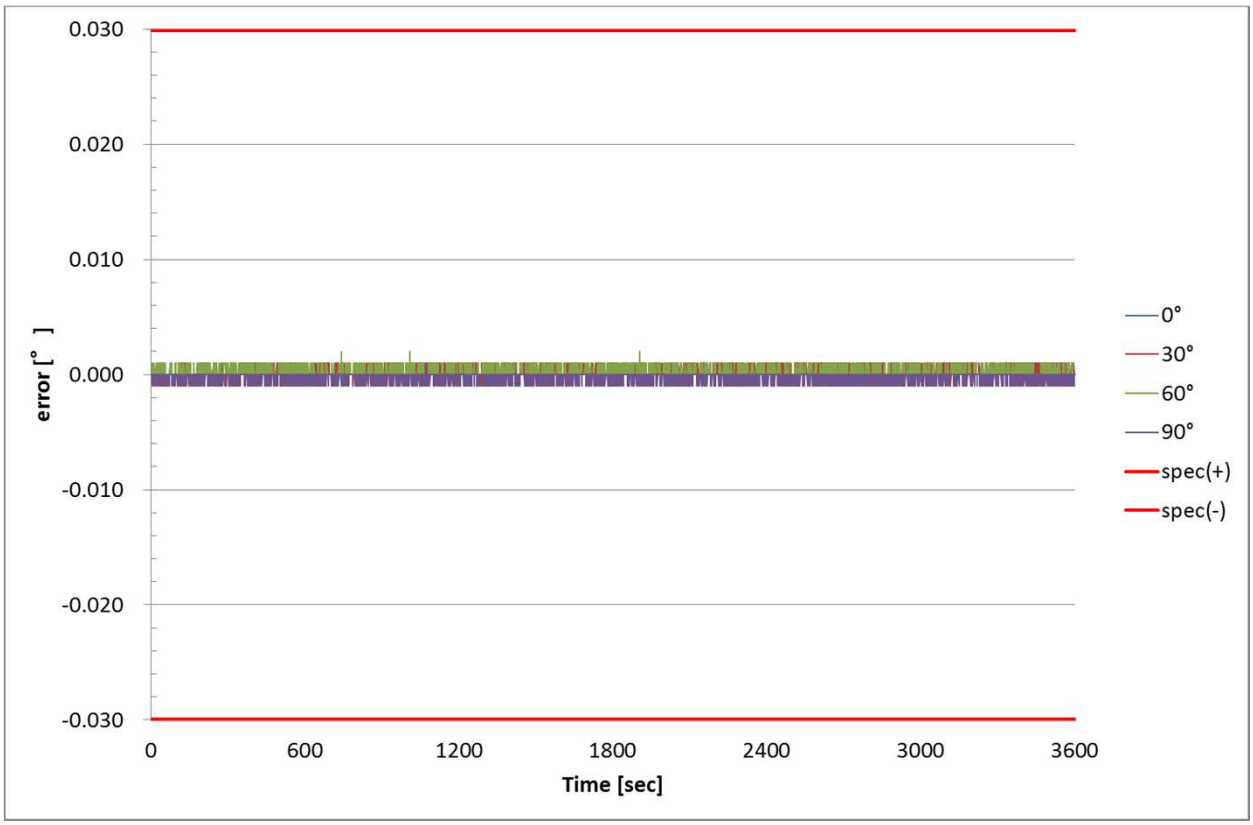
Phase Meter Clarke-Hess 6000A

Device settings

LS3300

Master & Slave	Range = 100 V, Output setting value = 100% setting, Wiring system = 1P2W
Master	Reference signal = INT, Frequency = 60 Hz, Phase = 0°
Slave	Reference signal = EXT, Phase = 0°,30°, 60°, 90°

Measurement result



2-2. Frequency characteristic

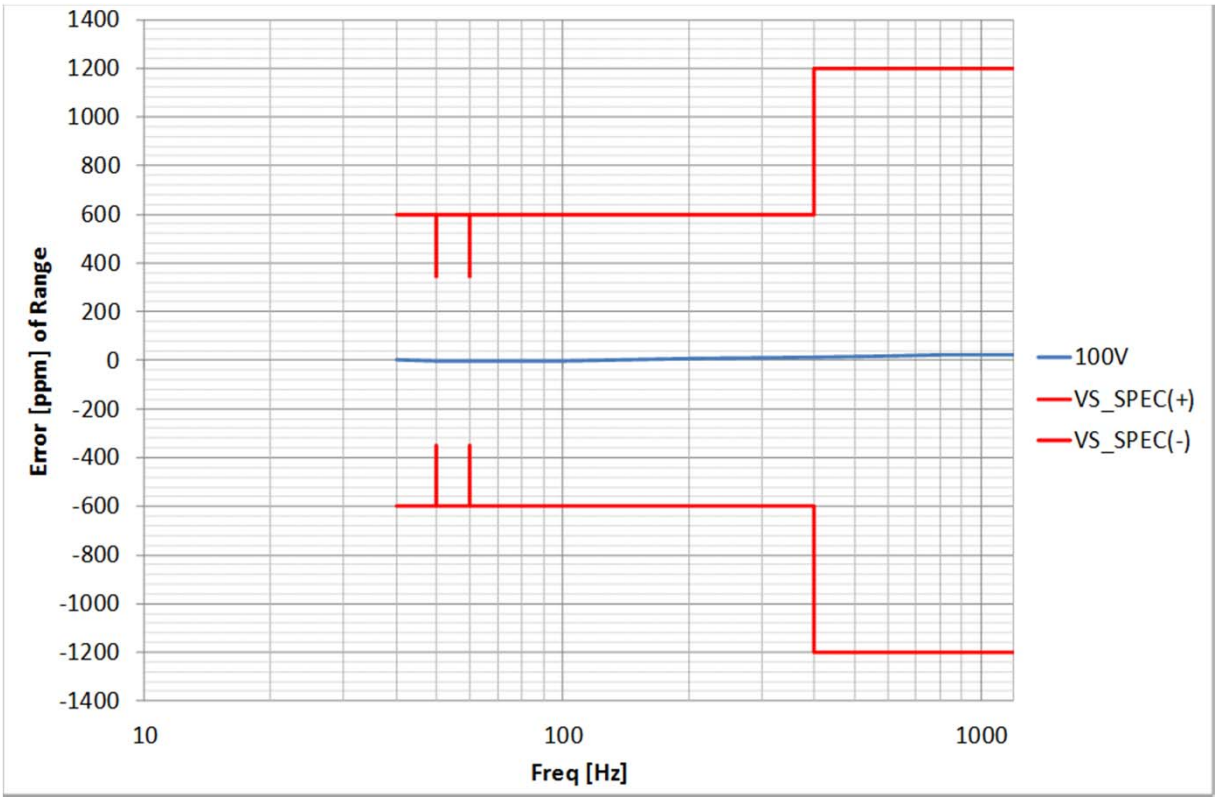
- **Overview**
  This is the frequency characteristic of LS3300's output accuracy.
  The output errors of each frequency are plotted.

- **Used device**
  Power Meter WT3000E

- **Device settings**
  WT3000E Update rate = 500 ms
  LS3300 No load (direct connection to the power meter)
  Range = 100 V, 10 A, AUX 5 V
  Output setting value = 100% of each range
  Wiring system = 1P2W
  Reference signal = INT
  Frequency = 40, 50, 60, 100, 200, 400, 600, 800, 1000, 1200 Hz

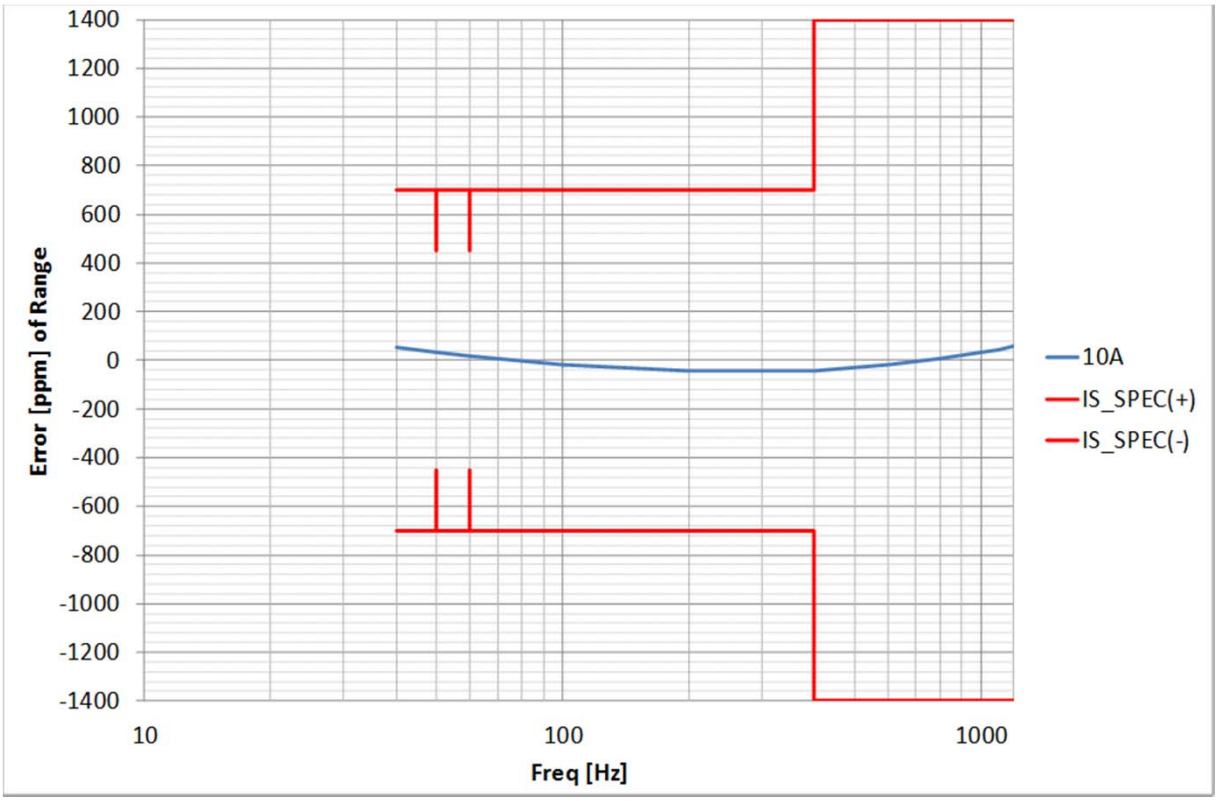
2-2-1. Frequency characteristic (Voltage)

Measurement result



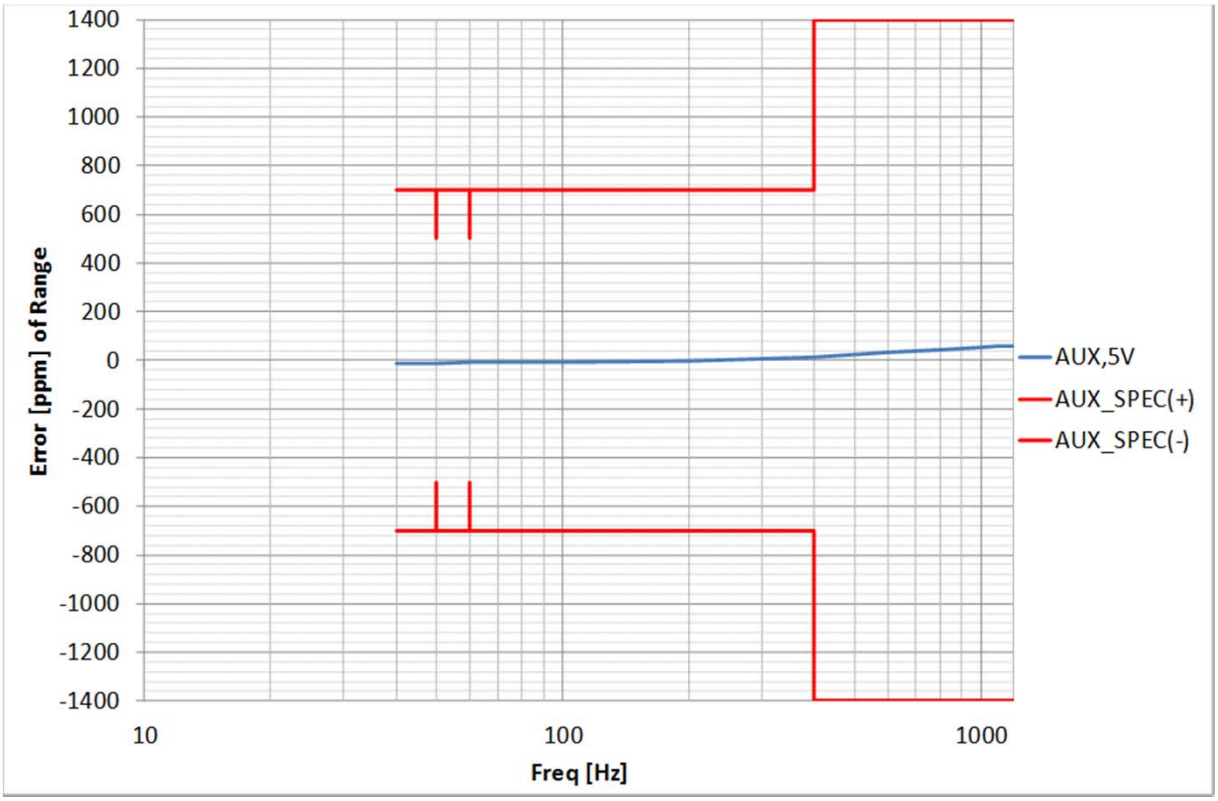
2-2-2. Frequency characteristic (Current)

Measurement result



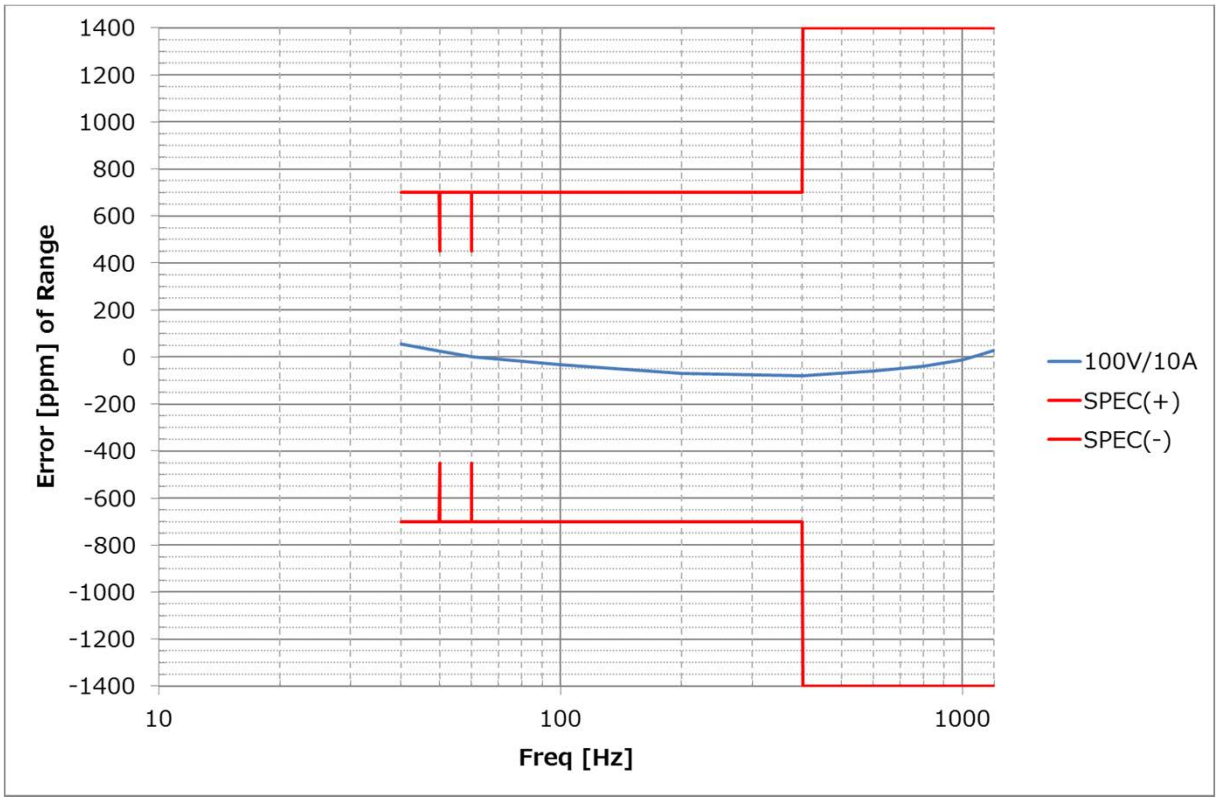
2-2-3. Frequency characteristic (AUX)

Measurement result



2-2-4. Frequency characteristic (Power)

Measurement result



2-2-4. Frequency characteristic (Phase)

Overview

This is the frequency characteristic of phase error between the devices when two LS3300s are connected to the 6000A and output 100V.

The plotted data is the average of 10 measurements.

Used device

Phase Meter Clarke-Hess 6000A

Device settings

LS3300

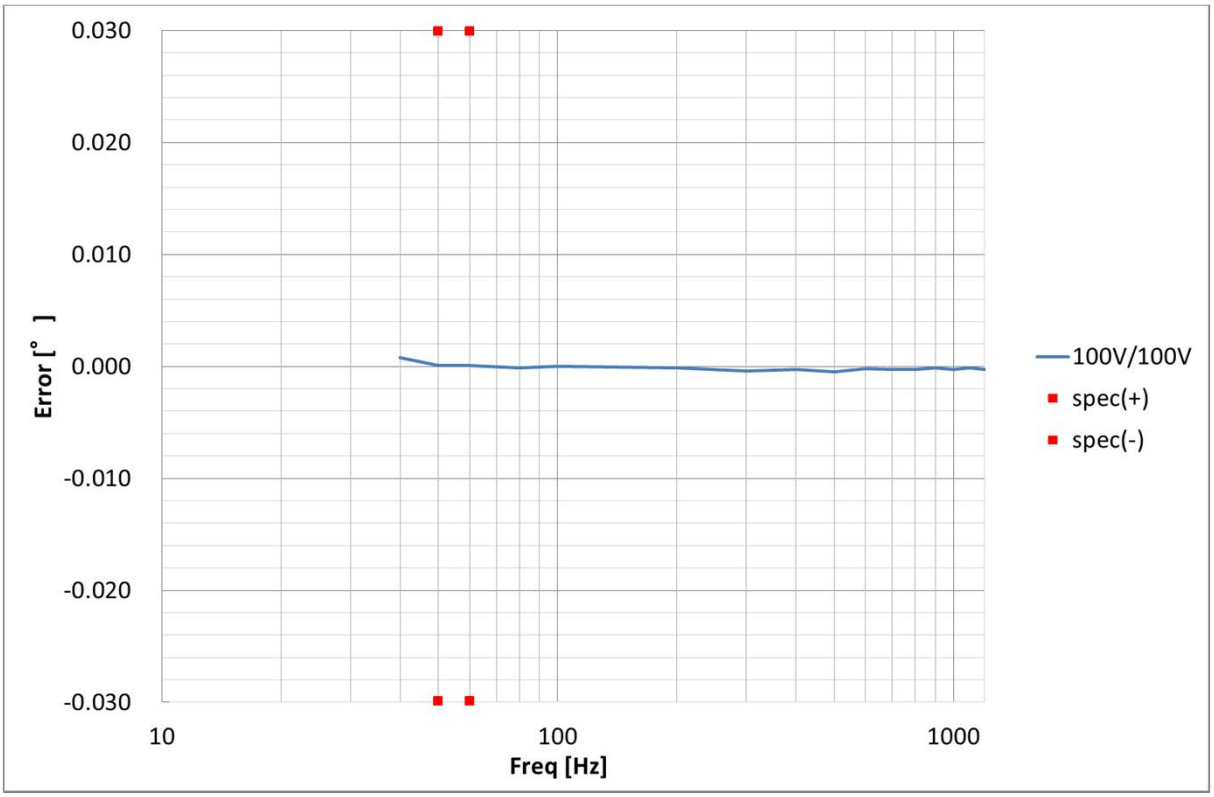
Master & Slave Range = 100 V, Output setting value = 100% setting, Wiring system = 1P2W

Master Reference signal = INT
Frequency = 40, 50, 60, 100, 200, 400, 600, 800, 1000, 1200 Hz
Phase = 0°

Slave Reference signal = EXT, Phase = 0°

Specs
50/60 Hz : ±0.03°
40 to 400 Hz : ±0.10°
400 to 1.2 Hz : ±0.40°

Measurement result



2-3. Linearity (1)

Overview

This is the relationship between a specified value and the output error of a representative range.
It also shows the measurement result by the Fluke8508A regarding the voltage range.
For measurement by the WT3000E and the Fluke8508A, an optimum range is used according to the output value of the LS3300.

Used device

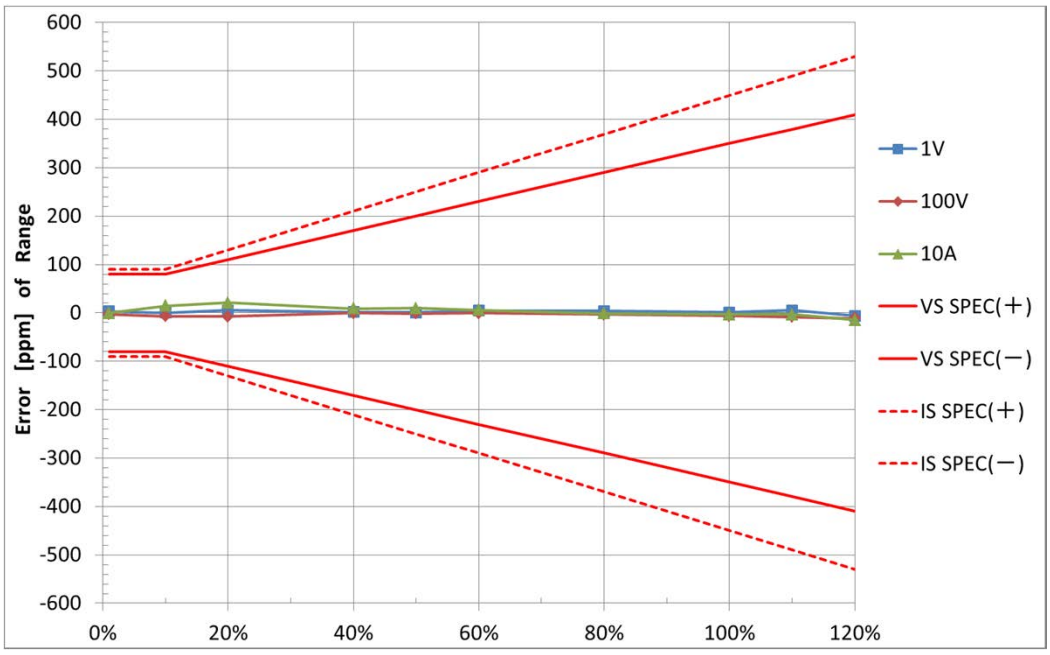
Power Meter WT3000E
Multi Meter Fluke8508A

Device settings

WT3000E Update rate = 500 ms
LS3300 No load (direct connection to the power meter)
Range = 1 V, 100 V, 10 A
Output setting value = 1, 10, 20, 40, 50, 60, 80, 100, 120% of each range
Frequency = 60Hz

Measurement result

➢ Measurement by the WT3000E



2-3. Linearity (2)

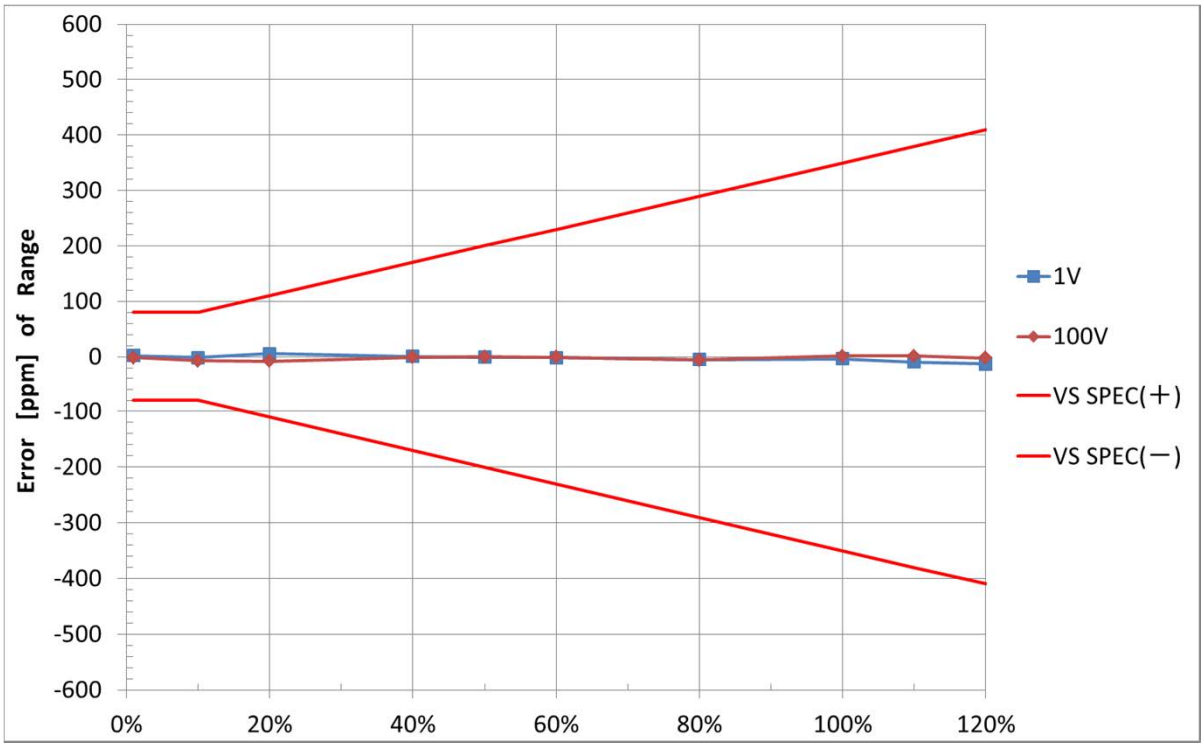
- **Device settings**

  LS3300 Range = 1 V, 100 V
  Output setting value = 1, 10, 20, 40, 50, 60, 80, 100, 120% of each range
  Frequency = 60 Hz

  8508A ACV Filter = 40 Hz
  ACV Resolution = 6

- **Measurement result**

  - **Measurement by the Fluke8508A**



2-4. Distortion rate (1)

Overview

This is the LS3300's distortion rate of a representative range (Measurement values by the WT3000E, Uthd and Ithd).

Used device

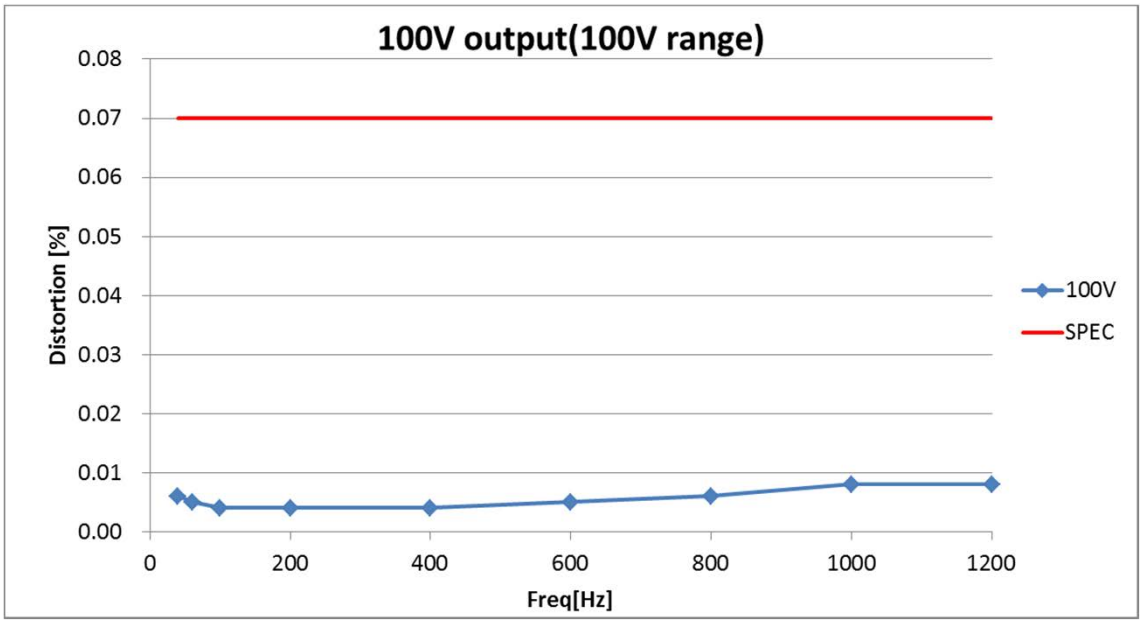
Power Meter WT3000E

Device settings

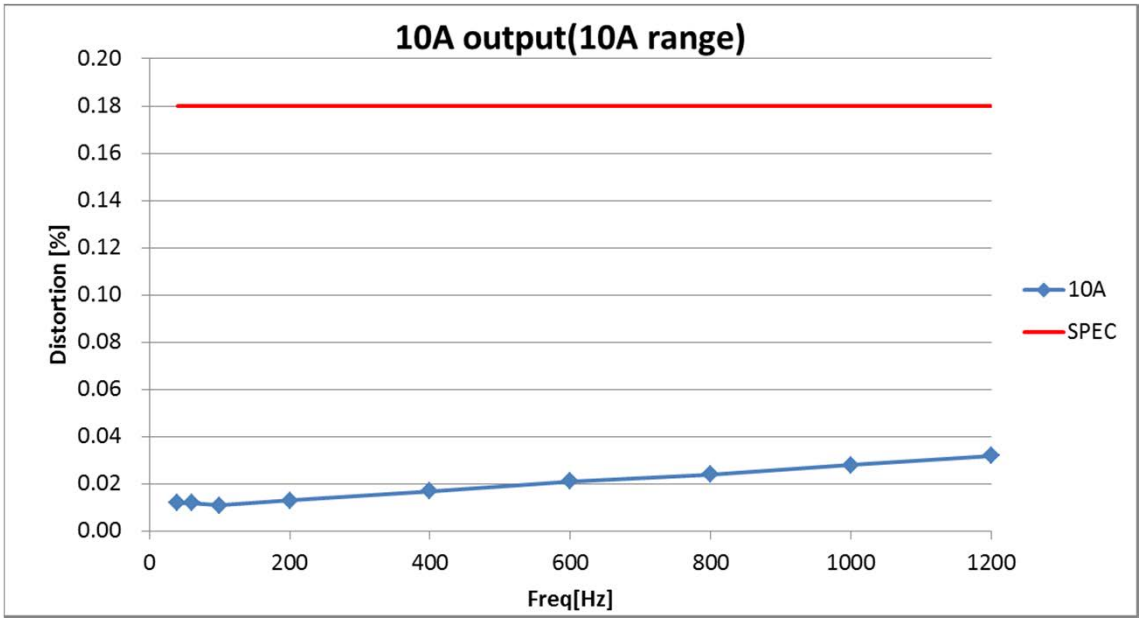
WT3000E Measurement mode = Wide-band harmonic measurement mode
Measurement order = 0 to 100
Arithmetic expression of distortion rate = 1/Fundamental

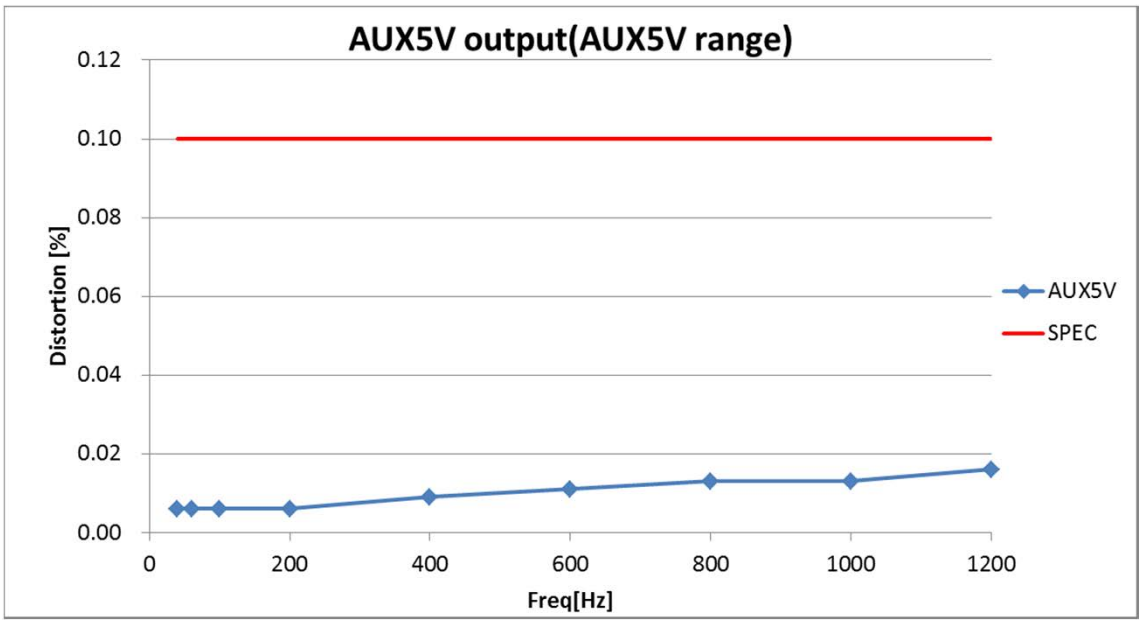
LS3300 No load (direct connection to the power meter)
Range = 100 V, 10 A, AUX 5 V
Output setting value = 100% of each range
Frequency = 40, 60, 100, 200, 400, 600, 800, 1000, 1200 Hz

Measurement result



2-4. Distortion rate (2)





2-5. Output noise (1)

Overview

This is the waveforms of output noise observed by the oscilloscope DLM2054 when the setting value of a representative range in the LS3300 is set at 0.

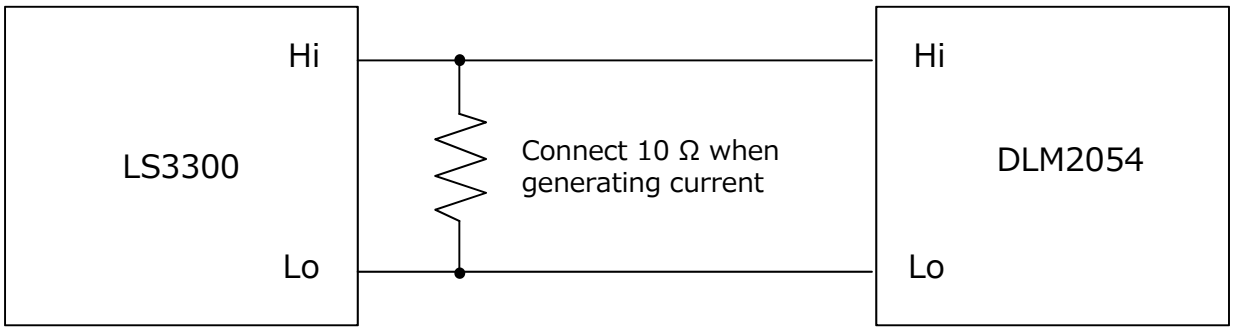
Used device

Oscilloscope DLM2054
Banana-BNC Cable, Alligator-BNC Cable (50 Ω, 1 m)

Device settings

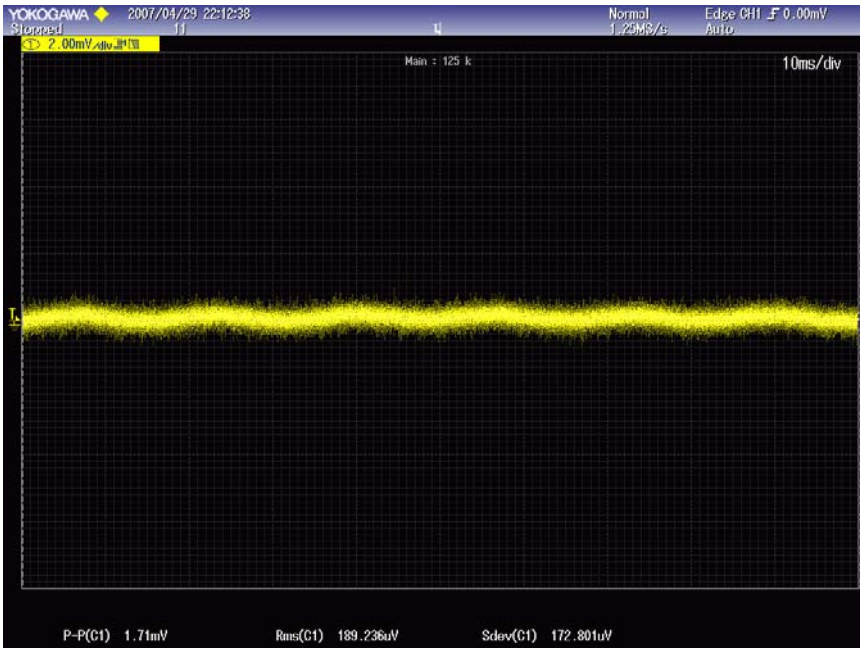
DLM2054	Vertical axis = 2 mV/div
	Horizontal axis = 10 ms/div
	Probe = 1:1
	Coupling = DC 1 MΩ
	Bandwidth = 1 MHz
	Acquisition Length = 125 k
LS3300	Range = 10 V, 1 A (10 Ω load), AUX 500 mV
	Output setting value = 0% of each setting
	Frequency = 60 Hz

Connection diagram



2-5. Output noise (2)

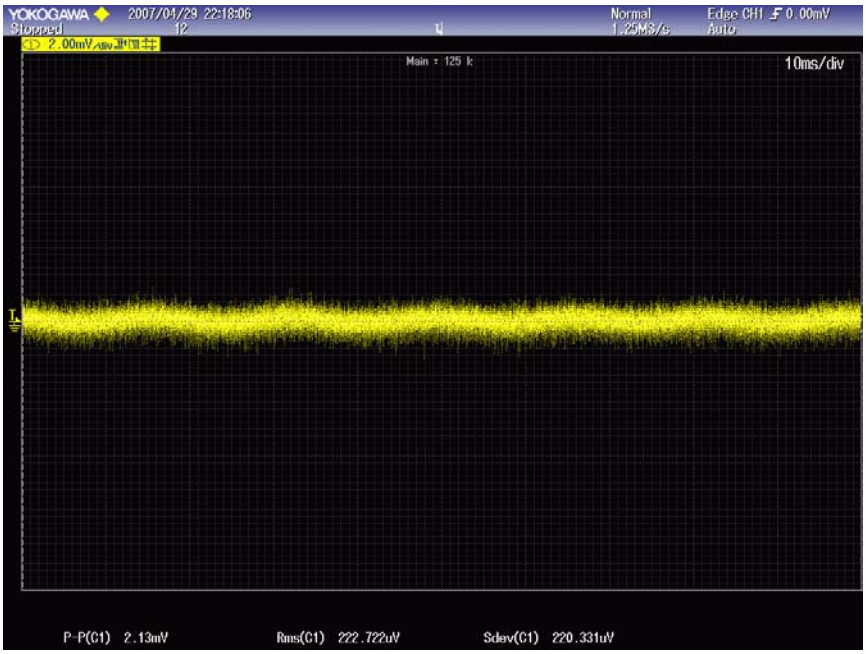
Measurement result



0 V output (10 V Range)

2.00 mV/div
10 ms/div

P-P(C1) 1.7 mV
Rms(C1) 189.2 uV
Sdev(C1) 172.8 uV



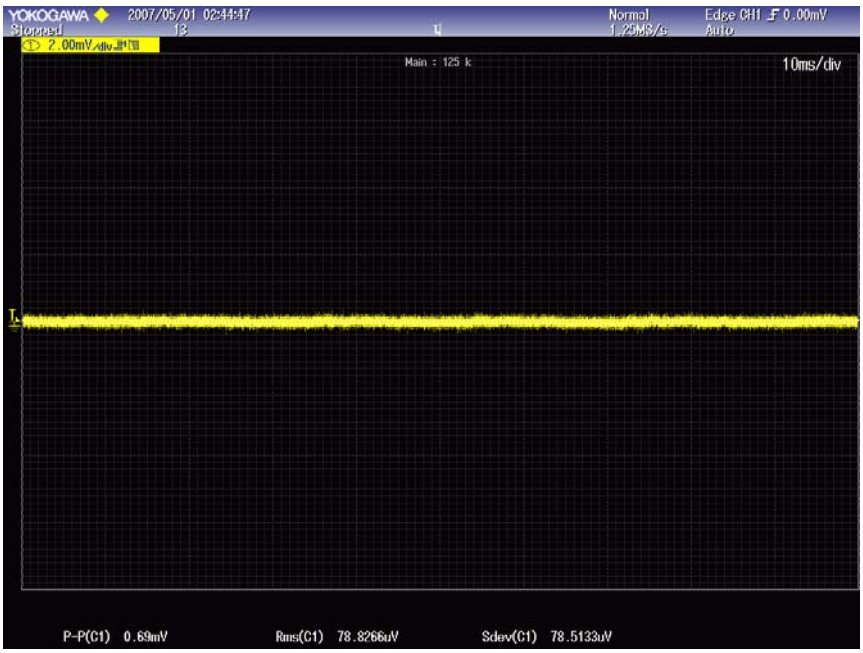
0 A output (1 A Range)
10 Ω load is connected

200 uA/div
10 ms/div

P-P(C1) 213 uA
Rms(C1) 22.3 uA
Sdev(C1) 22.0 uA

2-5. Output noise (3)

Measurement result

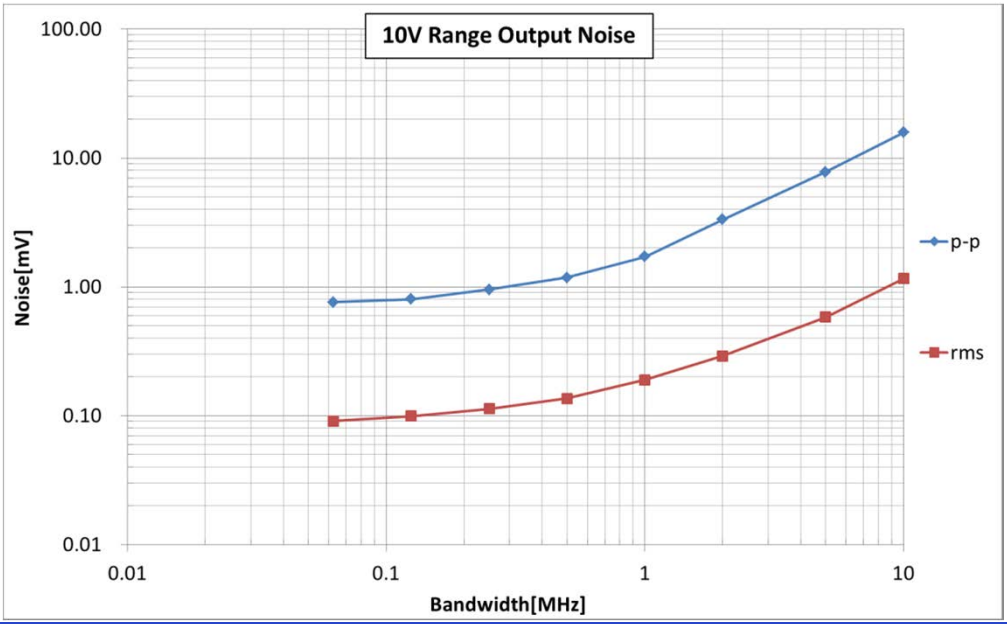


2.00 mV/div
10 ms/div

P-P(C1) 0.7 mV
Rms(C1) 78.8 uV
Sdev(C1) 78.5 uV

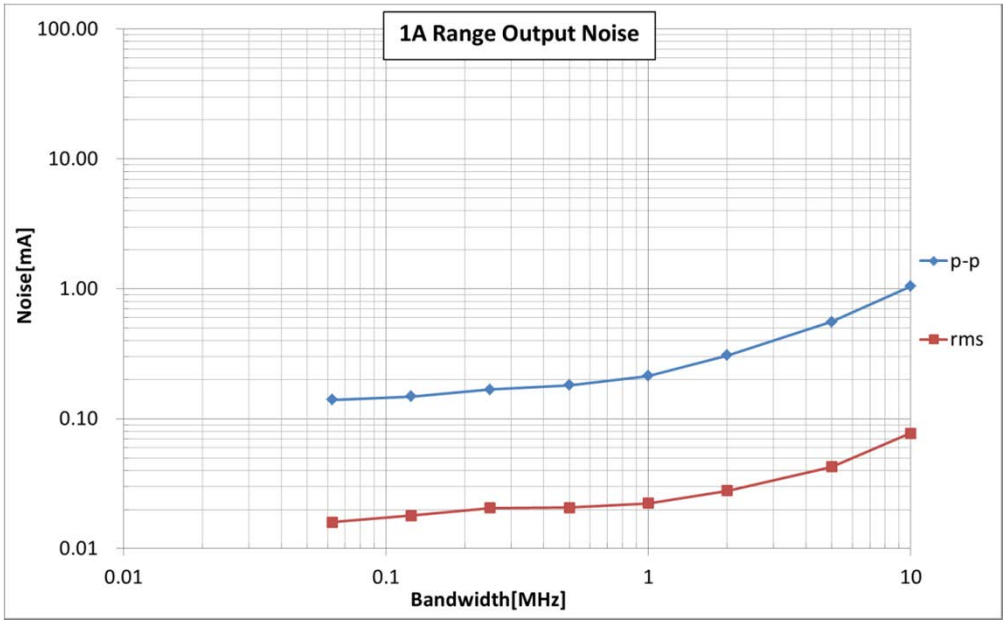
0 mV output (AUX 500 mV Range)

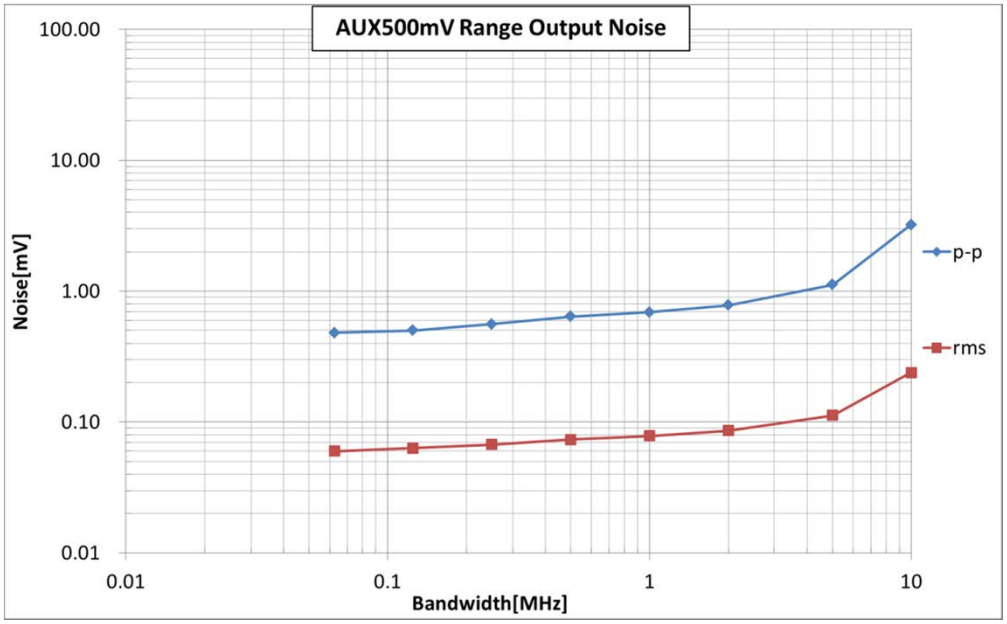
- **Fluctuations in the p-p and rms values of noise according to the change of bandwidth**
  The following graph is the measurement result of the p-p and rms values of noise changing the bandwidth of the DLM2054.
  Bandwidth = 62.5 kHz, 125 kHz, 250 kHz, 500 kHz,
  1 MHz, 2 MHz, 5 MHz, 10 MHz



2-5. Output noise (4)

- **Fluctuations in the p-p and rms values of noise according to the change of bandwidth**





2-6. Output response (1)

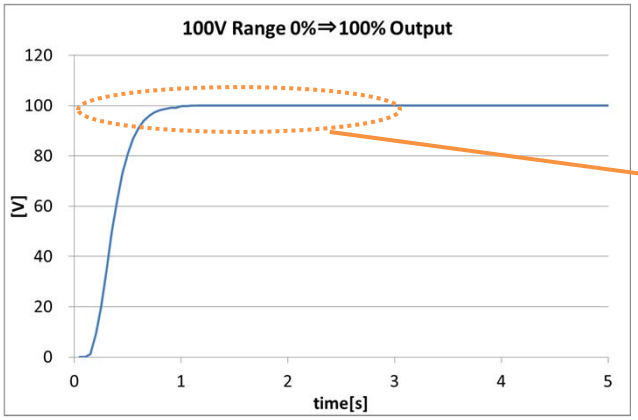
Overview
This is the output response of the LS3300 observed by the WT and a oscilloscope.

Used device
Power Meter WT3000E
Oscilloscope DLM2054

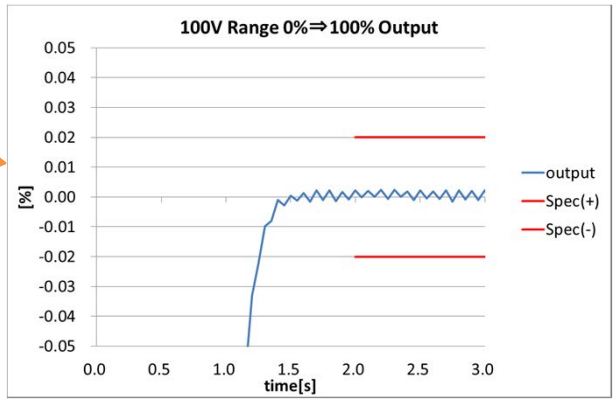
Device settings
WT3000E	Update rate = 50 ms
DLM2054	Horizontal axis = 200 ms/div
	Coupling = DC 1 MΩ
	Bandwidth = 1 MHz
	Acquisition Length = 125 k
LS3300	Range = 100 V, 10 A, AUX 5 V
	Output setting value = 100% of each range
	Frequency = 60 Hz

Measurement result (WT3000E)

0 to 100% output of 100 V range



Scope of ±0.05% of final value (100 V)

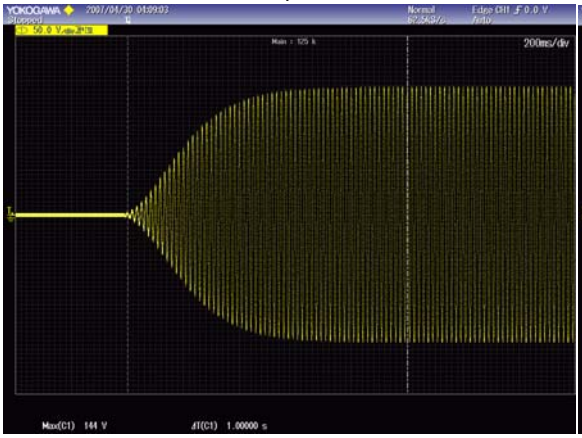


2-6. Output response (2)

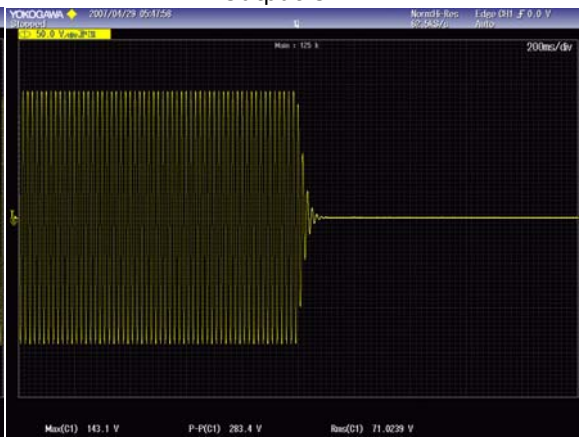
Measurement result (DLM2054)

100 V range

Output ON



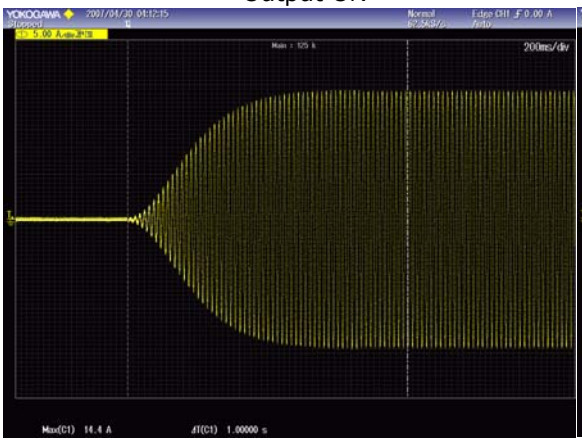
Output OFF



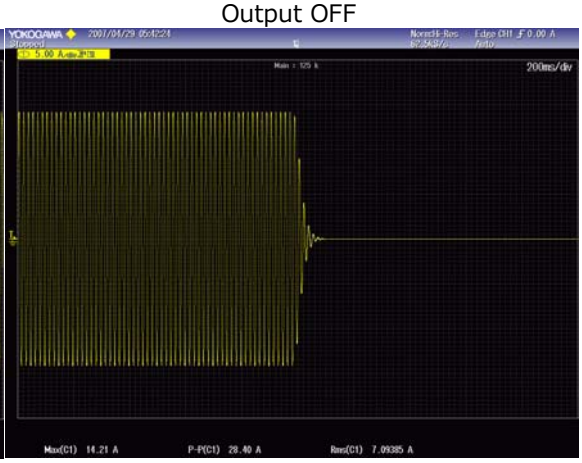
50 V/div
200 ms/div
Probe10:1

10 A range

Output ON



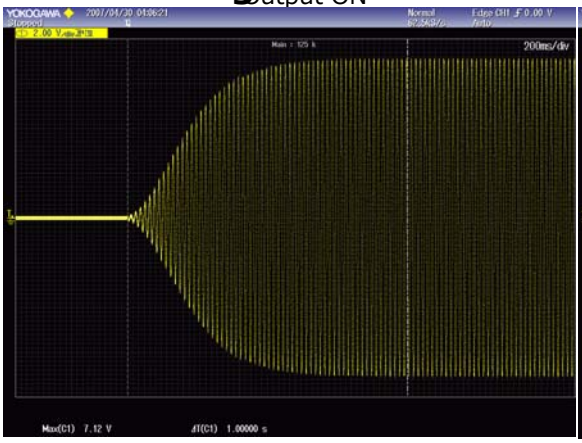
Output OFF



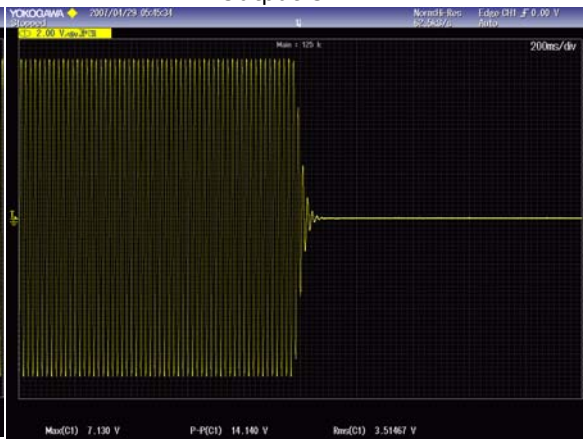
5 A/div
200 ms/div
Probe10:1

AUX 5 V range

Output ON



Output OFF



2 V/div
200 ms/div
Probe1:1

2-7. Compliance (1)

Overview

This is the comparison between maximum output values and specification values when an oscilloscope measures the current of the voltage output terminal during voltage output and the voltage of the current output terminal during current output regarding each range of the LS3300.
The maximum output of the 2558A is also shown as the object of a comparison.

Used device

Oscilloscope DLM2054

Device settings

LS3300 Range = 1 V, 10 V, 30 V, 100 V, 300 V, 1000 V,
30 mA, 100 mA, 1 A, 10 A, 50 A
Output setting value = 100% of each range
Frequency = 60 Hz

2558A Range = 1 V, 10 V, 100 V, 300 V, 1000 V, 100 mA, 1 A, 10 A, 50 A
Output setting value = 100% of each range
Frequency = 60 Hz

2-7. Compliance (2)

Measurement result

Reference: YOKOGAWA 2558A

Range	Setting value	Product spec	Actual value	Product spec	Actual value
1 V	1.00000 V	0.5 A or more	1.69 A	0.5 A or more	3.4 A
10 V	10.0000 V	Approx. 600 mA	945 mA	Approx. 3 A	4.4 A
30 V	30.0000 V	Approx. 60 mA	96 mA	-	-
100 V	100.000 V	Approx. 60mA	94 mA	Approx. 0.3 A	0.44 A
300 V	300.000 V	Approx. 20 mA	31.5 mA	Approx. 0.1 A	0.14 A
1000 V	1000.00 V	Approx. 6 mA	9 mA	Approx. 6 mA	10 mA

Range	Setting value	Product spec	Actual value	Product spec	Actual value
30mA	30.0000mA	Approx. 15V	21.4V	-	-
100 mA	100.000m A	Approx. 15 V	15.7 V	←Equivalent	
1 A	1.00000 A	Approx. 15 V	22.1 V		
10 A	10.0000 A	Approx. 3 V	3.8 V		
50 A	50.000 A	Approx. 0.6 V	0.68 V		

2-7. Compliance (3)

Overview

This is the influence of cable routing in the case of large current and high frequency.
The voltage between current terminals is measured when there are twists on an attached current cable and no twist.

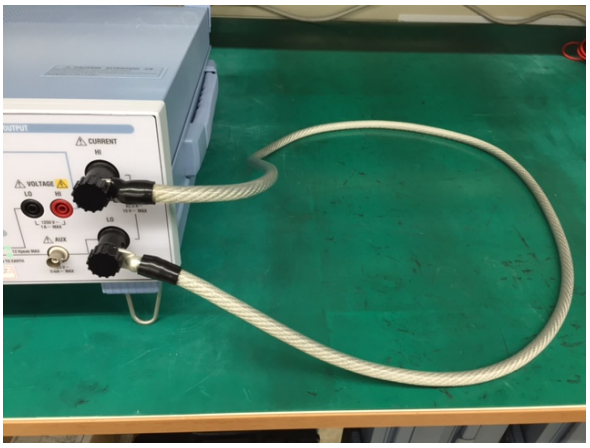
Used device

DMM 73402
B8506WA (attached current cable)

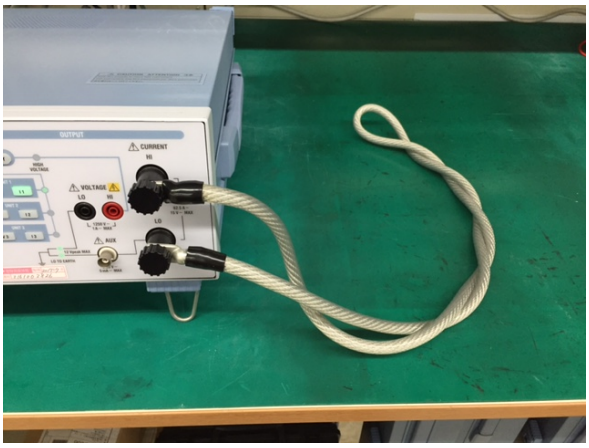
Device settings

LS3300 Range = 50 A
Output setting value = 100% of the range
Frequency = 1000 Hz

Measurement result



Without twist



With twists

Cable	Voltage between current terminals
Without twist	415 mV
With twists	197 mV

*The spec of the maximum output is approx. 600 mV

2-8-1. Communication speed (GPIB)

Overview
The processing speed of communication commands are as follows:

Measurement environment
OS: Windows 7 Enterprise SP1 64-bit
Processor: Intel(R) Core™ i5-5300U CPU @ 2.30GHz 2.30GHz
Memory: 16 GB
Tool: Visual Studio 2015 VC++

GP-IB

- When changing the range with ":SOUR:VOLT:RANG"

		After change					
		1V	10V	30V	100V	300V	1000V
Before change	1V	-	9.50 ms	9.51 ms	9.36 ms	9.21 ms	9.52 ms
	10V	9.41 ms	-	9.46 ms	9.52 ms	9.82 ms	9.30 ms
	30V	9.29 ms	9.42 ms	-	9.33 ms	9.59 ms	9.13 ms
	100V	9.97 ms	9.16 ms	9.32 ms	-	9.31 ms	9.33 ms
	300V	9.35 ms	9.33 ms	9.33 ms	9.42 ms	-	9.37 ms
	1000V	9.34 ms	9.35 ms	9.50 ms	9.27 ms	9.39 ms	-

- When changing the range with ":SOUR:CURR:RANG"

		After change						
		30mA	100mA	1A	10A	50A	AUX, 500mV	AUX, 5V
Before change	30mA	-	9.72 ms	9.86 ms	9.80 ms	9.66 ms	9.81 ms	9.66 ms
	100mA	9.62 ms	-	9.61 ms	9.85 ms	9.86 ms	9.65 ms	9.78 ms
	1A	9.60 ms	9.84 ms	-	9.65 ms	9.73 ms	10.12 ms	9.91 ms
	10A	9.76 ms	9.66 ms	9.79 ms	-	9.91 ms	10.02 ms	9.63 ms
	50A	9.60 ms	9.75 ms	9.63 ms	10.02 ms	-	9.76 ms	9.81 ms
	AUX, 500mV	9.67 ms	10.23 ms	10.36 ms	9.67 ms	10.30 ms	-	10.32 ms
	AUX, 5V	9.97 ms	9.63 ms	9.84 ms	10.47 ms	10.39 ms	10.43 ms	-

- When turning on and off with ":OUTPUT"

	1V	10V	30V	100V	300V	1000V	30mA	100mA	1A	10A	50A	AUX, 500mV	AUX, 5V
OFF → ON	32.29 ms	21.94 ms	29.29 ms	21.17 ms	20.78 ms	21.40 ms	21.82 ms	21.73 ms	21.06 ms	27.59 ms	21.12 ms	21.06 ms	21.59 ms
ON → OFF	8.14 ms	8.24 ms	8.39 ms	9.62 ms	8.55 ms	8.61 ms	8.19 ms	8.30 ms	8.97 ms	8.33 ms	8.21 ms	8.98 ms	8.45 ms

The periods mentioned above are not the period until actual behavior is finished but the one until a communication command is finished.
Actual behavior period is as follows;
OFF → ON: AUX range (approx. 160 ms), Other than the AUX range (approx. 60 ms)
ON → OFF: AUX range (approx. 310 ms), Other than the AUX range (approx. 210 ms)

2-8-2. Communication speed (GPIB)

GP-IB

- Time period until the ANS of the status register becomes 0 when changing the device structure with ":WIRing:TYPE"

		After change					
		1P2W	1P3W	3P3W	3V3A	3P4W	1P2WHC
Before change	1P2W	-	81.23 ms	85.74 ms	85.98 ms	85.50 ms	85.94 ms
	1P3W	-	-	95.65 ms	95.71 ms	96.76 ms	96.42 ms
	3P3W	-	97.02 ms	-	94.94 ms	96.35 ms	96.15 ms
	3V3A	-	96.35 ms	95.52 ms	-	95.27 ms	92.04 ms
	3P4W	-	95.44 ms	96.09 ms	96.40 ms	-	96.34 ms
	1P2WHC	-	96.76 ms	96.66 ms	96.88 ms	96.62 ms	-

- Time period until the ANS of the status register becomes 0 when changing the device structure with ":WIRing:PRIority"

		After change	
		UNIT2 → UNIT3	UNIT3 → UNIT2
Before change	1P2W	-	-
	1P3W	96.35 ms	91.97 ms
	3P3W	96.87 ms	95.17 ms
	3V3A	93.61 ms	95.29 ms
	3P4W	95.94 ms	94.68 ms
	1P2WHC	92.87 ms	93.90 ms

2-8-3. Communication speed (Ethernet)

■ Ethernet

- When changing the range with ":SOUR:VOLT:RANG"

		After change					
		1V	10V	30V	100V	300V	1000V
Before change	1V	-	9.50 ms	9.51 ms	9.36 ms	9.21 ms	9.52 ms
	10V	9.41 ms	-	9.46 ms	9.52 ms	9.82 ms	9.30 ms
	30V	9.29 ms	9.42 ms	-	9.33 ms	9.59 ms	9.13 ms
	100V	9.97 ms	9.16 ms	9.32 ms	-	9.31 ms	9.33 ms
	300V	9.35 ms	9.33 ms	9.33 ms	9.42 ms	-	9.37 ms
	1000V	9.34 ms	9.35 ms	9.50 ms	9.27 ms	9.39 ms	-

- When changing the range with ":SOUR:CURR:RANG"

		After change						
		30mA	100mA	1A	10A	50A	AUX, 500mV	AUX, 5V
Before change	30mA	-	9.72 ms	9.86 ms	9.80 ms	9.66 ms	9.81 ms	9.66 ms
	100mA	9.62 ms	-	9.61 ms	9.85 ms	9.86 ms	9.65 ms	9.78 ms
	1A	9.60 ms	9.84 ms	-	9.65 ms	9.73 ms	10.12 ms	9.91 ms
	10A	9.76 ms	9.66 ms	9.79 ms	-	9.91 ms	10.02 ms	9.63 ms
	50A	9.60 ms	9.75 ms	9.63 ms	10.02 ms	-	9.76 ms	9.81 ms
	AUX, 500mV	9.67 ms	10.23 ms	10.36 ms	9.67 ms	10.30 ms	-	10.32 ms
	AUX, 5V	9.97 ms	9.63 ms	9.84 ms	10.47 ms	10.39 ms	10.43 ms	-

- When turning on and off with ":OUTPUT"

	1V	10V	30V	100V	300V	1000V	30mA	100mA	1A	10A	50A	AUX, 500mV	AUX, 5V
OFF → ON	32.29 ms	21.94 ms	29.29 ms	21.17 ms	20.78 ms	21.40 ms	21.82 ms	21.73 ms	21.06 ms	27.59 ms	21.12 ms	21.06 ms	21.59 ms
ON → OFF	8.14 ms	8.24 ms	8.39 ms	9.62 ms	8.55 ms	8.61 ms	8.19 ms	8.30 ms	8.97 ms	8.33 ms	8.21 ms	8.98 ms	8.45 ms

- Time period until the ANS of the status register becomes 0 when changing the device structure with ":WIRing:TYPE"

		After change					
		1P2W	1P3W	3P3W	3V3A	3P4W	1P2WHC
Before change	1P2W	-	80.00 ms	91.67 ms	92.79 ms	92.57 ms	92.03 ms
	1P3W	-	-	98.11 ms	98.95 ms	98.65 ms	98.15 ms
	3P3W	-	97.90 ms	-	99.05 ms	98.80 ms	97.85 ms
	3V3A	-	96.99 ms	96.82 ms	-	97.38 ms	96.74 ms
	3P4W	-	96.35 ms	96.70 ms	97.28 ms	-	96.56 ms
	1P2WHC	-	98.23 ms	98.03 ms	98.86 ms	96.89 ms	-

- Time period until the ANS of the status register becomes 0 when changing the device structure with ":WIRing:PRIority"

		After change	
		UNIT2 → UNIT3	UNIT3 → UNIT2
Before change	1P2W	-	-
	1P3W	97.93 ms	96.71 ms
	3P3W	97.52 ms	96.55 ms
	3V3A	97.13 ms	96.56 ms
	3P4W	97.43 ms	96.56 ms
	1P2WHC	97.63 ms	96.74 ms

2-8-4. Communication speed (USB)

■ Ethernet

- When changing the range with ":SOUR:VOLT:RANG"

		After change					
		1V	10V	30V	100V	300V	1000V
Before change	1V	-	7.80 ms	7.82 ms	7.31 ms	7.28 ms	7.24 ms
	10V	7.19 ms	-	7.29 ms	7.19 ms	7.25 ms	7.19 ms
	30V	7.29 ms	7.25 ms	-	7.26 ms	7.23 ms	7.30 ms
	100V	7.26 ms	7.16 ms	7.89 ms	-	7.31 ms	7.23 ms
	300V	7.71 ms	7.25 ms	7.85 ms	7.30 ms	-	7.18 ms
	1000V	7.25 ms	7.24 ms	7.53 ms	7.32 ms	7.25 ms	-

- When changing the range with ":SOUR:CURR:RANG"

		After change						
		30mA	100mA	1A	10A	50A	AUX, 500mV	AUX, 5V
Before change	30mA	-	7.63 ms	8.11 ms	7.48 ms	7.52 ms	7.65 ms	7.60 ms
	100mA	7.57 ms	-	7.62 ms	7.75 ms	7.61 ms	7.59 ms	7.76 ms
	1A	7.51 ms	7.53 ms	-	7.60 ms	8.05 ms	7.64 ms	7.59 ms
	10A	7.59 ms	7.59 ms	7.87 ms	-	7.60 ms	7.61 ms	7.61 ms
	50A	7.53 ms	7.61 ms	7.52 ms	7.60 ms	-	7.55 ms	7.71 ms
	AUX, 500mV	7.69 ms	7.67 ms	7.57 ms	7.62 ms	7.96 ms	-	7.67 ms
	AUX, 5V	7.56 ms	7.54 ms	7.59 ms	7.57 ms	7.58 ms	7.78 ms	-

- When turning on and off with ":OUTPUT"

	1V	10V	30V	100V	300V	1000V	30mA	100mA	1A	10A	50A	AUX, 500mV	AUX, 5V
OFF → ON	22.15 ms	22.11 ms	23.41 ms	24.27 ms	23.80 ms	22.06 ms	22.15 ms	22.30 ms	22.22 ms	22.19 ms	23.93 ms	22.57 ms	23.95 ms
ON → OFF	6.37 ms	6.32 ms	6.74 ms	6.39 ms	6.16 ms	6.47 ms	6.26 ms	6.22 ms	6.30 ms	6.19 ms	6.20 ms	6.25 ms	6.23 ms

- Time period until the ANS of the status register becomes 0 when changing the device structure with ":WIRing:TYPE"

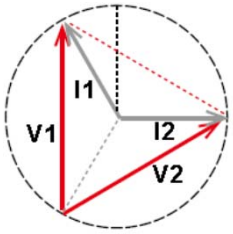
		After change					
		1P2W	1P3W	3P3W	3V3A	3P4W	1P2WHC
Before change	1P2W	-	596.15 ms	596.10 ms	596.11 ms	595.94 ms	596.28 ms
	1P3W	-	-	599.83 ms	599.87 ms	599.85 ms	599.79 ms
	3P3W	-	599.82 ms	-	599.79 ms	601.83 ms	599.83 ms
	3V3A	-	605.80 ms	601.79 ms	-	599.82 ms	599.85 ms
	3P4W	-	599.83 ms	599.85 ms	599.85 ms	-	603.85 ms
	1P2WHC	-	599.80 ms	599.78 ms	599.83 ms	599.80 ms	-

- Time period until the ANS of the status register becomes 0 when changing the device structure with ":WIRing:PRIority"

		After change	
		UNIT2 → UNIT3	UNIT3 → UNIT2
Before change	1P2W	-	-
	1P3W	599.82 ms	598.91 ms
	3P3W	599.88 ms	599.16 ms
	3V3A	599.85 ms	598.92 ms
	3P4W	599.90 ms	599.16 ms
	1P2WHC	599.87 ms	599.11 ms

3-1. Power error at three-phase power calibration

- Overview
  In the case of three-phase three wire system, there is a phase difference of 30° between voltage and current as indicated in the right diagram, and the characteristic of power error is different from other wiring system. This is the value in a representative range.



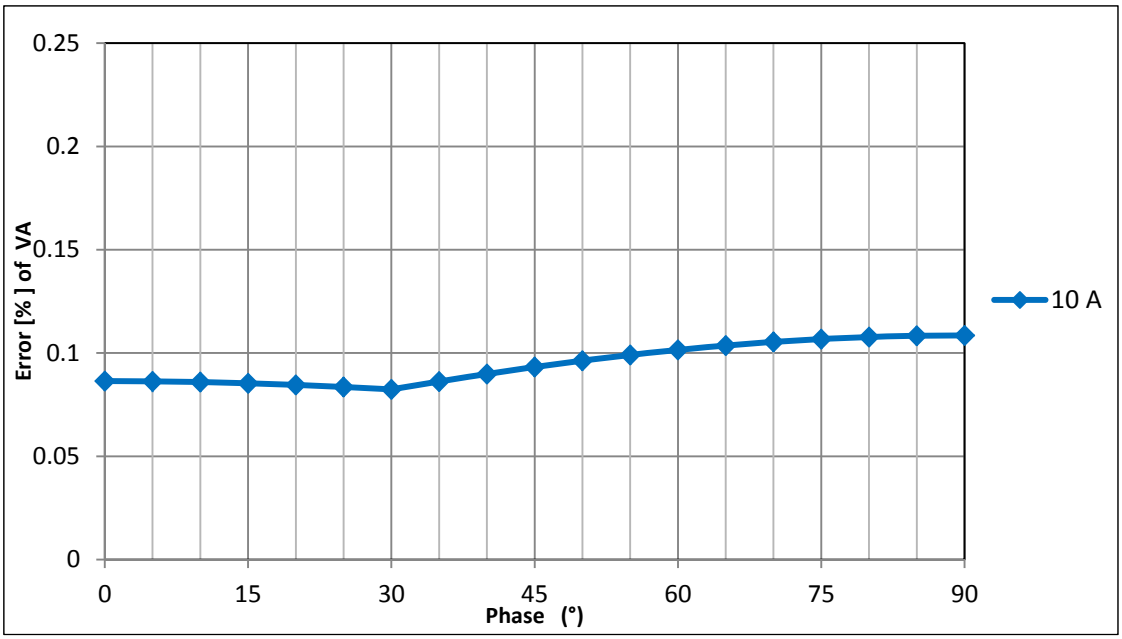
Phase diagram 3P3W

- Condition settings
  LS3300 3P3W
  Range = 300 V, 10 A
  Output setting value = 100√3 V=173.205 V (voltage between wires)
  10 A (wire current)
  Frequency = 50/60 Hz

- Three phase apparent power
  Three phase apparent power = √3 × voltage between wires × wire current VA

- View about error
  Error against each LS3300 = 0.04% of VA+0.005% of Range + PWRerror% of VA
  * PWRerror is the computational expression of addition value to active power accuracy by phase error (ΔΦ)
  PWRerror (%) = 100 x {cosΦ - cos(Φ + ΔΦ)}
  Whole error is the total of each LS3300's error.

- Computational expression of power error of 3P3W



3-2. Stability of large 1P2W current

Overview

This is the fluctuation of the output error of a representative range when three LS3300s performs synchronous output with the wiring setting of “Hi Current” connecting the power meter WT3000E.
The period of the plotted data is one hour from one minute after the output is turned on.

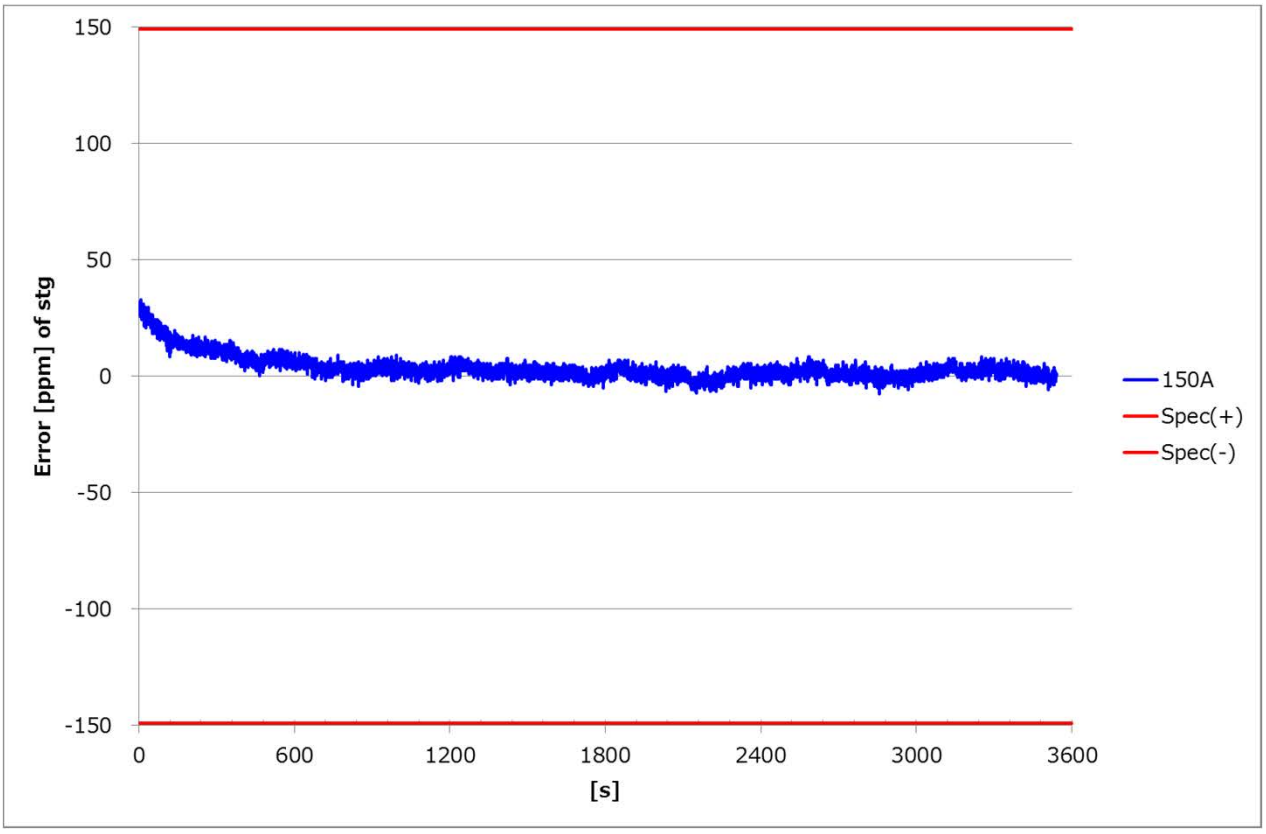
Used device

Power Meter WT3000E, CT1000

Device settings

WT3000E Update rate = 500 ms
LS3300 Range = 150 A
Output setting value = 100% of the range
Frequency = 60 Hz

Measurement result



3-3-1. Example of calibration using AUX terminal

- **Overview**
  This is the calibration example of the power quality analyzer YOKOGAWA CW500 when the AUX terminal of the LS3300 is used.

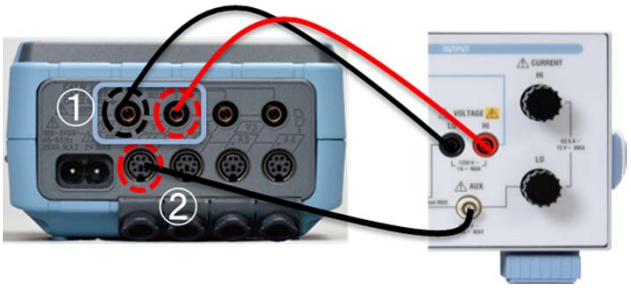
- **Detailed explanation**
  Because the YOKOGAWA CW500 uses a current clamp for current input, the input of the current clamp is connected to the AUX terminal of the LS3300.
  The LS3300 outputs voltage as usual, outputs voltage converted at the conversion ratio of a current clamp from the AUX terminal and performs calibration in the same manner as the calibration of a power meter.

- **Used device**
  YOKOGAWA CW500 Power quality analyzer

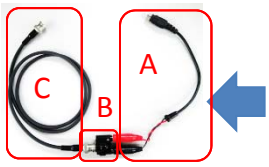
- **Device settings**
  LS3300 Range = 100 V, AUX 500 mV
  Output setting value = Arbitrary setting value of a current clamp to be used
  Frequency = 50 Hz
  CW500 Range = 600 V, Clamp 1 A/1 mV: 96064 (500 A)

- **Actual measurement screen**

<Connection example of LS3300 and CW500>



<② Conversion cable for current clamp>



As the cable ②, A: 99073 (banana-DIN conversion cable)＋B: banana (male)-BNC conversion cable＋C: 366924 (BNC cable) are used.

3-3-2. Notes on connection of AUX terminals

Overview

This subsection shows an error cause when AUX is connected.

Detailed explanation

The common terminals of the current input terminal and the external current sensor input terminal are connected internally in the YOKOGAWA WT series. If the current terminal of the LS3300 and the AUX terminal are connected simultaneously, an error develops in the AUX output.

When you calibrate a power meter whose current input and external current sensor input are connected internally, if you connecting the AUX terminal, please remove the connection of the current terminal.

Used device

Power meter YOKOGAWA WT3000

Device settings

WT3000 Range = EXT 500 mV, EXT 5 V
Update rate = 1 S
LS3300 Range = AUX 500 mV, AUX 5 V
Output setting value = 125% of each range
Frequency = 60 Hz

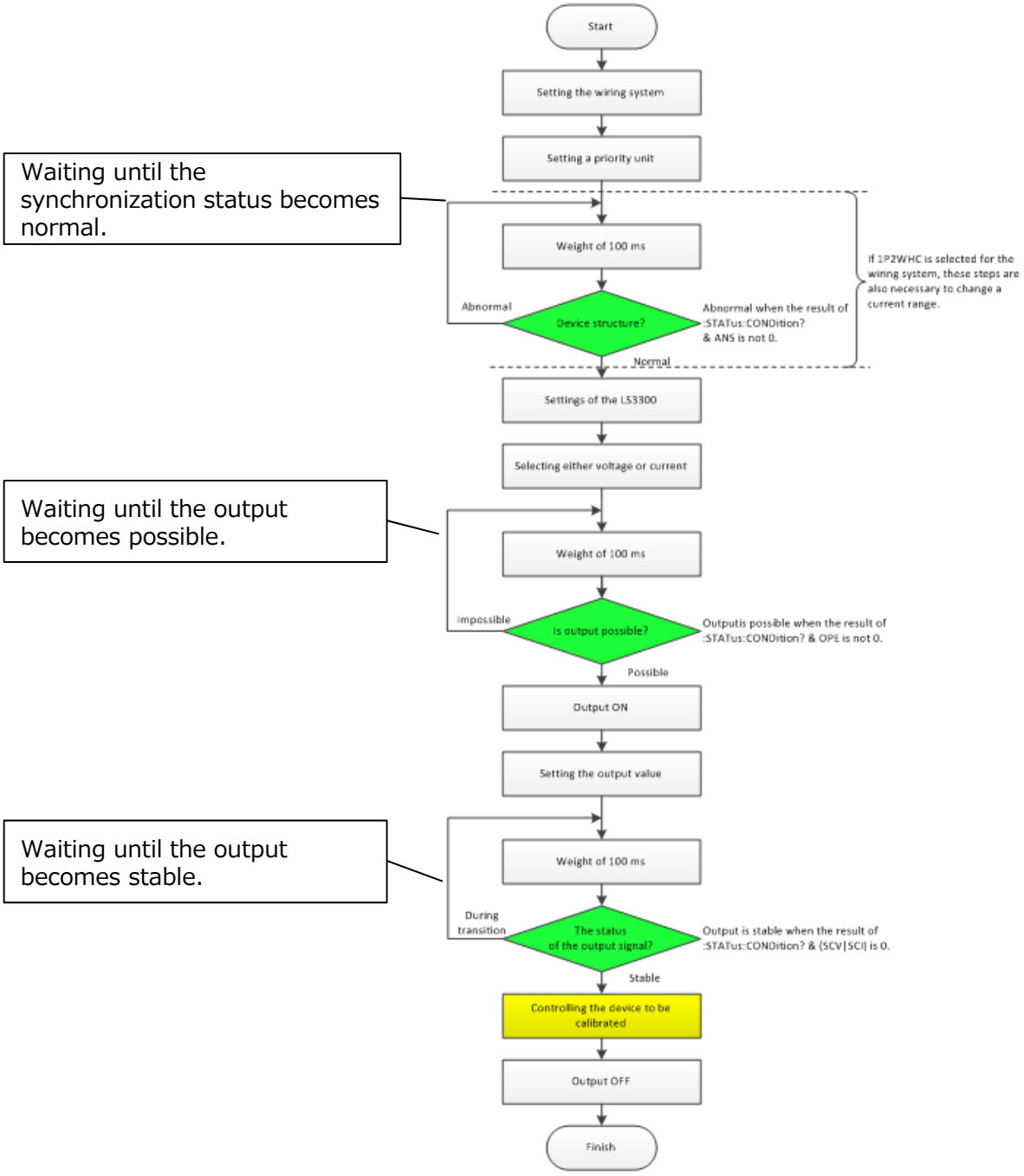
Measurement result

LS3300 range	Setting value	Only AUX is connected	Current and AUX are connected	Error (ppm)
AUX 500 mV	625.00 mV	624.984 mV	625.143 mV	317
AUX 5 V	6.2500V	6.25017 V	6.25032 V	30

*Voltage and current output are the same.

3-4. Change of wiring system via communication and setting procedure

■ Overview
The procedure of setting change of wiring system/priority unit using a communication command is as follows:



4-1. Safety of output terminal

Overview

This section shows the safety of the output terminals.

Voltage terminal

Even though the voltage output terminals are safety terminals, it generates high voltage, maximum 1250 Vrms. If you operate it in a wrong manner, there is a possibility that a serious accident affecting people's lives may occur. To prevent electric shock, be sure to read the user's manual before use.

Current terminal

Because the compliance voltage is 22 Vrms or less when the LS3300 generates current, and the voltage is lower than the danger voltage 46.7Vpeak, so the current output terminals are safety. In case that the Lo terminal of the current is not connect into the earth (Lo to Earth = off), because 12 Vpeak is the maximum additional voltage against the earth and the voltage between Hi terminal and the case is under the danger voltage 46.7 Vpeak, the current output terminals are safety.

4-2. Example of error cause during voltage/current generation (1)

Overview

This is the influence of the interference when the LS3300 outputs the combination of high voltage and small current or high current and low voltage at simultaneous output of voltage and current.

Used device

Power Meter WT3000E

Device settings

WT3000E Update rate = 500 ms

Notes on the output of high voltage and large current

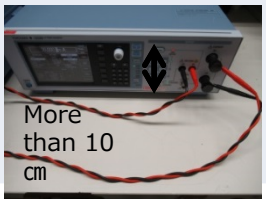
When high voltage and small current are output together, a current output value sometimes fluctuates according to output frequency and phase due to the influence of the electric field of high voltage output. To reduce the influence of the electric field, please twist voltage and current cables respectively and construct routing avoiding the influence of the electric field.

When large current and low voltage are output together, a voltage output value sometimes fluctuates according to output frequency and phase due to the influence of the magnetic field of large current output. To reduce the influence of the magnetic field, please twist voltage and current cables respectively and construct routing avoiding the influence of the magnetic field.

4-2. Example of error cause during voltage/current generation (2)

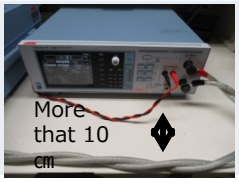
■ **Variation of current output by high voltage output**

● **Variation of 30 mA when 1250 V is output***

Frequency	When voltage cables and current cables are apart from each other	When voltage cables and current cables are close together
60 Hz	No impact	100 ppm
400 Hz	90 ppm	620 ppm
1200Hz	250 ppm	1800 ppm
		

■ **Variation of voltage output by large current output**

● **Variation of 1 V when 62.5 A is output***

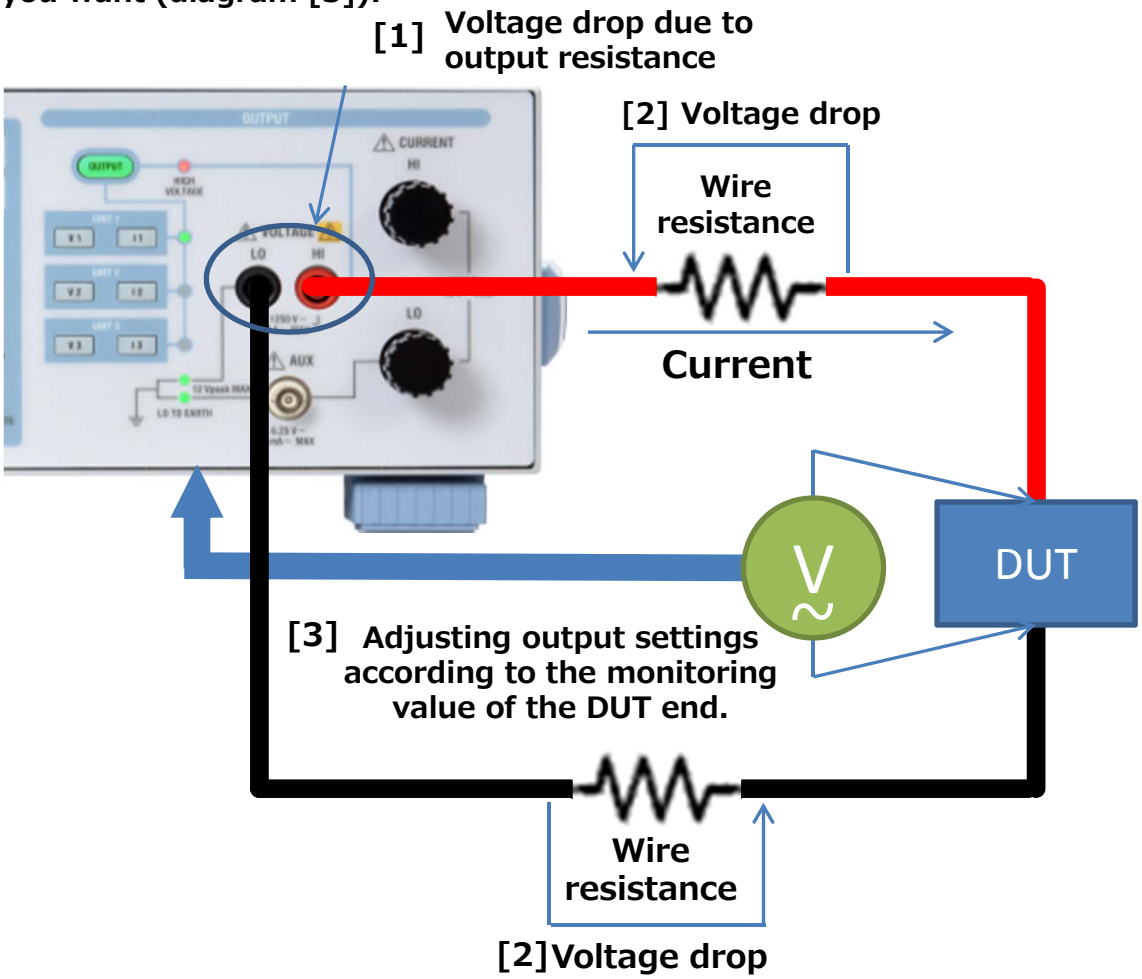
Frequency	When voltage cables and current cables are apart from each other	When voltage cables and current cables are close together
60 Hz	No impact	50 ppm
400 Hz	70 ppm	400 ppm
1200 Hz	260 ppm	1300 ppm
		

***The cables are twisted.**

4-2. Example of error cause during voltage/current generation (3)

- **Overview**
  This is the error cause during voltage generation.

- **Detailed explanation**
  Because the LS3300 is a generator with two terminal connection, an error of output value is caused by output current.
  The guaranteed output resistance of a terminal part (including the contact resistance of a safety terminal in a recommended cable) is 6 mΩ (except for the 100 mV range). The voltage drop of 6 mV accordingly occurs at the terminal part when output current is 1 A. (diagram [1]).
  In addition, a voltage drop caused by a cable to a DUT also makes an error happen (diagram [2]).
  You therefor have to monitor voltage at the DUT end if output current exerts an influence and adjust output settings to make the LS3300 output voltage you want (diagram [3]).



4-3. Maximum capacity and inductive load

Overview

This is the maximum capacity and the inductive load of each range of the LS3300A.

Overview

The following tables show the range where oscillation doesn't occur on the premise that output is within the compliance.
If the LS3300 performs output while a large inductive load or a load of resonance circuit is connected to the current terminal, it is possible that oscillation occurs and large voltage is output to internal output circuit. If oscillation occurs, turn off output ASAP.
Because there is a possibility that oscillation occurs, do not connect an inductive load at voltage output and a capacity load at current output.

Range	Max. capacity load
1 V	10 uF
10 V	10 uF
30 V	1 uF
100 V	1 uF
300 V	0.1 uF
1000 V	0.01 uF

Range	Max. inductive load
30 mA	1 mH
100 mA	1 mH
1 A	1 mH
10 A	1 mH
50 A	1 mH

Range	Max. capacity load
AUX 500 mV	1000 pF
AUX 5 V	1000 pF

4-4. Power meter in which voltage and current terminals are connected internally

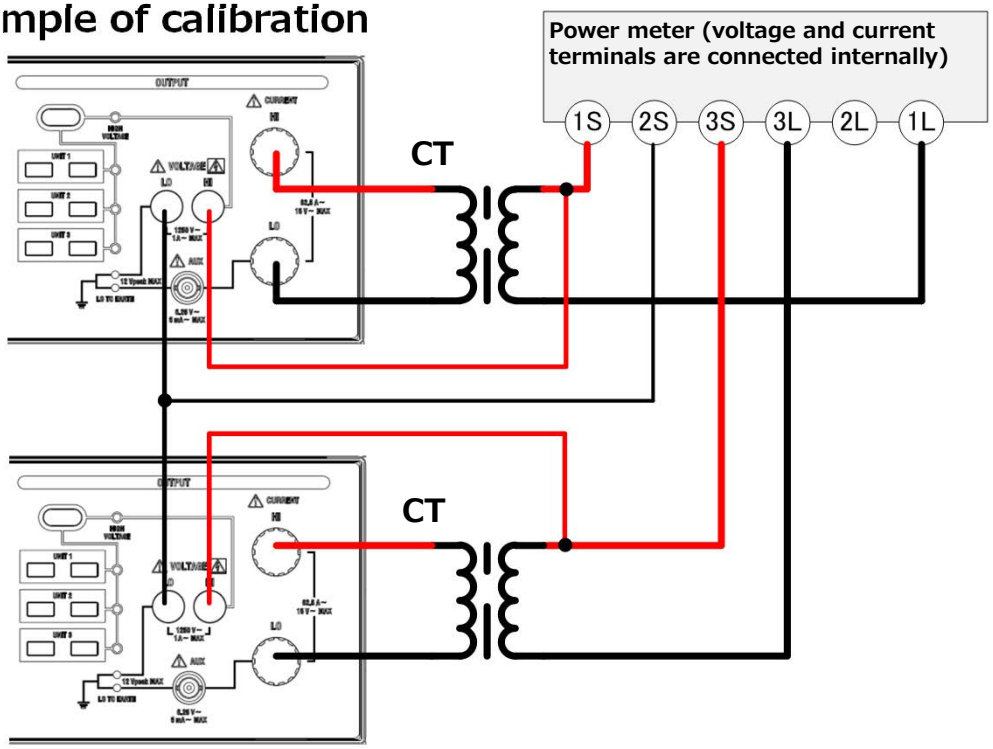
Overview

This is the connection to a power meter where voltage and current terminals are connected internally.

Detailed explanation

When voltage and current terminals are connected internally in a 3P3W power meter, the LS3300 has to input current to the power meter isolating with a CT because the maximum application voltage between the Lo terminal of current output and the ground is 12 Vpk.
We recommend to use another power meter for reference because an error may occur due to the current transformation ratio and the phase of the CT.

Example of calibration



4-5. Example of calibration of clamp-on power meter

- **Overview**
  This section shows how to set the LS3300 for the calibration of a clamp-on power meter.
  With the use of a coil, the LS3300 can perform a test equivalent for energization of output current x turn count.

- **Used device**
  Clamp-on Power Checker YOKOGAWA CW10
  Test coil for a clamp-on meter (wire material: PEWΦ2.3 mm, the number of turns: 60)

- **Device settings**
  LS3300 Voltage terminal: No load (direct connection to the voltage input terminal of the CW10)
  Current terminal: Connection to a test coil for a clamp-on meter
  Voltage range = 1000 V, Voltage output setting value = 100%
  Current range = 10 A, current output setting value = 100%
  (Current at the center of the coil: 10 A × 60 turns = 600 A)
  Wiring system = 1P2W
  Reference signal = INT, Frequency = 60 Hz

- **Example of calibration**

*Display value of clamp-on power meter: 600.0 kW
Voltage between LS3300's current terminals during output mentioned above: 2.1 V (maximum output spec: approx. 3V)

4-6. Indication of output value

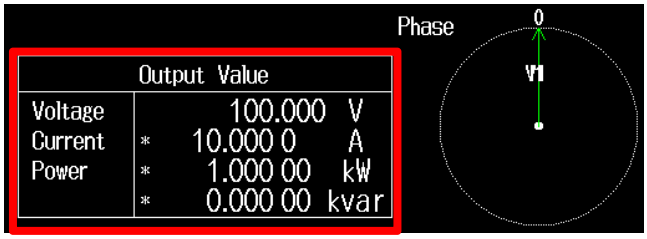
Overview

This section explains differences from the 2558A in the indication of the output values of LS3300's voltage, current, power and apparent power.

Differences between the 2558A and the LS3300

	LS3300	2558A
Indication value	Output value = calculated value of output level x level ratio While output varies, "STABILIZEING" is displayed at the upper right of the screen and it disappears when the output becomes stable.	Measurement value: When the OUTPUT switch is turned on, the value fluctuates until it becomes stable. Indication sometimes changes according to the state of a load during output.
Indication location	The field of Output Value on the screen as shown in the diagram 1 below	OUTPUT indication in the right side of the front panel as shown in the diagram 2 below
Others	When "*" is displayed next to the indication of output value, the target signal is not being output.	When the OUTPUT switch is turned off, "– – – – –" is displayed.

■Indication example of the LS3300: Diagram 1



Indication example of the 2558A: Diagram 2

4-7. Sweep behavior

Overview

This is the comparison of the sweep function of the 2558A and the LS3300.

Item	2558A	LS3300
Sweep target	Voltage/current/frequency	Voltage/current
Sweep range	0 to 120% of main setting value	Selectable from 0 to 100%/105%/110%/120% of output level
Sweep time	8 s/16 s/32 s/64 s	←
Sweep setting item	Output division setting, deviation	Output level ratio
Sweep direction	UP/DOWN	←

4-8. LINE synchronization

Overview

This section explains the LINE synchronization function.
With this function, the LS3300 can synchronize output frequency with the commercial power supply frequency.
It can be used for checkup of the interference from a power supply.

Detailed explanation

When a specified frequency of an AC generator and the frequency of commercial power supply are almost the same, a beat that the indication value of a calibration target increases and decreases at intervals of several tens seconds occurs on rare occasion.
There are following two methods to prevent beat with the commercial power supply:

① Changing the setting frequency

② Synchronizing the output of a generator with the commercial power supply

The LINE synchronization achieves the latter method.
When the reference signal of the LS3300 is set at INT or EXT, if suspecting the occurrence of a beat with the commercial power source, you can confirm the problem by changing to the LINE synchronization.
However, the phase difference between the commercial power source and output is not zero.

Application examples (external magnetic field test)

With the LINE synchronization function, it is possible to output voltage/current of an arbitrary phase against the commercial power supply.
The JIS standard test confirming the influence of the external magnetic field prescribes that "the frequency is the same as the one that drives the instrument and the phase exerts the maximum influence on the instrument."
The commercial power source is generally used for a coil generating a magnetic field.
With the LINE synchronization function, you can confirm the influence of the external magnetic field by applying the output whose phase is changed with reference to the commercial power source to a device under test.