# Compatibility of the PW3390 to the accuracy required in the WLTP test procedures

## 1. Background

WLTP (Worldwide harmonized Light vehicles Test Procedure) is released as one of the worldwide technical regulations at the World Forum for the harmonization of vehicle regulations (WP.29). The WLTP specifies to measure the charge and discharge power balance of the REESS (rechargeable energy storage system) and to calculate the CO2 emission and fuel consumption by the RCB (REESS charge balance) correction. In the charge and discharge power measurement, there is the accuracy requirement for measuring instruments to assure the certain accuracy level. So, we summarize how to understand the accuracy requirement and effective usage of a power analyzer.

## 2. Requirements for the accuracy and resolution of energy, current and voltage measurement

The WLTP standard (ECE/TRANS/WP.29/GRPE/2016/3) specifies the accuracy and resolution requirements of energy, current and voltage measurement in the Table A8/1 of Annex 8.

Table 1: Accuracy and resolution requirement in the WLTP

1.1. Units, accuracy and resolution of electric parameters

Parameters, units and accuracy of measurements shall be as shown in Table A8/1.

Table A8/1
**Parameters, units and accuracy of measurements**

| *Parameter* | *Units* | *Accuracy* | *Resolution* |
|---|---|---|---|
| Electrical energy (1) | Wh | ±1 per cent | 0.001 kWh(2) |
| Electrical current | A | ±0.3 per cent FSD or ±1 per cent of reading (3,4) | 0.1 A |
| Electric voltage | V | ±0.3 per cent FSD or ±1 per cent of reading (3) | 0.1 V |

(1) Equipment: static meter for active energy.
(2) AC watt-hour meter, Class 1 according to IEC 62053-21 or equivalent.
(3) Whichever is greater.
(4) Current integration frequency 20 Hz or more.

## 3. Understanding the accuracy requirement for energy measurement

In the standard, the accuracy for energy is specified as “±1%”, and we understand it as “±1% reading”. In addition, the IEC 62053-21 is referred in the note (2). In addition, the note (2) refers to the IEC 62053-21 which is the standard applied to the type test of static meters for active energy of 50Hz or 60Hz. The IEC62053-21 (Edition 1.1 2016-11) specifies the accuracy requirement as shown in the Table 2.

Table 2: Accuracy requirement for energy measurement in the IEC 62053-21

**Table 6 – Percentage error limits**
**(single-phase meters and polyphase meters with balanced loads)**

| Value of current | | Power factor | Percentage error limits for meters of class | |
|---|---|---|---|---|
| for direct connected meters | for transformer operated meters | | 1 | 2 |
| $0{,}05\ I_b \le I < 0{,}1\ I_b$ | $0{,}02\ I_n \le I < 0{,}05\ I_n$ | 1 | ±1,5 | ±2,5 |
| $0{,}1\ I_b \le I \le I_{max}$ | $0{,}05\ I_n \le I \le I_{max}$ | 1 | ±1,0 | ±2,0 |
| $0{,}1\ I_b \le I < 0{,}2\ I_b$ | $0{,}05\ I_n \le I < 0{,}1\ I_n$ | 0,5 inductive<br>0,8 capacitive | ±1,5<br>±1,5 | ±2,5<br>- |
| $0{,}2\ I_b \le I \le I_{max}$ | $0{,}1\ I_n \le I \le I_{max}$ | 0,5 inductive<br>0,8 capacitive | ±1,0<br>±1,0 | ±2,0<br>- |
| When specially requested by the user: From $0{,}2\ I_b \le I \le I_b$ | $0{,}1\ I_n \le I \le I_n$ | 0,25 inductive<br>0,5 capacitive | ±3,5<br>±2,5 | -<br>- |

The WLTP measures the DC power of REESS, so that it is reasonable to consider the accuracy when power factor is 1 in the accuracy requirement of the IEC 62053-21. Also, it is appropriate to refer to “class 1” of the IEC 62053-21, because the class of the IEC62053-21 represents the basic accuracy of static meters and the WLTP requires “±1%”.

In the accuracy requirement chart of the IEC62053-21, “direct connected meters” are not incorporated with any current transformer (sensor) and are used individually and “transformer operated meters” input the current through a transformer (sensor). The accuracy of current transformer (sensor) is not included in this requirement.

We think that it is reasonable to refer to “transformer operated meters” for the requirement of WLTP measurement if you carry it out with the power analyzer which inputs the current through a current transformer (sensor).

So, referring to the accuracy shown in [redacted] is appropriate.

## 4. Comparison of accuracy requirement and accuracy of the PW3390 Power Analyzer

The Table 3 shows the comparison of the required accuracy in the Table 1 and Table 2 and the accuracy specifications of the PW3390 Power Analyzer with the CT6843-05/CT6844-05/CT6845-05/CT6846-05 AC/DC Current Probe.

In the Table 3, the PW3390’s accuracy specification is not able to satisfy the required accuracy when the input is rather low to the measurement range. This is due to the f.s. (full scale) accuracy of the range becomes dominant error when the input is rather small to the rated current. This is the same on the higher end model PW6001 Power Analyzer. Those ranges are verified in the latter section by analyzing the actual measurement performance.




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Table 3: Comparison of required accuracy and the accuracy specifications of the PW3390

| Items | Required accuracy | Accuracy of PW3390 | Judge |
|---|---|---|---|
| Energy (accuracy) | ±1.5%rdg. (Current input: 2 to 5% of range) #1 | ±3.555% to ±1.455% #2<br>Refer to Fig. 4.1. | △ |
| Energy (accuracy) | ±1.0%rdg. (Current input: 5 to 100% of range) #1 | ±1.455% to ±0.125% #2<br>Refer to Fig. 4.1. | △ |
| Energy (resolution) | 0.001kWh | 0.0001kWh or better | ○ |
| Current (accuracy) | ±0.3%f.s. or ±1%rdg. (whichever greater) | Refer to Fig. 4.2. #3 | ○ |
| Current (resolution) | 0.1A | 0.1A or better | ○ |
| Voltage (accuracy) | ±0.3%f.s. or ±1%rdg. (whichever greater) | Refer to Fig. 4.3. #4 | ○ |
| Voltage (resolution) | 0.1V | 0.1V or better | ○ |

#1: Applying the transformer operated meters in the IEC62053-21.

#2: Power accuracy of the PW33990

#3: Total current accuracy of the PW3390 with the CT6844-05. The DC amplitude accuracy of CT6843-05, CT6845-05 and CT6846-05 is the same as CT6844-05's.

#4: Voltage accuracy of the PW3390

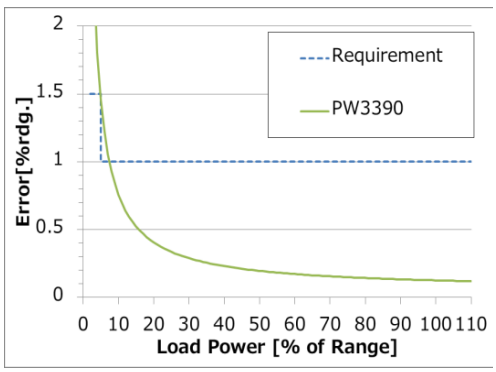


Fig. 4.1: Comparison of DC energy accuracy

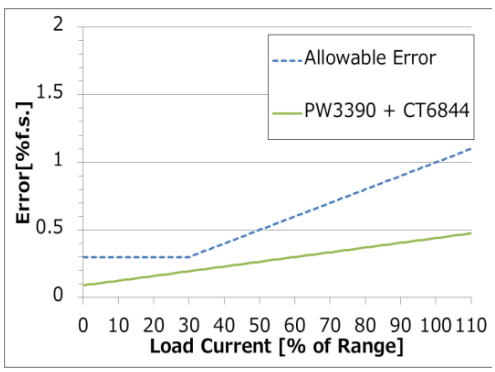


Fig. 4.2: Comparison of DC current accuracy

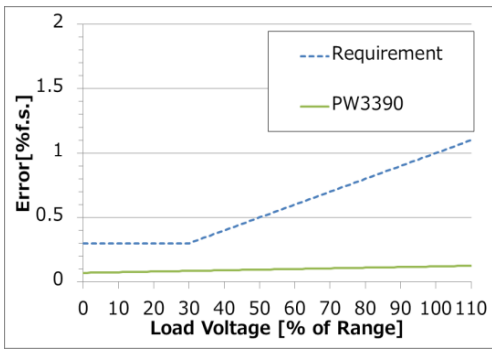


Fig. 4.3: Comparison of DC voltage accuracy

## 5. Evaluation of actual energy measurement performance

### 5.1. Purpose

Evaluate if the PW3390 has ability to satisfy the WLTP energy measurement accuracy requirement by the actual measurement.

### 5.2. Equipment used

Table 4 List of equipment used

| | Description | Model | Serial No. | Brand |
|---|---|---|---|---|
| DUT | Power Analyzer | PW3390-03 | 170113266 | HIOKI |
| Equipment | Standard Calibrator | 5700A | 2002601 | FLUKE |
| Equipment | Multi-product Calibrator | 5520A | 3066901 | FLUKE |

### 5.3. Required conditions

Satisfy the accuracy requirement of energy measurement in the Table 3.

### 5.4. Test method

Measure the DC energy on CH1 to CH4 of the PW3390 under the following conditions and judge the measurement accuracy. The current input method of PW3390 is a voltage input through current sensors. When measuring the rated current of current sensor, assuming that 2V is inputted from the current sensor, the voltage corresponding to each current value is inputted into PW3390.

Table 5: Test conditions

| | |
|---|---|
| Voltage input | 15V DC |
| Current input | Input the following DC voltage equivalent to 50A full scale.<br>±1%, ±2%, ±5%, ±10%, ±20%, ±50%, ±100% |
| PW3390 ranges | Voltage: 15V, Current: 50A |
| PW3390 LPF | OFF |
| PW3390 averaging | OFF |
| PW3390 sync. source | DC50ms |
| PW3390 integration period | 1 minute |
| PW3390 integration mode | DC |

### 5.5. Test result

PASS for the accuracy requirement of the IEC 62053-21 by having about 9 times margin.

Table 6: Test result

| CH | % of Rated current[%] | IEC 62053-21<br>Requirement [%] | Calibration Value[%] | Result |
|---|---|---|---|---|
| 1 | 2 to 5 | ±1.5 | -0.16 to +0.02 | **PASS** |
| 1 | 5 to 100 | ±1.0 | -0.02 to +0.02 | **PASS** |

| | | | | |
|---|---|---|---|---|
| 2 | 2 to 5 | ±1.5 | -0.16 to +0.16 | **PASS** |
| 2 | 5 to 100 | ±1.0 | -0.05 to +0.09 | **PASS** |
| 3 | 2 to 5 | ±1.5 | -0.11 to +0.05 | **PASS** |
| 3 | 5 to 100 | ±1.0 | -0.01 to +0.05 | **PASS** |
| 4 | 2 to 5 | ±1.5 | -0.16 to +0.01 | **PASS** |
| 4 | 5 to 100 | ±1.0 | -0.03 to +0.02 | **PASS** |

## 5.6. Method to confirm the actual capability of Energy (WP) Measurement

The energy (WP) is considered as the arithmetic mean of instantaneous active power (P) within the integration period. The test result of active power value can be understood as the integrated power result as shown in the Table 7. (The integration timer accuracy of the PW3390 is ±50ppm±1dgt., so that it is low enough to ignore for the power accuracy calculation.)

To assure the actual capability of the PW3390 for the accuracy required in the WLTP, we recommend to add the calibration points shown in the Table 6 (Input: % and ±5% of range),in addition to the standard calibration points.

Table 7: CH1 Test Result

| % of Rated current[%] | Udc[V] | Idc[A] | P[W] | WP[Wh] | P Error[%] | WP Error[%] |
|---|---|---|---|---|---|---|
| 1 | 15.002 | 0.502 | 7.54 | 0.12551 | 0.53 | 0.41 |
| 2 | 15.002 | 0.999 | 14.98 | 0.24959 | -0.13 | -0.16 |
| 5 | 15.002 | 2.499 | 37.50 | 0.62510 | 0.00 | 0.02 |
| 10 | 15.002 | 5.000 | 75.00 | 1.25000 | 0.00 | 0.00 |
| 20 | 15.002 | 10.000 | 150.01 | 2.50017 | 0.01 | 0.01 |
| 50 | 15.002 | 25.002 | 375.07 | 6.25133 | 0.02 | 0.02 |
| 100 | 15.002 | 50.006 | 750.17 | 12.5027 | 0.02 | 0.02 |
| -1 | 15.002 | -0.502 | -7.53 | -0.12546 | 0.40 | 0.37 |
| -2 | 15.002 | -0.999 | -14.99 | -0.24978 | -0.07 | -0.09 |
| -5 | 15.002 | -2.499 | -37.49 | -0.62488 | -0.03 | -0.02 |
| -10 | 15.002 | -4.998 | -74.98 | -1.24974 | -0.03 | -0.02 |
| -20 | 15.002 | -9.999 | -150.00 | -2.50004 | 0.00 | 0.00 |
| -50 | 15.002 | -25.002 | -375.07 | -6.25124 | 0.02 | 0.02 |
| -100 | 15.002 | -50.005 | -750.17 | -12.5031 | 0.02 | 0.02 |

## 6. Summary

- This document describes the understandings of the accuracy required for the RCB compensation by measuring the charge/discharge energy according to the WLTP.
- The accuracy specifications of the PW3390 are not able to satisfy the requirement when the input energy is very low to the measurement range.
- However, the PW3390 should be understood to have the enough capability to satisfy the requirement even when the input energy is very low to the measurement range, according to the energy test results.
- It is recommended to add the points shown in the Table 6 (Input: % and ±5% of range) for energy calibration to confirm and to assure the actual performance of the PW3390 when it is used for the WLTP measurement.

**Edition**

| Date | Edition | Details |
|---|---|---|
| June 8, 2017 | 1.0 | Initial release |
| November 28, 2017 | 1.1 | Correction of erroneous description and add an explanation |