6 Bainard Street
London, Ontario N6P 1A8 CANADA
tel (519)652-9959 www.elkor.net

Application Note AN2003

WattsOn/WattsOn-Mark II Performance Verification

Associated Product: WattsOn/WattsOn-Mark II

Summary

This application note discusses the equipment and procedure required to verify performance of a WattsOn or WattsOn-Mark II meter.

Equipment

1. WattsOn or WattsOn-Mark II meter (EUT)
2. Stable AC Voltage & Current Source (Current output isolated from Voltage outputs)
3. Accurate AC Voltmeter
4. Accurate AC Ammeter
5. Accurate AC Frequency Meter
6. Accurate AC Power Meter
7. Accurate AC kWh Meter
8. Data Collection System (any of the following):
   a. WattsOn Meter with Digital Display
   b. PC with Modbus Software (ie: Modbus Commander)
   c. Pulse Counter

Meter Models

The WattsOn and WattsOn-Mark II are available in various input/output configurations. All meters are capable of measuring up to 347Vac (line-to-neutral) / 600Vac (line-to-line).

It is imperative that the model type be observed with respect to the current inputs. Common input configurations include 5A, mA, mV and Rogowski Coil. For all meter types, it is recommended to perform any accuracy verifications with the CTs connected to the meter, as most often the meters are calibrated to take specific CT performance considerations into account. Additionally, non-5A meters (mA, mV, Rogowski Coil) do not have isolation between voltage and current channels (they rely the external CTs for isolation). If direct injection of signals is required into these meter types, contact Elkor for additional information and verification, as any damage will not be covered under warranty.

In the case of 5A meters, it is possible to inject up to the maximum rated amount of AC current directly into the CT terminals. The 5A meters have additional isolation between each CT channel, as well as between the CT inputs and voltage inputs. *The maximum ratings for the meters are 6A for the WattsOn and 10A for the WattsOn-Mark II.*

Meter Specifications

Inputs		
Control Power Input Rating	12-35V VDC / 24VAC, 100 mA max	
System Types Supported	Upto 347V (line-to-neutral) / 600V line-to-line (Delta/Wye) Single-phase installations up to 347V RMS Split-phase (two phase) installations	
Frequency	40-70 Hz	
Voltage Input Rating	5 to 347V L-N (600 V L-L)	
Voltage Continued Overload Rating	+20%	
Voltage Absolute Maximum Rating	450V L-N, 780V L-L	
Voltage Input Impedance	1.5MΩ (line-to-neutral) minimum, 3.0MΩ (line-to-line) minimum	
Voltage Wire Size	AWG 30-12, solid / stranded (AWG 16-22 recommended)	
Current Input Rating	Up to 200 mA RMS (–mA model) Up to 333 mV RMS (–mV model) Up to 10A RMS (–5A model)	
Current Continued Overload Rating	+20%	
Current Absolute Maximum Rating	400 mA RMS (–mA model) 666 mV RMS (–mV model) 20A RMS (–5A model)	
Current Burden/Input Impedance	1.5Ω total maximum(–mA model) 800kΩ minimum, 1.2MΩ typical (–mV model) 0.05Ω total maximum (–5A model)	
Current Wire Size	AWG 24-12, solid / stranded (AWG12-16 recommended for 5A CTs)	
Tightening Torque	7.0 Lb-In (Voltage), 4.4 Lb-In (Other)	
Outputs		
Serial	RS-485 2-wire Modbus RTU, 9600 (default) to 230400 baud Elkor Expansion Bus Port	
Relay	2x Solid-State Relay Outputs (100 mA @ 50V max)	
Indicators	3x Current Bi-color LEDs 3x Voltage LEDs 2x Relay State LEDs 1x Status Bi-color LED 2x Communication Bi-color LEDs	
Display	Back-lit Graphic LCD Display 128x32 (–DL models only)	
Accuracy		
Current (A)	0.05% typical	0.1% max
Voltage, Line-to-Neutral (V)	0.1% typical	0.2% max
Voltage, Line-to-Line (V)	0.2% typical	0.3% max
Real Power (W)	0.1% typical	0.2% max
Apparent Power (VA)	0.1% typical	0.2% max
Reactive Power (VAR)	0.1% typical	0.2% max
Energy	0.1% typical	0.2% max
Power Factor	0.2% max	
Frequency	0.01% max	
Sampling Rate	2 KHz	
Data Update Time	2 Hz	
Environmental		
Operating Temperature	–40°C to +70°C	
Storage Temperature	–65°C to +85°C	
Humidity	10 to 90% non-condensing	
Mechanical		
Mass	0.15 kg (–mA and –mV models) - 0.23 kg (–5A-DL model)	
Mounting	DIN Rail mounting 2-point screw mounting	
Regulatory		
Electromagnetic Emissions	FCC part 15 Class B (residential and industrial)	
Safety	UL 508 listed	
Accuracy	ANSI C12.20 Class 0.2	

Connection Methodology

The connection to the meter may be achieved by either a single, or three phase voltage source. In most cases a single phase calibrator is used and the voltages are connected in parallel so that each voltage channel measures the same voltage. It should be noted that in this case the line-to-line voltage measurements for the WattsOn will be incorrect (since it assumes a 120° angle phases). For the WattsOn-Mark II (which measures the voltage angle), the measurements will all be zero for both angle and line-to-line voltages.

For 5A meters, AC current inputs may be connected in series such that each channel measures the same current.

Unless using external CTs, for non-5A meters, it is mandatory to verify each current channel separately since the current channels are not isolated from each other, nor from the voltage inputs.

Due to the higher complexity of verifying a non-5A meter, it is highly advised to utilize the appropriate external CTs to avoid errors in measurement or damage to the meter.

Figure 1 shows the recommended connection method for a **5A meter**, using a single phase source:

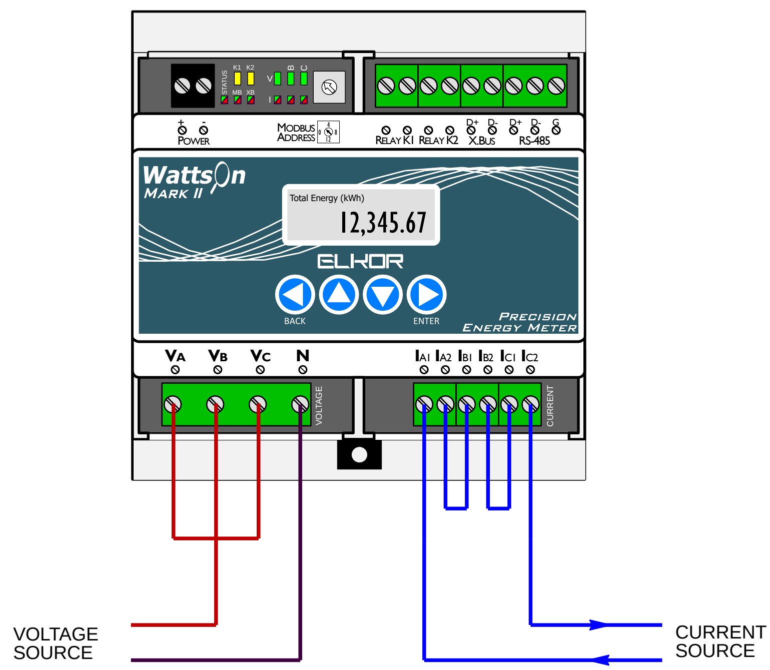

Figure 1

CT and PT Ratios

Prior to verifying the meter performance, the CT and PT ratio settings should be noted. If the meter verification is performed with a direct connection (ie: without CTs and PTs), then the ratio settings should either be changed to 1:1 for the measurements to match the input signals, or the appropriate correction factors should be later applied to the data collected.

Test points

The voltage, current, frequency and power factor values for each test point may be determined by the end application, however must not exceed the limits set out by the specification.

Typically, voltage and frequency remains constant and the current and power factor are varied over a number of test points. The meter has excellent linearity, and one test point at a line voltage, ½ scale current, and 0.7 power factor will yield sufficient data to assert the overall performance of the meter. A power factor of 0.7071 [cos(45°)] will yield a kW value equal to kVAR.

Instantaneous Measurement Verification

Verification of instantaneous values (Volts, Amps, kW, kVAR, kVA, Power Factor, Frequency, Voltage Angle), should be done using either the on-board display, or digital communications methods (ie: reading the Modbus Registers). Unless the source is extremely stable, it is recommended to average the readings over some time to minimize the effect of input signal fluctuation.

While it is possible to verify power (ie: kW) values using the pulse outputs, this is not recommended as the pulses have a relatively slow output rate. The effect of quantization would need to be considered, which would necessitate a rather long test cycle. This method also relies on a very steady voltage/current source.

Accumulated Measurement Verification (Register Reading Method)

The verification of accumulated values (kWh, kVARh, kVAh):

1. It is recommended to energize the voltages but leave the current disconnected/disengaged. It is also possible to do the opposite (apply current, but no voltage), however is rarely used based on how other meters work.
2. Either zero out the WattsOn energy registers, or note the register values, with as much precision as possible).
3. Zero out or record the accumulated energy on the reference meter.
4. Engage the voltage or current.
5. Allow the energy to accumulate for some time. The longer the accumulation period, the lower the error contribution of quantization affects, or timing issues. Typically 5 minutes is sufficient.
6. Collect the data from the relevant WattsOn registers (or reading the display), as well as the reference meter.
7. Perform error calculations taking into account CT/PT settings if applicable.

Accumulated Measurement Verification (Pulse Output Method)

It is possible to use the pulse outputs to confirm energy accumulation. For this method, it is necessary to know the scaling of the pulse outputs, as well as the CT and PT ratio settings. The WattsOn and WattsOn-Mark II have differing output scaling for the pulse outputs (specifically, the WattsOn does not take into account the CT/PT ratios, while the WattsOn-Mark II does).

1. Engage the voltage or current.
2. After the first pulse output from the WattsOn meter, zero out the reference meter.
3. Allow the energy to accumulate for some time, counting the subsequent pulses from the WattsOn meter. The longer the accumulation period, the lower the error contribution of quantization affects, or any timing issues. Typically 5 minutes is quite sufficient, depending on the methodology used to start/stop the reference meter accumulator.
4. After a sufficient number of pulses, STOP the reference meter accumulator immediately on the output of the last WattsOn pulse.
5. Higher reading accuracy may be achieved by monitoring the reading on the reference meter and slowing the energy accumulation (by reducing the current) shortly before the expected pulse. In this way, the effect of stray energy accumulation during pulse trigger is minimized.
6. Perform the error analysis by taking into account the WattsOn pulse scaling and corresponding reference meter data.