

Achieving Accurate EV Range and Energy Consumption Testing Under WLTP Standards

Content

- Introduction
- Measurement Challenges
- Solutions
- Hioki's Approach to WLTP Integrated Power Accuracy
- Sample Verification Results for WLTP Measurements
 - 1. DC Integrated Power Accuracy
 - 2. 50/60 Hz Integrated Power Accuracy
- Conclusion
- Related Products
- Contact Information

Introduction

As electric vehicles (EVs) gain traction in the pursuit of sustainable mobility, accurate testing of range and energy consumption is critical for compliance with global standards. The Worldwide Harmonized Light Vehicles Test Procedure (WLTP) and SAE J1634 (aligned with EPA tests) mandate strict accuracy for parameters like energy (integrated power), current, and voltage to ensure reliable one-charge driving distance (km) and energy efficiency (Wh/km) calculations. WLTP requires $\pm 1\%$ accuracy for energy (per IEC 62053-21 Class 1), while both standards demand accuracy of $\pm 0.3\%$ of range or $\pm 1\%$ of reading (whichever is greater) for current and voltage.

Parameter	Unit	Accuracy	Resolution
Energy (electricity accumulation)	Wh	$\pm 1\%$ (IEC 62053-21 Class 1 equivalent)	0.001 kWh
Electric current	A	$\pm 0.3\%$ of range or $\pm 1\%$ of reading Whichever is greater	0.1 A

Voltage	V	$\pm 0.3\%$ of range or $\pm 1\%$ of reading Whichever is greater	0.1 V
---------	---	--	-------

Table 1. WLTP (Worldwide harmonized Light duty driving Test Procedure)

Parameter	Unit	Accuracy
Electric current	A	$\pm 0.3\%$ of range or $\pm 1\%$ of reading (whichever is greater)
Voltage	V	$\pm 0.3\%$ of range or $\pm 1\%$ of reading (whichever is greater)

Table 2. SAE J1634: Battery Electric Vehicle Energy Consumption and Range Test Procedure

Yet, meeting these standards poses challenges in vehicle testing. Many challenges exist in deciding the sensors and power analyzers that are to be used for measurement. This user’s guide will attempt to give a practical guide as to measurements and Hioki’s suggestions for solutions to these challenges.

Measurement Challenges

WLTP specifies pass-through or clamp-type current sensors, but many clamp sensors lack sufficient accuracy. At the same time, high-accuracy pass-through sensors that comply are cumbersome to install, making them impractical for vehicle testing. Additionally, since WLTP requires an accuracy of $\pm 1\%$ for energy (equal to integrated power), both the sensor and the power analyzer need to have excellent power accuracy. Furthermore, the testing requirements necessitate this level of performance at 23°C and -7°C (73.4°F and 19.4°F). Selecting tools that balance accuracy and practicality is challenging, as clamp-type sensors, while easier to attach, often fail to meet WLTP and SAE J1634 standards, requiring careful selection to ensure compliance.

Balancing these accuracy needs with practical vehicle measurements calls for highly accurate clamp-type current sensors in addition to high-accuracy power analyzers. Navigating the wide range of available instruments to find a suitable combination is challenging, but doing so offers users benefits like simplified workflows and assured compliance.

Solutions

Meeting WLTP and SAE J1634 Standards with Hioki Equipment

Hioki's PW4001 power analyzer, combined with our precision clamp current sensors, delivers the accuracy performance required by WLTP and SAE J1634 standards. The following performance charts (Figures 1-6) demonstrate how our equipment exceeds regulatory requirements:

- **Dotted lines** represent the minimum accuracy thresholds mandated by WLTP/SAE J1634
- **Solid lines** show the specifications of Hioki's PW4001 system

Key Performance Results

Voltage Measurements (Figure 1): The PW4001 consistently outperforms WLTP requirements for both DC and 50/60 Hz applications at 23°C and -7°C conditions.

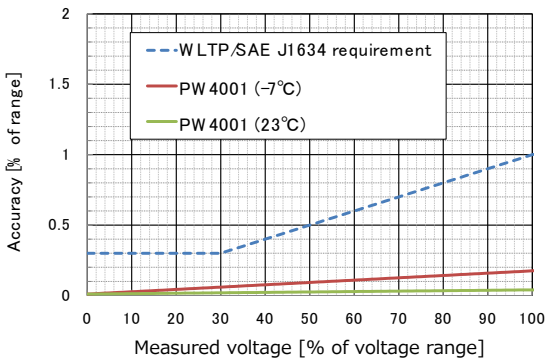


Fig. 1. PW4001 Voltage Accuracy (DC, 50/60 Hz)

Current Measurements (Figure 2): When paired with Hioki current sensors (CT6843A/6844A/6845A/6846A series and CT6833/6834 series), the system exceeds accuracy standards across the full measurement range.

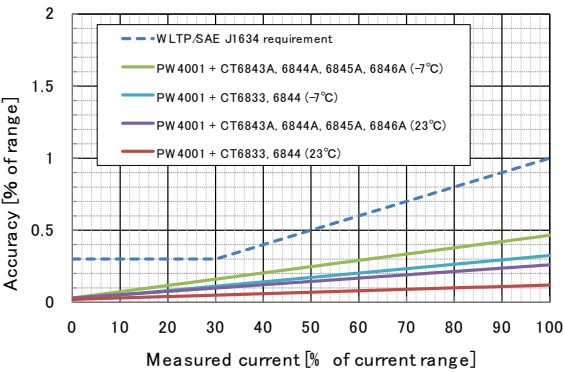


Fig. 2. Current Accuracy (DC, 50/60 Hz)

Integrated Power Accuracy (Figures 3-6): The PW4001 demonstrates superior performance for:

- DC applications at 400V and 800V system voltages
- AC applications at 50/60 Hz with various power factors (PF1 and PF0.5)

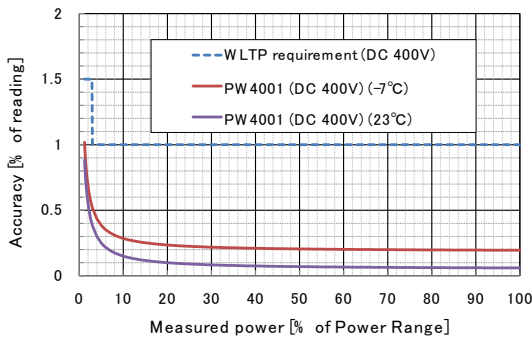


Fig. 3. PW4001 Integrated Power Accuracy (DC 400 V)

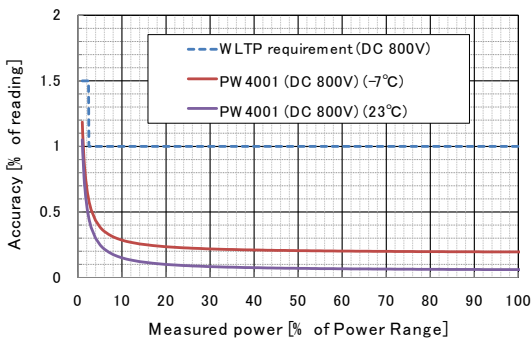


Fig. 4. PW4001 Integrated Power Accuracy (DC 800 V)

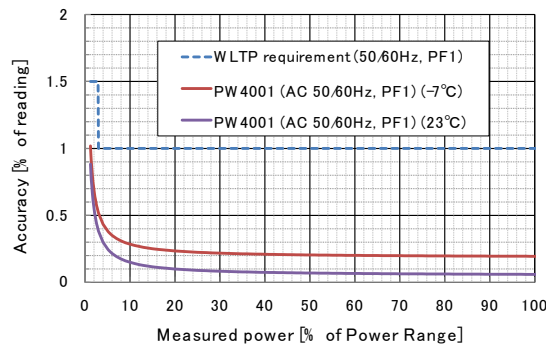


Fig. 5. PW4001 Integrated Power Accuracy (50/60 Hz, PF1)

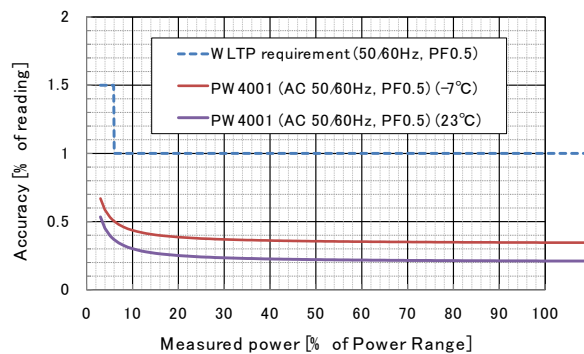


Fig. 6. PW4001 Integrated Power Accuracy (50/60 Hz, PF0.5)

Understanding Integrated Power Accuracy: This specification combines two critical factors:

1. Active power accuracy
2. Integration time accuracy ($\pm 0.02\%$ of reading)

Temperature Performance: The system maintains exceptional accuracy even under challenging test conditions. Under the WLTP, testing is required at -7°C and 23°C . At -7°C , compared to 23°C , the accuracy deteriorates by $\pm 0.135\%$ due to temperature effects; however, it still meets the requirements of WLTP.

Bottom Line: This combination of power analyzer and current sensors provides measurement accuracy that not only meets but significantly exceeds WLTP and SAE J1634 requirements, giving you confidence in regulatory compliance across these testing scenarios.

Hioki's Approach to WLTP Integrated Power Accuracy

Understanding the $\pm 1\%$ WLTP Requirement

WLTP mandates $\pm 1\%$ accuracy for integrated power measurements, referencing IEC 62053-21 Class 1 standards. While this IEC standard was originally designed for 50/60 Hz AC energy meters, WLTP applies its principles to EV testing scenarios.

Which Standard Applies to Your Testing?

IEC 62053-21 Class 1 defines two measurement categories:

- **Direct-connected meters:** No external sensors required
 - **Transformer-operated meters:** Use external sensors for measurement
- Since WLTP testing requires external current sensors, the transformer-operated meter accuracy requirements are what matter for your application (highlighted in red box in Table 3).

Current value for direct connected meters	Current value for transformer operated meters	Power factor	Percentage error limits for meters of class 1
$0.05I_b \leq I < 0.1I_b$	$0.02I_n \leq I < 0.05I_n$	1	± 1.5
$0.1I_b \leq I \leq I_{max}$	$0.05I_n \leq I \leq I_{max}$	1	± 1.0
$0.1I_b \leq I < 0.2I_b$	$0.05I_n \leq I < 0.1I_n$	0.5 (inductive) 0.8 (capacitive)	± 1.5 (inductive) ± 1.5 (capacitive)
$0.2I_b \leq I \leq I_{max}$	$0.1I_n \leq I \leq I_{max}$	0.5 inductive 0.8 (capacitive)	± 1.0 (inductive) ± 1.0 (capacitive)

Table 3. Integrated Power Accuracy of IEC 62053-21 Class 1 (I_b , I_n : rated current)

Key Accuracy Requirements from IEC 62053-21:

For power factor 1 (DC measurements), the standard requires:

- $\pm 1.5\%$ accuracy when current is between 2-5% of the instrument's current range
- $\pm 1.0\%$ accuracy when current is $\geq 5\%$ of the instrument's current range

Critical Consideration: Power Level Calculations

Here's an important point often overlooked: **Power accuracy depends on both**

current AND voltage levels.

Example:

- Current at 2% of range + Voltage at 50% of range = Power at 1% of range ($2\% \times 50\% = 1\%$)
- This means the required $\pm 1.5\%$ accuracy must be met starting from just 1% of the power range

The Key Insight: Lower voltage levels require accuracy compliance at correspondingly lower power levels. The lower your test voltage relative to the instrument's voltage range, the more demanding the accuracy requirements become across the power measurement range.

Why This Matters for EV Testing: This relationship between voltage level and power accuracy requirements is crucial when selecting measurement ranges for different EV architectures (12V, 24V, 48V, 400V, 800V systems), ensuring your equipment meets WLTP standards across these testing scenarios.

Sample Verification Results for WLTP Measurements

Below are a set of typical verification results for common WLTP conditions (all assuming -7°C and 23°C testing).

1. DC Integrated Power Accuracy

During chassis dynamometer tests, DC power (power factor 1) from a rechargeable energy storage system (REESS) is measured. REESS voltages include 12 V, 24 V, and 48 V—considered low-voltage architecture; and 400 V and 800 V—considered high-voltage architecture. When measuring high-voltage architecture, the input voltage will become a small percentage of the measuring instrument's voltage range.

- 400 V measurement on 600 V range: $400\text{ V} / 600\text{ V} = 66.7\% > 60\%$.
- 800 V measurement on 1500 V range: $800\text{ V} / 1500\text{ V} = 53\% > 50\%$.

See detailed comparisons of requirements and PW4001 specifications in Table 4 for a 400 V system and in Table 5 for an 800 V system.

Parameter	Requirements	PW4001 specifications	Judgment
Integrated power accuracy	$\pm 1.5\%$ of reading for 1.2% to 3% of power range (2% to 5% of current range ^{*1} , 60% of voltage range)	$\pm 0.883\%$ to $\pm 0.395\%$ of reading (23°C), $\pm 1.018\%$ to $\pm 0.530\%$ of reading (-7°C) (Fig. 3)	Compliant
Integrated power accuracy	$\pm 1.0\%$ of reading for $\geq 3\%$ of power range ($\geq 5\%$ of current range ^{*1} , 60% of voltage range)	$\pm 0.383\%$ to $\pm 0.060\%$ of reading (23°C), $\pm 0.518\%$ to $\pm 0.195\%$ of reading (-7°C) (Fig. 3)	Compliant
Integrated power resolution	0.001 kWh	0.001 kWh for 100 kWh to 1 MWh, ≤ 0.0001 Wh for < 100 kWh	Compliant
Current accuracy	Larger of $\pm 0.3\%$ of range or $\pm 1\%$ of reading	Fig. 2	Compliant
Current resolution	0.1 A	≤ 0.01 A	Compliant
Voltage accuracy	Larger of $\pm 0.3\%$ of range or $\pm 1\%$ of reading	Fig. 1	Compliant
Voltage resolution	0.1 V	≤ 0.01 V	Compliant

Table 4. Requirements and System Specifications for DC Measurements (DC 400 V System)

*1 See Table 3

Parameter	Requirements	PW4001 specifications	Judgment
Integrated power accuracy	$\pm 1.5\%$ of reading for 1% to 2.5% of power range (2% to 5% of current range ^{*1} , 50% of voltage range)	$\pm 1.050\%$ to $\pm 0.467\%$ of reading (23°C), $\pm 1.185\%$ to $\pm 0.602\%$ of reading (-7°C) (Fig. 3)	Compliant
Integrated power accuracy	$\pm 1.0\%$ of reading for $\geq 2.5\%$ of power range ($\geq 5\%$ of current range ^{*1} , 50% of voltage range)	$\pm 0.450\%$ to $\pm 0.060\%$ of reading (23°C), $\pm 0.585\%$ to $\pm 0.195\%$ of reading (-7°C) (Fig. 3)	Compliant

Integrated power resolution	0.001 kWh	0.001 kWh for 100 kWh to 1 MWh, ≤ 0.0001 Wh for < 100 kWh	Compliant
Current accuracy	Larger of $\pm 0.3\%$ of range or $\pm 1\%$ of reading	Fig. 2	Compliant
Current resolution	0.1 A	≤ 0.01 A	Compliant
Voltage accuracy	Larger of $\pm 0.3\%$ of range or $\pm 1\%$ of reading	Fig. 1	Compliant
Voltage resolution	0.1 V	≤ 0.01 V	Compliant

Table 5. Requirements and System Specifications for DC Measurements (DC 800 V System)

*1 See Table 3.

2. 50/60 Hz Integrated Power Accuracy

During charging, AC power (50/60 Hz) is measured, with voltages like AC 100 V, 200 V, and 400 V. Table 6 shows a comparison of required accuracy and accuracy specifications of the PW4001. Since these voltages are $\geq 60\%$ of voltage range, all evaluation results in the table are done at 60% voltage range with the stricter 0.5 inductive power factor.

Parameter	Requirements	PW4001 specifications	Judgment
Integrated power accuracy, power factor 1	$\pm 1.5\%$ of reading for 1.2% to 3% of power range (2% to 5% of current range*1, 60% of voltage range)	$\pm 0.883\%$ to $\pm 0.395\%$ of reading (23°C), $\pm 1.018\%$ to $\pm 0.530\%$ of reading (-7°C) (Fig. 5)	Compliant
Integrated power accuracy, power factor 1	$\pm 1.0\%$ of reading for $\geq 3\%$ of power range ($\geq 5\%$ of current range*1, 60% of voltage range)	$\pm 0.383\%$ to $\pm 0.060\%$ of reading (23°C), $\pm 0.518\%$ to $\pm 0.195\%$ of reading (-7°C) (Fig. 5)	Compliant
Integrated power accuracy, power factor 0.5 (inductive)	$\pm 1.5\%$ of reading for 3% to 6% of power range (5% to 10% of current range*1, 60% of voltage range)	$\pm 0.535\%$ to $\pm 0.371\%$ of reading (23°C), $\pm 0.670\%$ to $\pm 0.506\%$ of reading (-7°C) (Fig. 6)	Compliant
Integrated power accuracy, power factor 0.5	$\pm 1.0\%$ of reading for $\geq 6\%$ of power range ($\geq 10\%$ of current range*1, 60% of voltage range)	$\pm 0.368\%$ to $\pm 0.211\%$ of reading (23°C), $\pm 0.503\%$ to $\pm 0.346\%$ of reading (-7°C) (Fig. 6)	Compliant

(inductive)	voltage range)	7°C) (Fig. 6)	
Integrated power resolution	0.001 kWh	0.001 kWh for 100 kWh to 1 MWh, ≤ 0.0001 Wh for < 100 kWh	Compliant
Current accuracy	Larger of ±0.3% of range or ±1% of reading	Fig. 2	Compliant
Current resolution	0.1 A	≤ 0.01 A	Compliant
Voltage accuracy	Larger of ±0.3% of range or ±1% of reading	Fig. 1	Compliant
Voltage resolution	0.1 V	≤ 0.01 V	Compliant

Table 6. Requirements and System Specifications for 50/60 Hz Measurements

*1 See Table 3.

Conclusion

Meeting WLTP and SAE J1634 accuracy requirements alongside vehicle testing practicality demands high-accuracy power analyzers and clamp-type current sensors. Hioki’s solutions deliver this accuracy with user-friendly features, enabling confident EV range and energy consumption tests even in harsh conditions. This ensures compliance, speeds up development, cuts costs, and improves data integrity for better R&D decisions in mobility.

Visit [Hioki's website](#) or contact a local Hioki representative for details. Explore these tools for your needs and download technical notes for further insights.

Related Products

- Power Analyzer PW4001
- AC/DC Current Probe CT6833/CT6833-01
- AC/DC Current Probe CT6834/CT6834-01
- AC/DC Current Probe CT6843A
- AC/DC Current Probe CT6844A
- AC/DC Current Probe CT6845A
- AC/DC Current Probe CT6846A

Contact Information

If you have any questions or need further information, please feel free to reach out to us using our inquiry form at the link below:

[Contact Us](#)

To learn more about our power analyzers, please visit the following page for detailed information:

[Learn More About Hioki's Power Analyzers](#)

We are always here to assist you with any questions or inquiries.