ARBITER 1133A POWER SENTINEL TEST

IEC 687 CERTIFICATION TESTS

DTC LABORATORY TEST REPORT

Report No. CL-212379

Prepared for

Arbiter Systems Inc.
1324 Vendels Circle, Suite 121
Paso Robles, CA 93446

Prepared by
Anthony D. Clarke

AMERICAN ELECTRIC POWER
(DOLAN TECHNOLOGY CENTER)

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Certificate of Conformance

Client:	Arbiter Systems Inc. 1324 Vendels Circle, Suite 121 Paso Robles, CA 93446
Product:	Power Sentinel GPS synchronized power quality/revenue standard
Model No.:	1133A
Test No.:	CL-212379

This certifies that the above device was found to be in conformance with the following specifications:

IEC 687 International Standard for Alternating Current Static Watt-hour Meter for Active Energy
(Classes 0.2 S and 0.5 S)

Section 5.4.6.2 Impulse voltage test
Section 5.4.6.3 A.C. voltage test
Section 5.5.2 Test of immunity to electrostatic discharges
Section 5.5.4 Fast transient burst test

Certified by:	Anthony D. Clarke
Title:	Sr. Engineering Technologist
Date:	September 14, 2001

Tested by: A. D. Clarke

Approved by: Kevin Sloving

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American Electric Power Laboratory Test Report

Client: Arbiter Systems Inc.
Tested by: A. D. Clarke
Date: 09-17-2001
Approved by:

1.0 GENERAL

The single sample device tested in this report is identified in Table 1. Functional performance of the EUT before and after each test was evaluated using the supplied GPS antenna and PSCSV™ configuration and data retrieval software. The sample unit tested included an optional RS-232 communications port. Other optional communications ports such as Ethernet, RS-485 and modem were not tested.

Table 1. Description of Equipment Under Test (EUT)

Manufacturer	Arbiter Systems Inc.	
Product Name	Power Sentinel – GPS Synchronized Power Quality/Revenue Standard 120V, 5A, (RS-232 option)	
Model No.	1133A	
EUT Identification	**Sample No.**	**Serial No.**
	1	0000058

2.0 PURPOSE

The purpose of this test was to perform certain Electromagnetic Compatibility (EMC), electrical stress and accuracy tests on a single EUT sample for certification to selected IEC 687 requirements. The specific tests listed in Table 2 were to be performed.

Table 2. Specific Test Objectives

Test Description	Product Standard	General Standard
A.C. Voltage Insulation Test	IEC 687	IEC 60-1
Impulse Voltage Insulation Test	IEC 687	IEC 60-1
EFT/Burst EMC Immunity Test	IEC 687	IEC 61000-4-4
Electrostatic Discharge (ESD) EMC Immunity Test	IEC 687	IEC 61000-4-2
Accuracy Requirement Tests	IEC 687	-

3.0 PROCEDURES

3.1 Impulse Voltage Insulation Test

This test was performed in accordance with IEC 687-1992-06/IEC 60-1 (1989). Ten positive and 10 negative impulses with a crest voltage of 6 kV were applied to the EUT. The impulses were applied between all circuits and ground, and between each circuit combination. The test was performed on circuits with a reference voltage greater than 40 V and with the EUT deenergized. The primary test equipment and associated configuration settings are noted in the following table.

Table 3. Impulse Voltage Insulation Test Equipment and Configuration

Test Equipment		Test Equipment Configurations	
Manufacturer/Description	**Model No.**	**Parameter**	**Value**
Haefely Impulse Tester	PU-12	Voltage	± 6 kV
		Impulses	10 pos./10 neg.
		Pulse Period	4s

3.2 A.C. Voltage Insulation Test

This test was performed in accordance with IEC 687-1992-06/IEC 60-1 (1989). A test voltage of 2.0 kV was applied to the EUT for 60 seconds, while monitoring the resulting leakage current. The test was performed on circuits with a reference voltage greater than 40 V and with the EUT deenergized The primary test equipment and associated configuration settings are noted in the following table.

Table 4. A.C. Voltage Insulation Test Equipment and Configuration

Test Equipment		Test Equipment Configurations	
Manufacturer/Description	**Model No.**	**Parameter**	**Value**
Associated Research Safety Analyzer	7530DT	Current Limit	18.00 mA
		Final Voltage	2.0 kV
		Ramp Rate	100 V/s
		Ramp Time	20 s
		Dwell Time	60 s

3.3 EFT/Burst Immunity Test

The EFT/Burst test was performed in accordance with the IEC 687-1992-06/IEC 61000-4-4 (1995-01) test specifications. The ±2 kV transient voltage was applied to the power supply, voltage/current measurement, relay output and event input circuits of the EUT in common mode only. The IRIG B and RS-232 ports were tested at ±1 kV using a capacitive coupling clamp. To fulfill the specified differential coupling mode tests between independent circuits, the voltage disturbance was applied to one circuit in common mode with the terminals of the other circuit tied to ground. The primary test equipment and associated configuration settings are noted in the following table.

Table 5. EFT/Burst Immunity Test Equipment and Configuration

Test Equipment		Test Equipment Configurations	
Manufacturer/Description	**Model No.**	**Parameter**	**Value**
Keytek EFT/Burst Simulator	ECAT with E411 Module	Voltage	± 2/1 kV
		Burst Frequency	2.5/5 kHz
		Burst Duration	15 ms
		Burst Period	300 ms
		Test Duration	60 s

3.4 ESD Immunity Test

This test was performed in accordance with IEC 687-1992-06/IEC 61000-4-2 (1995-01) using severity class level 4, direct-air mode electrostatic discharges. Ten 15 kV air discharges in each polarity were applied to each EUT target. The EUT was tested with rated measurement and power supply voltages applied, with the current inputs open circuited. The primary test equipment and associated configuration settings are noted in the following table.

Table 6. ESD Test Equipment and Configuration

Test Equipment		Test Equipment Configurations	
Manufacturer/Description	**Model No.**	**Parameter**	**Value**
Keytek Series 2000 ESD Test System	2030	Voltage	± 15 kV
		Test Mode	Direct air discharges
		Rate	Single shot

3.5 Accuracy Requirement Tests

The accuracy requirement tests were performed by the AEP Canton Meter Laboratory. The report section for this test is located in Appendix C.

4.0 TEST RESULTS

4.1 Impulse Voltage Insulation Test

Table 7. Impulse Voltage Insulation Test Results Summary

Application Point	Mode/Connection	Voltage (kV)	Results
All input/output terminals to ground	Common (L/V/I/R/C) – (G)	± 6	Pass
Power supply input	Differential (L1) – (L2/G)	± 6	Pass
Voltage input	Differential (V1) – (G/N/V2/V3) (V2) – (G/N/V1/V3) (V3) – (G/N/V1/V2)	± 6	Pass
Current Input	Differential (I1+) – (G/I2/I3) (I2+) – (G/I1/I3) (I3+) – (G/I1/I2) **Note: (Ix-) open circuited**	± 6	Pass
Contact Outputs	Differential (R1a) – (G/R1c/R2/R3/R4) (R2a) – (G/R2c/R1/R3/R4) (R3a) – (G/R3c/R1/R2/R4) (R4a) – (G/R4c/R1/R2/R3) **Note: across N.O. contact**	± 6	Pass
Event Inputs	Differential (C1+) – (G/C1-/C2/C3/C4) (C2+) – (G/C2-/C1/C3/C4) (C3+) – (G/C3-/C1/C2/C4) (C4+) – (G/C4-/C1/C2/C3)	± 6	Pass

4.2 A.C. Voltage Insulation Test

Table 8. A.C. Voltage Insulation Test Results Summary

Application Point	Final Voltage (kV)	Leakage Current	Results
All input/output terminals to ground	2.0	17.3 mA	Pass
Power supply input to Voltage inputs	2.0	5.6 mA	Pass
Power supply input to Current inputs	2.0	3.2 mA	Pass
Power supply input to Contact outputs	2.0	0.027 mA	Pass
Power supply input to Event inputs	2.0	2.8 mA	Pass
Voltage inputs to Current inputs	2.0	3.5 mA	Pass
Voltage inputs to Contact outputs	2.0	0.027 mA	Pass
Voltage inputs to Event inputs	2.0	3.1 mA	Pass
Current inputs to Contact outputs	2.0	0.027 mA	Pass
Current inputs to Event inputs	2.0	2.1 mA	Pass
Contact outputs to Event inputs	2.0	0.030 mA	Pass

4.3 ESD Immunity Test

Table 9. ESD Test Results Summary

Application Point	Discharge Mode	Voltage (kV)	Results
EUT front panel (LCD area)	Air	± 15	Pass
EUT front panel (Keypad/LED area)	Air	± 15	Pass
EUT front panel (Left area)	Air	± 15	Pass
EUT front panel (Right area)	Air	± 15	Pass
EUT left side area	Contact	± 15	Pass
EUT right side area	Contact	± 15	Pass
EUT top side area	Contact	± 15	Pass

4.4 EFT/Burst Immunity Test

Table 10. EFT/Burst Test Results Summary

Application Point	Common Mode Connection	Voltage (kV)	Results
Power supply input	(L1/L2) – (G)	± 2.0	Pass
Voltage inputs	(V1/V2/V3/N) – (G)	± 2.0	Pass
Current inputs	(I1+/I2+/I3+/N) – (G)	± 2.0	Pass
Contact outputs	(R1/R2/R3/R4) – (G)	± 2.0	Pass
Event inputs	(C1/C2/C3/C4) – (G)	± 2.0	Pass
IRIG B output	Cable clamp	± 1.0	Pass
RS-232 port	Cable clamp	± 1.0	Pass
Power supply input to Voltage inputs	(L1/L2) – (V1/V2/V3/N/G)	± 2.0	Pass
Power supply input to Current inputs	(L1/L2) – (I1/I2/I3/G)	± 2.0	Pass
Power supply input to Contact outputs	(L1/L2) – (R1/R2/R3/R4/G)	± 2.0	Pass
Power supply input to Event inputs	(L1/L2) – (C1/C2/C3/C4/G)	± 2.0	Pass
Voltage inputs to Current inputs	(V1/V2/V3/N) – (I1/I2/I3/G)	± 2.0	Pass
Voltage inputs to Contact outputs	(V1/V2/V3/N) – (R1/R2/R3/R4/G)	± 2.0	Pass
Voltage inputs to Event inputs	(V1/V2/V3/N) – (C1/C2/C3/C4/G)	± 2.0	Pass
Current inputs to Contact outputs	(I1+/I2+/I3+/N) – (R1/R2/R3/R4/G)	± 2.0	Pass
Current inputs to Event inputs	(I1+/I2+/I3+/N) – (C1/C2/C3/C4/G)	± 2.0	Pass
Contact outputs to Event inputs	(R1/R2/R3/R4) – (C1/C2/C3/C4/G)	± 2.0	Pass

4.5 Accuracy Requirement Tests

Refer to Appendix C for test results and data pertaining to the accuracy requirement tests.

5.0 CONCLUSION

The Arbiter 1133A Power Sentinel withstood the applied EMC and electrical stress tests without incidents. The device was found to be in compliance with the selected electrical and accuracy requirements specified in IEC 687.

APPENDIX A SAMPLE TEST WAVEFORMS

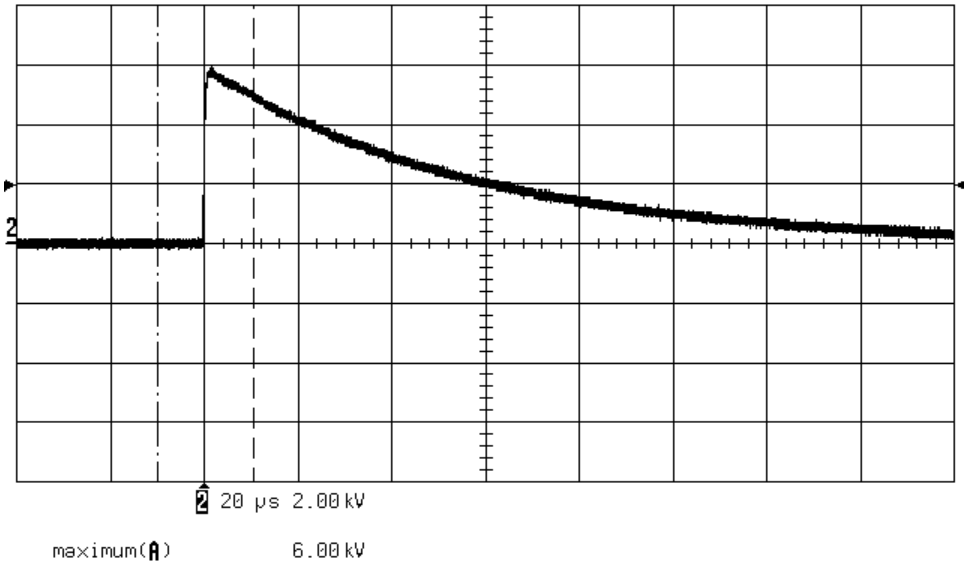


FIGURE 1. IEC 60-1 IMPULSE VOLTAGE WAVEFORM

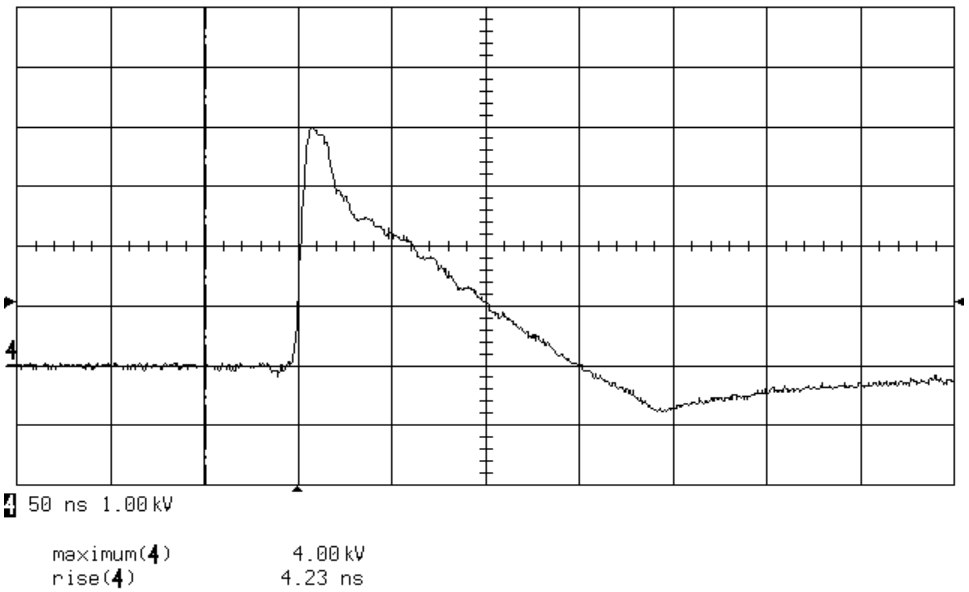


FIGURE 2. IEC 61000-4-4 IMPULSE VOLTAGE WAVEFORM

APPENDIX B TEST CONFIGURATIONS

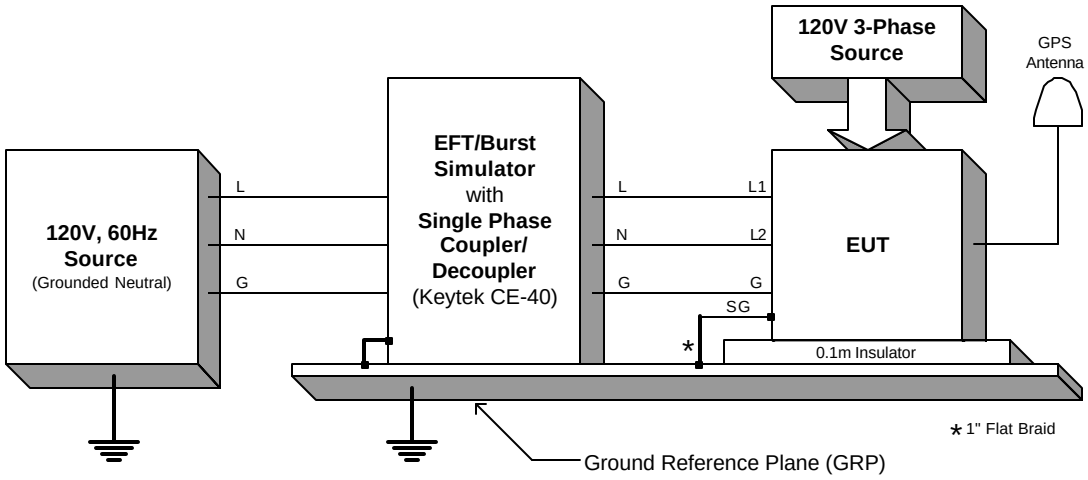


Figure 1. IEC 61000-4-4 EFT/Burst Test Setup
(Power Supply Input Test)

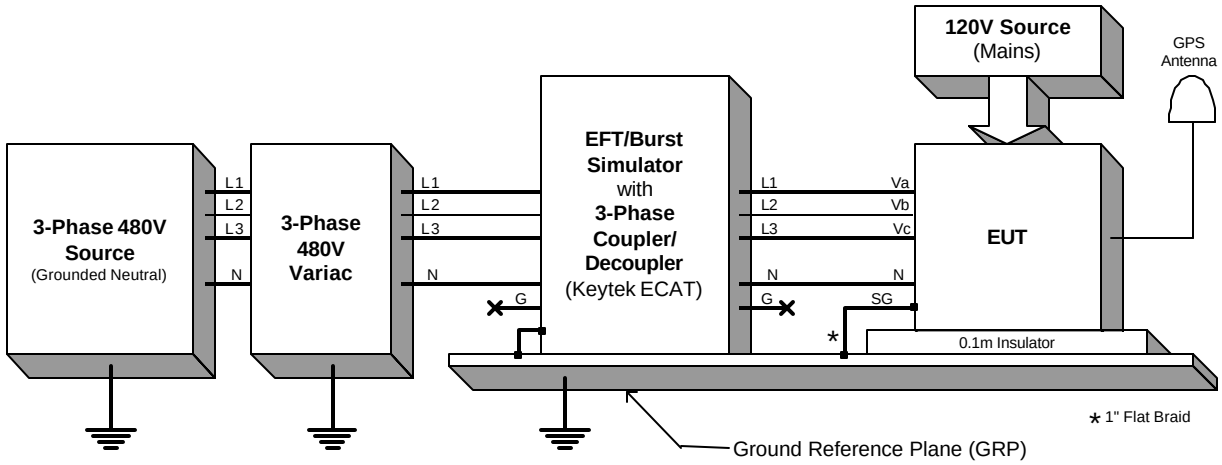


Figure 2. IEC 61000-4-4 EFT/Burst Test Setup
(Voltage Measurement Input Test)

APPENDIX B TEST CONFIGURATIONS

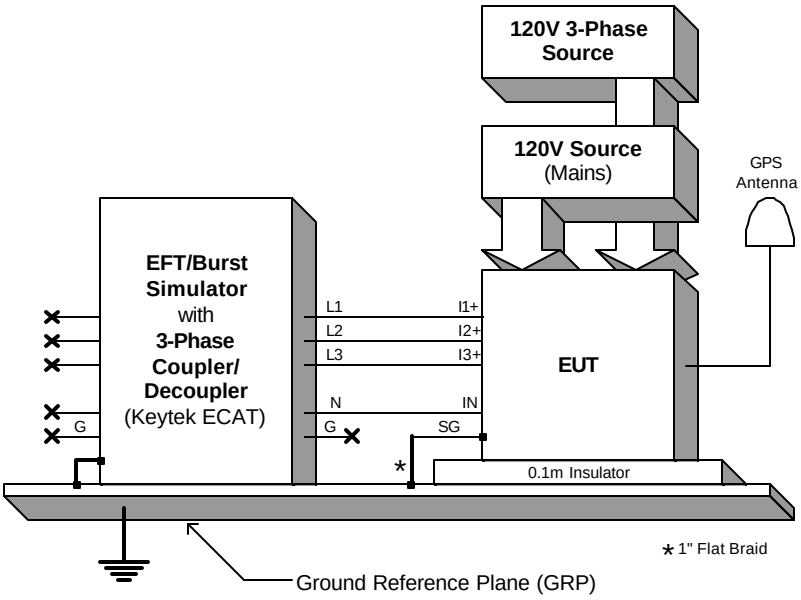


Figure 3. IEC 61000-4-4 EFT/Burst Test Setup
(Current Measurement Input Test)

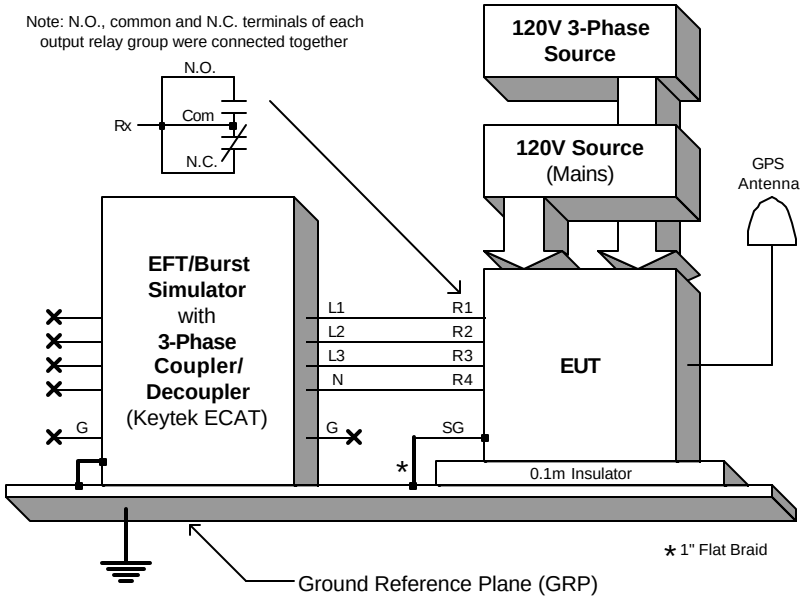


Figure 4. IEC 61000-4-4 EFT/Burst Test Setup
(Relay Contact Output Test)

APPENDIX B TEST CONFIGURATIONS

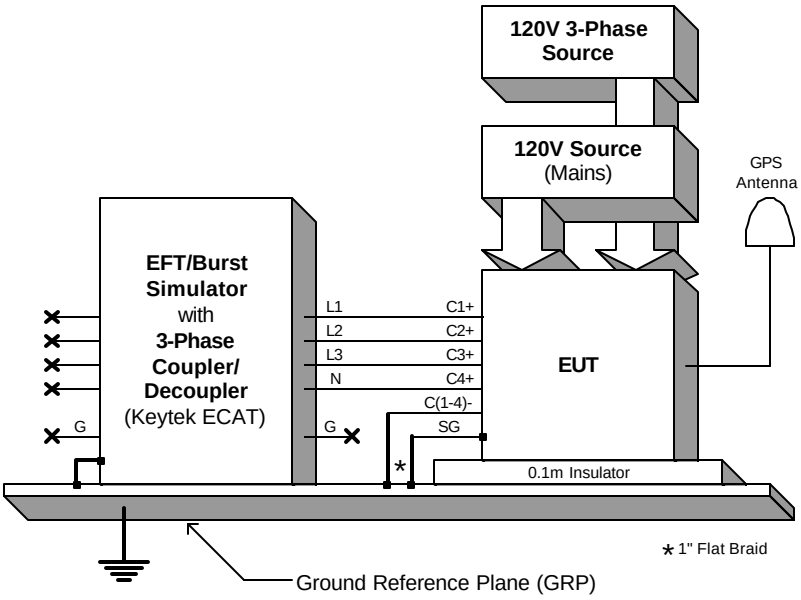


Figure 5. IEC 61000-4-4 EFT/Burst Test Setup
(Event Input Test)

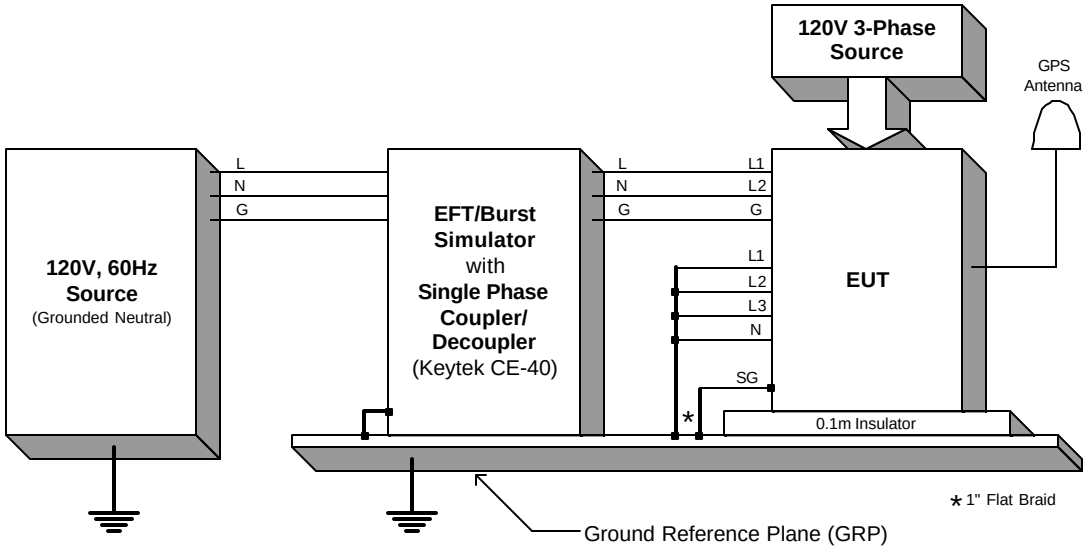
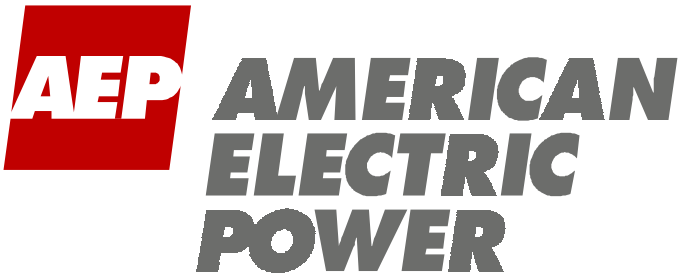


Figure 6. Sample Independent Circuit IEC 61000-4-4 EFT/Burst Test Setup
(Between Power Supply and Voltage Input Test)

APPENDIX C ACCURACY REQUIREMENTS TEST REPORT

(See following attachment)



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AMERICAN ELECTRIC POWER
Canton Meter Lab

Test Report for Arbiter Systems, Inc.

Test No. ABD 03765

Report by: T.V. Schrader Approved by: Jack Carr / Director of Meter Operations

Date: October 11, 2001

SUBJECT: Performance Test of Arbiter Systems, Inc. Model 1133A Power Sentinel

PURPOSE: To determine the performance of the Arbiter Model 1133A Power Sentinel with respect to the requirements of IEC 687, Second edition 1992-06, the International Standard for Alternating Current Static Watt-hour Meters for Active Energy (class 0.2 S).

The manufacturer provided one sample meter for test. This unit is identified as Serial Number 0000058.

The selected input configuration of this meter for most tests was three phase, three element, 120 Vrms, 5 Arms.

The manufacturer requested that these tests be performed:

4.6 Accuracy requirements

4.6.1 Limits of error due to variation of the current

4.6.2 Limits of error due to other influence quantities (voltage variation, frequency variation, waveform, phase sequence, voltage unbalance)*

4.6.3 Limits of error due to ambient temperature variation

4.6.4 Starting and running with no-load

*With the exception of electromagnetic HF fields

CONCLUSIONS: The performance of this meter was within the requirements of IEC 687 on all tests performed with one exception:

4.6.4.1 Initial startup of the meter specifies that, “the meter shall be functional within five seconds after the rated voltage is applied to the meter terminals”. It appears to take slightly longer (approximately six seconds) before the 1133A startup routine is completed.

TEST PROCEDURE: The meter was tested in accordance with the requirements of IEC 687, Second edition 1992-06, the International Standard for Alternating Current Static Watt-hour Meters for Active Energy (Class 0.2 S).

These meter quantities were used for most tests:
The reference voltage (Un) = 120 volts.
The rated current (In) = 5.0 amps.
The maximum current (Imax) = 5.9 amps*
* Note that the maximum rated current when the 5 amp range is selected is 5.9 Arms. Imax cannot be specified as 5.9 amps for all tests because the Waveform influence quantity adds 10% third harmonic to the fundamental, causing an over range condition. For testing of the Waveform influence quantity the meter input configuration was changed to 10 Arms, with In = 5.0 amps, and Imax = 10.0 amps.

Unless otherwise noted in the test results:
Polyphase loading was employed. This load was provided from an RFL 5800 Meter Calibration System. The common voltage input was connected to earth ground.
The meter was mounted in a Tenney Environmental Model No. T20S-1.5 chamber. The temperature in the chamber was maintained at 23C throughout the test.
The meter power supply was energized at 120 VAC, 60 Hz at all times.
The meter was synchronized via GPS satellite at all times during testing.
The meter was tested against Radian Research, Inc. Metronic Watthour Standards. The accuracy of these standards was verified by comparison with a Radian Research, Inc. Model RM-11-07 Metronic Primary Watthour Standard. A copy of the latest certificate of calibration for this standard is attached to this report.
The meter Revenue Log was programmed to record Watthours Delivered and Watthours Received at one-minute intervals. An Arbiter Systems, Inc. Model 1084B Satellite-Controlled Clock was used to provide synchronized pulses at the rate of one per second to the Standard Input of a Radian RM-109 Digital Watthour Comparator. The RM output of the RM-109 was connected to the Reset input of each Radian Standard. In order to provide a test length of two minutes the RM-109 Comparator was set to 120 pulses. To initiate a test run the RM-109 Start button was pressed just after 59 seconds after the minute was displayed on the 1084B clock. This caused the Radian Standards to begin running at the next pulse from the 1084B clock. At the end of each test run the Radian Standard readings were recorded, then later compared with the values recorded in the 1133A revenue log for those two minutes. At least two, two-minute tests were run at each test point.
The 1133A was programmed and read with via the RS-232 serial port with Arbiter Systems Power Sentinel CSV software, version 0.9.0.3.

TEST RESULTS:

4.6.1 Limits of error due to variation of the current

Table 9 - Balanced loads at reference conditions

A. 1.0 Power Factor

Amps	Percent Accuracy	
	Delivered	Received
0.05	99.80	99.79
0.10	99.91	99.91
0.15	99.94	99.95
0.25	99.97	99.96
0.50	99.99	99.98
1.00	99.99	99.99
1.50	100.00	99.99
2.00	100.00	99.99
2.50	100.00	99.99
3.00	100.00	99.99
3.50	100.00	99.99
4.00	100.00	99.99
4.50	100.00	99.99
5.00	100.00	99.99
5.50	100.00	99.99
5.90	99.98	99.97

B. 0.5 Lag Power Factor

Amps	Percent Accuracy	
	Delivered	Received
0.10	99.95	99.94
0.25	99.99	99.99
0.50	100.01	100.01
1.00	100.01	100.01
2.00	100.01	100.01
3.00	100.01	100.01
4.00	100.01	100.01
5.00	100.01	100.01
5.90	99.99	99.99

C. 0.8 Lead Power Factor

Amps	Percent Accuracy	
	Delivered	Received
0.10	99.89	99.89
0.25	99.96	99.95
0.50	99.98	99.97
1.00	99.98	99.98
2.00	99.99	99.98
3.00	99.99	99.98
4.00	99.99	99.98
5.00	99.99	99.98
5.90	99.97	99.96

Table 10 - Single-phase loads at reference conditions
A. 1.0 Power Factor

Amps	Percent Accuracy					
	Delivered			Received		
	Element A	Element B	Element C	Element A	Element B	Element C
0.25	99.97	99.96	99.96	99.96	99.96	99.97
0.50	99.98	99.98	99.99	99.97	99.98	99.99
1.00	99.99	99.99	99.99	99.99	99.98	99.99
3.00	100.00	99.99	99.99	99.99	99.99	99.99
5.00	99.99	99.99	99.99	99.99	99.99	99.99
5.90	99.98	99.98	99.97	99.98	99.97	99.97

B. 0.5 Lag Power Factor

Amps	Percent Accuracy					
	Delivered			Received		
	Element A	Element B	Element C	Element A	Element B	Element C
0.50	100.02	100.00	100.00	100.00	100.00	100.01
1.00	100.01	100.00	100.01	100.00	100.00	100.01
3.00	100.01	100.00	100.02	100.01	100.01	100.02
5.00	100.01	100.01	100.01	100.01	100.00	100.01
5.90	100.00	99.98	100.00	100.00	99.98	99.99

IEC 687 states that, “The difference between the percentage error when the meter is carrying a single-phase load and a balanced polyphase load at rated current and unity power factor, shall not exceed 0.4 % for meters of class 0.2 S”.
The maximum obtained deviation was 0.01 %.

4.6.2 Limits of error due to other influence quantities (voltage variation, frequency variation, waveform, phase sequence, voltage unbalance)

Table 11 - Influence quantities

A. Measuring circuit voltage +15% to -20%

1. Reference Performance

Volts	Amps	Power Factor	Percentage Error
120.0	0.25	1.0	-0.03
120.0	0.50	1.0	-0.01
120.0	1.00	1.0	-0.01
120.0	2.00	1.0	0.00
120.0	3.00	1.0	0.00
120.0	4.00	1.0	0.00
120.0	5.00	1.0	-0.01
120.0	5.90	1.0	-0.02
120.0	0.50	0.5 Lagging	0.01
120.0	1.00	0.5 Lagging	0.01
120.0	2.00	0.5 Lagging	0.02
120.0	3.00	0.5 Lagging	0.02
120.0	4.00	0.5 Lagging	0.02
120.0	5.00	0.5 Lagging	0.01
120.0	5.90	0.5 Lagging	-0.01

2. Variation of Influence Quantity - Reference Voltage minus 20%

Volts	Amps	Power Factor	Variation in Percentage Error from Reference Performance	
			Allowable	Obtained
96.0	0.25	1.0	+/- 0.3	0.00
96.0	0.50	1.0	+/- 0.3	0.00
96.0	1.00	1.0	+/- 0.3	0.00
96.0	2.00	1.0	+/- 0.3	0.00
96.0	3.00	1.0	+/- 0.3	0.00
96.0	4.00	1.0	+/- 0.3	0.00
96.0	5.00	1.0	+/- 0.3	0.00
96.0	5.90	1.0	+/- 0.3	0.00
96.0	0.50	0.5 Lagging	+/- 0.6	0.00
96.0	1.00	0.5 Lagging	+/- 0.6	0.00
96.0	2.00	0.5 Lagging	+/- 0.6	0.00
96.0	3.00	0.5 Lagging	+/- 0.6	0.00
96.0	4.00	0.5 Lagging	+/- 0.6	0.00
96.0	5.00	0.5 Lagging	+/- 0.6	0.00
96.0	5.90	0.5 Lagging	+/- 0.6	0.00

3. Variation of Influence Quantity - Reference Voltage plus 15%

Volts	Amps	Power Factor	Variation in Percentage Error from Reference Performance	
			Allowable	Obtained
96.0	0.25	1.0	+/- 0.3	0.00
96.0	0.50	1.0	+/- 0.3	0.00
96.0	1.00	1.0	+/- 0.3	0.00
96.0	2.00	1.0	+/- 0.3	0.00
96.0	3.00	1.0	+/- 0.3	0.00
96.0	4.00	1.0	+/- 0.3	0.00
96.0	5.00	1.0	+/- 0.3	0.00
96.0	5.90	1.0	+/- 0.3	0.00
96.0	0.50	0.5 Lagging	+/- 0.6	0.00
96.0	1.00	0.5 Lagging	+/- 0.6	0.00
96.0	2.00	0.5 Lagging	+/- 0.6	0.00
96.0	3.00	0.5 Lagging	+/- 0.6	0.00
96.0	4.00	0.5 Lagging	+/- 0.6	0.00
96.0	5.00	0.5 Lagging	+/- 0.6	0.00
96.0	5.90	0.5 Lagging	+/- 0.6	0.00

B. Frequency Variation +/- 5%

1. Reference Performance

Frequency (Hz)	Amps	Power Factor	Percentage Error
60.0	0.25	1.0	-0.03
60.0	0.50	1.0	-0.01
60.0	1.00	1.0	-0.01
60.0	2.00	1.0	0.00
60.0	3.00	1.0	0.00
60.0	4.00	1.0	0.00
60.0	5.00	1.0	-0.01
60.0	5.90	1.0	-0.02
60.0	0.50	0.5 Lagging	0.01
60.0	1.00	0.5 Lagging	0.01
60.0	2.00	0.5 Lagging	0.02
60.0	3.00	0.5 Lagging	0.02
60.0	4.00	0.5 Lagging	0.02
60.0	5.00	0.5 Lagging	0.01
60.0	5.90	0.5 Lagging	-0.01

2. Variation of Influence Quantity - Reference Frequency minus 5%

Frequency (Hz)	Amps	Power Factor	Variation in Percentage Error from Reference Performance	
			Allowable	Obtained
57.0	0.25	1.0	+/- 0.1	0.00
57.0	0.50	1.0	+/- 0.1	0.00
57.0	1.00	1.0	+/- 0.1	0.00
57.0	2.00	1.0	+/- 0.1	0.00
57.0	3.00	1.0	+/- 0.1	0.00
57.0	4.00	1.0	+/- 0.1	0.00
57.0	5.00	1.0	+/- 0.1	0.00
57.0	5.90	1.0	+/- 0.1	0.00
57.0	0.50	0.5 Lagging	+/- 0.1	0.00
57.0	1.00	0.5 Lagging	+/- 0.1	0.00
57.0	2.00	0.5 Lagging	+/- 0.1	0.00
57.0	3.00	0.5 Lagging	+/- 0.1	0.00
57.0	4.00	0.5 Lagging	+/- 0.1	0.00
57.0	5.00	0.5 Lagging	+/- 0.1	0.00
57.0	5.90	0.5 Lagging	+/- 0.1	0.00

3. Variation of Influence Quantity - Reference Frequency +5%

Frequency (Hz)	Amps	Power Factor	Variation in Percentage Error from Reference Performance	
			Allowable	Obtained
63.0	0.25	1.0	+/- 0.1	0.00
63.0	0.50	1.0	+/- 0.1	0.00
63.0	1.00	1.0	+/- 0.1	0.00
63.0	2.00	1.0	+/- 0.1	0.00
63.0	3.00	1.0	+/- 0.1	0.00
63.0	4.00	1.0	+/- 0.1	0.00
63.0	5.00	1.0	+/- 0.1	0.00
63.0	5.90	1.0	+/- 0.1	0.00
63.0	0.50	0.5 Lagging	+/- 0.1	0.00
63.0	1.00	0.5 Lagging	+/- 0.1	0.00
63.0	2.00	0.5 Lagging	+/- 0.1	0.00
63.0	3.00	0.5 Lagging	+/- 0.1	0.00
63.0	4.00	0.5 Lagging	+/- 0.1	0.00
63.0	5.00	0.5 Lagging	+/- 0.1	0.00
63.0	5.90	0.5 Lagging	+/- 0.1	0.00

C. Waveform: 10% of third harmonic in the current

For this test the meter voltage circuits were connected in parallel and the current circuits in series. The test voltage and current was then provided by the "A" phase of the RFL 5800 Meter Calibration System. The meter input configuration was changed to 10 Arms.

1. Reference Performance

Amps	Power Factor	Percentage Error
0.25	1.0	-0.06
0.50	1.0	-0.04
1.00	1.0	-0.01
2.00	1.0	-0.01
3.00	1.0	0.00
4.00	1.0	0.00
5.00	1.0	0.00
6.00	1.0	0.00
7.00	1.0	0.00
8.00	1.0	-0.01
9.00	1.0	0.00
10.00	1.0	-0.01

2. Variation of Influence Quantity - 10% of Third Harmonic in Phase with the Fundamental

Amps	Power Factor	Variation in Percentage Error from Reference Performance	
		Allowable	Obtained
0.25	1.0	+/- 0.1	-0.02
0.50	1.0	+/- 0.1	-0.01
1.00	1.0	+/- 0.1	0.00
2.00	1.0	+/- 0.1	0.00
3.00	1.0	+/- 0.1	0.00
4.00	1.0	+/- 0.1	0.00
5.00	1.0	+/- 0.1	0.00
6.00	1.0	+/- 0.1	0.00
7.00	1.0	+/- 0.1	0.00
8.00	1.0	+/- 0.1	0.00
9.00	1.0	+/- 0.1	0.00
10.00	1.0	+/- 0.1	0.00

3. Variation of Influence Quantity - 10% of Third Harmonic in Antiphase with the Fundamental

Amps	Power Factor	Variation in Percentage Error from Reference Performance	
		Allowable	Obtained
0.25	1.0	+/- 0.1	-0.02
0.50	1.0	+/- 0.1	0.01
1.00	1.0	+/- 0.1	0.00
2.00	1.0	+/- 0.1	0.00
3.00	1.0	+/- 0.1	0.00
4.00	1.0	+/- 0.1	0.00
5.00	1.0	+/- 0.1	0.00
6.00	1.0	+/- 0.1	0.00
7.00	1.0	+/- 0.1	0.00
8.00	1.0	+/- 0.1	0.00
9.00	1.0	+/- 0.1	0.00
10.00	1.0	+/- 0.1	0.00

D. Reversed phase sequence

1. Reference Performance - Phase Sequence ABC

Amps	Power Factor	Percentage Error
0.50	1.0	-0.01

2. Variation of Influence Quantity - Phase Sequence CBA

Amps	Power Factor	Variation in Percentage Error from Reference Performance	
		Allowable	Obtained
0.50	1.0	+/- 0.05	0.00

E. Voltage unbalance

1. Reference Performance - All Phases Energized - Balanced Load

Amps	Power Factor	Percentage Error
5.00	1.0	0.00

2. Variation of Influence Quantity - One or Two Phases Interrupted

Amps	Power Factor	Energized Phase(s)	Variation in Percentage Error from Reference Performance	
			Allowable	Obtained
5.00	1.0	AB	+/- 0.5	0.00
5.00	1.0	AC	+/- 0.5	0.00
5.00	1.0	BC	+/- 0.5	0.00
5.00	1.0	A	+/- 0.5	0.00
5.00	1.0	B	+/- 0.5	0.00
5.00	1.0	C	+/- 0.5	0.00

F. Auxiliary voltage +/- 15%

For this test the meter voltage circuits were connected in parallel and the current circuits in series. The load for this test was supplied from a Rotek 800A Precision Calibrator/ 880B High Current Amplifier. The auxiliary voltage was supplied from a Superior Electric Co. Powerstat variable autotransformer connected to Phase 1-N of a 3-phase, 4-wire source. The Rotek output was synched to Phase 1-N.

1. Reference Performance

Amps	Power Factor	Auxiliary Voltage	Percentage Error
0.05	1.0	120.0	-0.25

2. Variation of Influence Quantity - Auxiliary Voltage +/- 15%

Amps	Power Factor	Auxiliary Voltage	Variation in Percentage Error from Reference Performance	
			Allowable	Obtained
0.05	1.0	102.0	+/- 0.05	0.05
0.05	1.0	138.0	+/- 0.05	0.02

G. Phase of auxiliary supply voltage changed by +/- 120 degrees.

For this test the meter voltage circuits were connected in parallel and the current circuits in series. The load for this test was supplied from a Rotek 800A Precision Calibrator/ 880B High Current Amplifier. The Rotek output was synched to the line. A States Co. Catalog No. PR2-33603 phase shifter was used to adjust the relationship between the load voltage and current and the auxiliary supply voltage.

1. Reference Performance

Amps	Power Factor	Auxiliary Voltage	Percentage Error
0.05	1.0	In Phase with Load	-0.23

2. Variation of Influence Quantity - Phase of Auxiliary Voltage +/- 120 degrees

Amps	Power Factor	Auxiliary Voltage	Variation in Percentage Error from Reference Performance	
			Allowable	Obtained
0.05	1.0	Leads by 120 Degrees	+/- 0.1	0.00
0.05	1.0	Leads by 240 Degrees	+/- 0.1	0.04

H. Continuous magnetic induction of external origin

5.6.2 Test of influence quantities states “this magnetic field shall be applied to all accessible surfaces of the meter when it is mounted as for normal use”.

The specified electromagnet was placed at fifteen evenly spaced points on the top (five rows from side to side, three rows from front to back); three evenly spaced points on each side; five evenly spaced points on the front; and fifteen evenly spaced points on the bottom of the 1133A. This provided a total of 41 test points.

1. Reference Performance - No External Field

Amps	Power Factor	Percentage Error
5.00	1.0	-0.01

2. Variation of Influence Quantity - Extemal Magnetic Field

Amps	Power Factor	Electromagnet Position	Variation in Percentage Error from Reference Performance	
			Allowable	Maximum Obtained
5.00	1.0	Any	+/- 2.0	-0.01

I. Magnetic induction of external origin 0.5 mT

Table 11 states that a magnetic induction of external origin of 0.5 mT should be applied to the meter “under the most unfavourable conditions of phase and direction”.

For this test the meter was placed in the center of the external coil. The meter was positioned parallel to the plane of the field, and then tested with the phase angle of the load with respect to the current in the external field coil adjusted every 30 degrees from zero to 330.

The meter was then repositioned so that it was perpendicular to the plane of the field and all test points were repeated.

For this test the meter voltage circuits were connected in parallel and the current circuits in series.

A States Co. Catalog No. PR2-33603 phase shifter was used to adjust the relationship between the load voltage and current and the external field current. The test voltage was then provided from a Superior Electric Co. Powerstat variable autotransformer, and the test current from a Tesco RC-50A load box.

The strength of the external field was verified with a Magnetic Sciences International Model 20/25 Magnetic Field Meter.

1. Reference Performance - No External Field

Amps	Power Factor	Percentage Error
5.00	1.0	0.02

2. Variation of Influence Quantity - Extemal Magnetic Field

a. Meter **perpendicular** to external field

Amps	Power Factor	Phase Angle Between Load and Ext. Field (Degrees)	Variation in Percentage Error from Reference Performance	
			Allowable	Obtained
5.00	1.0	0.0	+/- 0.5	-0.02
5.00	1.0	30.0	+/- 0.5	-0.02
5.00	1.0	60.0	+/- 0.5	-0.01
5.00	1.0	90.0	+/- 0.5	0.00
5.00	1.0	120.0	+/- 0.5	0.01
5.00	1.0	150.0	+/- 0.5	0.02
5.00	1.0	180.0	+/- 0.5	0.02
5.00	1.0	210.0	+/- 0.5	0.02
5.00	1.0	240.0	+/- 0.5	0.01
5.00	1.0	270.0	+/- 0.5	0.00
5.00	1.0	300.0	+/- 0.5	-0.01
5.00	1.0	330.0	+/- 0.5	-0.02

b. Meter **parallel** to external field

Amps	Power Factor	Phase Angle Between Load and Ext. Field (Degrees)	Variation in Percentage Error from Reference Performance	
			Allowable	Obtained
5.00	1.0	0.0	+/- 0.5	0.01
5.00	1.0	30.0	+/- 0.5	0.00
5.00	1.0	60.0	+/- 0.5	0.00
5.00	1.0	90.0	+/- 0.5	0.00
5.00	1.0	120.0	+/- 0.5	0.00
5.00	1.0	150.0	+/- 0.5	0.00
5.00	1.0	180.0	+/- 0.5	-0.01
5.00	1.0	210.0	+/- 0.5	0.00
5.00	1.0	240.0	+/- 0.5	0.00
5.00	1.0	270.0	+/- 0.5	0.00
5.00	1.0	300.0	+/- 0.5	0.01
5.00	1.0	330.0	+/- 0.5	0.01

J. Electromagnetic HF fields.

This test was not performed.

K. Magnetic field of an accessory.

This influence quantity is not applicable to this meter.

4.6.3 Limits of error due to ambient temperature variation

Table 12 - Temperature coefficient

The Standard states that "the determination of the mean temperature coefficient for a given temperature shall be made over a 20 K temperature range, 10 K above and 10 K below that temperature".
The selected temperature for this test was 23 C.

Volts	Amps	P.F.	Percentage Error		
			13C	23C	33C
120.0	0.25	1.0	-0.03	-0.04	-0.04
120.0	0.50	1.0	-0.01	-0.02	-0.02
120.0	1.00	1.0	-0.01	-0.01	-0.01
120.0	2.00	1.0	0.00	-0.01	-0.01
120.0	3.00	1.0	0.00	0.00	-0.01
120.0	4.00	1.0	0.00	-0.01	-0.01
120.0	5.00	1.0	-0.01	-0.01	-0.01
120.0	5.90	1.0	-0.02	-0.02	-0.03
120.0	0.50	0.5 Lag	0.01	0.01	0.00
120.0	1.00	0.5 Lag	0.01	0.01	0.01
120.0	2.00	0.5 Lag	0.02	0.01	0.01
120.0	3.00	0.5 Lag	0.02	0.01	0.02
120.0	4.00	0.5 Lag	0.01	0.01	0.01
120.0	5.00	0.5 Lag	0.01	0.01	0.01
120.0	5.90	0.5 Lag	0.00	0.00	-0.01

Volts	Amps	P.F.	Temperature Coefficient at 23C (%/K)	
			Allowable	Obtained
120.0	0.25	1.0	0.01	0.001
120.0	0.50	1.0	0.01	0.000
120.0	1.00	1.0	0.01	0.000
120.0	2.00	1.0	0.01	0.000
120.0	3.00	1.0	0.01	0.000
120.0	4.00	1.0	0.01	0.000
120.0	5.00	1.0	0.01	0.000
120.0	5.90	1.0	0.01	0.000
120.0	0.50	0.5 Lag	0.02	0.001
120.0	1.00	0.5 Lag	0.02	0.000
120.0	2.00	0.5 Lag	0.02	0.000
120.0	3.00	0.5 Lag	0.02	0.000
120.0	4.00	0.5 Lag	0.02	0.000
120.0	5.00	0.5 Lag	0.02	0.000
120.0	5.90	0.5 Lag	0.02	0.000

4.6.4 Starting and running with no-load

4.6.4.1 Initial startup of the meter

The Standard states “the meter shall be functional within 5 seconds after the rated voltage is applied to the meter terminals”. When auxiliary power was applied to this 1133A, it appeared to take about six seconds before the meter responded to the keypad. After the meter had been synchronized to GPS and auxiliary power was interrupted, it took an average of approximately 13 seconds after the auxiliary power was restored before the UNLOCKED LED was extinguished.

4.6.4.2 Running with no-load

The specifications of this test do not strictly apply to this meter as it has no test pulse output at this time. The Standard says that “the minimum length of the test period shall be 20 times longer than the time between two pulses, when starting load (1.8 watts since In = 5A) is applied to the meter. During this test the test output device of the meter shall not emit more than one pulse”.
With the procedure used for these tests, the Standard could be viewed in this manner:
At starting load the Revenue Log of the 1133A would show .9 Wh in thirty minutes. The registration at no load must be less than 1/20 of that value (.045 Wh).
The energy recorded by the 1133A was far less than that value. With open current circuits and the voltage circuits energized at 138 volts, as specified in 5.6.4, some energy was registered in the Revenue Log. The maximum during this test was .006 Watthours Received in thirty minutes, with an average of .005 Wh per thirty minutes over the test period of 15 hours.

4.6.4.3 Starting

The Standard states “the meter shall start and continue to register at .001 In (0.005 amps) and unity power factor. For this test the meter voltage circuits were connected in parallel and the current circuits in series. The load was supplied from a Rotek 800A Precision Calibrator/ 880B High Current Amplifier. At the specified load this meter registered 99.5% with watthours delivered, and 100.1% with watthours received.

4.6.5 Meter Constant

This test does not apply to this meter as it has no test pulse output.

Radian Research, Inc.

Power and Energy Measurement Specialists

Certificate of Calibration

RM-11-07 Metronic Primary Watthour Standard
Serial Number: 5216
Customer Name: American Electric Power
P.O. Number: ED07-00009
Calibration Date: 16-Mar-01
CE Numbers:
RMA Number: 11495

ISO 9001Certified

This certifies the above instrument was calibrated in compliance with ISO 9001:1994 and ANSI/NCSL Z540-1-1994 using applicable Radian Research procedures. Radian Research Inc. certifies this instrument meets or exceeds all published specifications. This instrument was calibrated by an RS-703A Syntron Automated Calibration System which is traceable to the National Institute of Standards and Technology. The RS-703A Calibration System is traceable within the limitations of NIST's services, by accuracies derived from accepted values of natural physical constants, or by accuracies derived from accepted ratio type calibration techniques. The RS-703A Calibration System is cross checked and calibrated on a schedule which is adjusted to maintain required accuracies and traceability.

Our As Found Test Results showed your instrument was:
[X] In Tolerance [ ] Out of Tolerance [ ] Inoperative [ ] Limited Calibration
For out of tolerance conditions, As found Data Reports are furnished.
Radian Research recommends a 12 month Calibration interval for Standards.
Calibration due date: 16-Mar-02

Applicable Traceability & Report Numbers for Radian Research Primary References:

Watthour, VA hour; Varhour, Qhour, Milliamp hour
Radian Watthour Reference Standard #800
3)RM-11-01's: S/N'S:5213, 5293, 5303
1)RM-110 S/N 102659
NIST Test No.....811/263914-00 Calibration Due Date 12-Jul-01.

Millivolt hour and Volts-Squared hour;
Radian Volts-Squared hour Reference Standard
3)RM-11-V2's: S/N'S:503896, 503898, 503899
NIST Test No.....811/264394-01 Calibration Due Date 7-Nov-01.

Timebase;
Hewlett Packard Model 5334B 100 MHz Universal Counter (serial number 2839A02175)
Agilent Technologies Cert. No. 2613H252501 Calibration Due Date 29-Jan-02.

Technician Signature

Scott E Blackwell LAB 47

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Radian Research, Inc.

Power and Energy Measurement Specialists

Calibration Report

RM-11-07 Metronic Primary Watthour Standard

Mode.....Watthour 60 Hertz

Date..... 16-Mar-01

Serial Number..... 5216

The following data was collected by an RS-703A Syntron Automated Calibration System
The RS-703A is calibrated to a bank of three RM-11 Standards certified by the National Institute of Standards and Technology (NIST) to an uncertainty of .004% @ unity, and .005% @ 60° lagging Power Factor. Calibration temperature is 23 degrees Centigrade. Test time is 15 seconds per point with a 5 second stabilization time between points. Timing is done by gating the pulse output. For lagging power factors, current lags voltage. All readings are in percent error. RM-11 watthour accuracy is +/- .025% (worst case). The RS-703A has a (5) times greater accuracy in Watthour.

Voltage & Phase Angle

Amps	120 Unity	120 60°Lag	240 Unity	240 60°Lag	480 Unity	480 60°Lag	600 Unity	600 60°Lag
0.25	-0.003	-0.003	-0.005	-0.005	-0.005	-0.002	-0.004	0.000
0.5	-0.004	-0.007	-0.007	-0.010	-0.010	-0.006	-0.008	-0.005
1.0	-0.004	-0.004	-0.005	-0.001	-0.005	-0.002	-0.004	0.000
2.0	-0.005	-0.008	-0.008	-0.008	-0.009	-0.008	-0.008	-0.005
2.5	-0.003	-0.009	-0.006	-0.008	-0.008	-0.007	-0.006	-0.003
3.0	-0.003	-0.005	-0.006	-0.003	-0.007	-0.002	-0.004	-0.001
5.0	-0.002	-0.002	-0.003	-0.002	-0.005	0.000	-0.005	0.001
10.0	-0.003	-0.004	-0.006	-0.007	-0.006	-0.005	-0.005	-0.002
12.0	-0.004	-0.005	-0.005	-0.004	-0.005	-0.004	-0.004	0.000
15.0	-0.001	-0.002	-0.005	-0.001	-0.005	0.001	-0.005	0.001
20.0	-0.003	0.000	-0.003	-0.002	-0.005	0.002	-0.005	0.002
25.0	-0.001	-0.003	-0.003	-0.002	-0.004	0.000	-0.004	0.002
30.0	-0.004	-0.012	-0.008	-0.009	-0.008	-0.008	-0.005	-0.005
40.0	-0.004	-0.008	-0.006	-0.005	-0.007	-0.006	-0.005	-0.003
45.0	-0.002	-0.004	-0.005	-0.005	-0.007	-0.002	-0.005	-0.001
50.0	-0.003	-0.003	-0.004	-0.002	-0.003	0.000	-0.004	0.001
Average	**-0.003**	**-0.005**	**-0.005**	**-0.005**	**-0.006**	**-0.003**	**-0.005**	**-0.001**
Minimum	-0.005	-0.012	-0.008	-0.010	-0.010	-0.008	-0.008	-0.005
Maximum	-0.001	0.000	-0.003	-0.001	-0.003	0.002	-0.004	0.002

Overall	Unity	60°Lag
Average	-0.005	-0.003
Minimum	-0.010	-0.012
Maximum	-0.001	0.002

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Web Site: www.radianresearch.com

Radian Research, Inc.

Power and Energy Measurement Specialists

Calibration Report

RM-11-07 Metronic Primary Watthour Standard

Mode.....Varhour 60 Hertz

Date..... 16-Mar-01

Serial Number..... 5216

The following data was collected by an RS703A Syntron Automated Calibration System. The RS-703A Varhour Calibration is derived directly from the (NIST) Watthour Calibration by the use of ultra low distortion synthesis and digital delay. Uncertainty is .005% for Varhour. Calibration temperature is 23 degrees Centigrade. Test time is 15 seconds per point with a 5 second stabilization time between points. Timing is done by gating the pulse output. For for lagging power factors, current lags voltage. All readings are in percent error. RM-11 Varhour accuracy is +/- .05% (worst case). The RS-703A has a (10) times greater accuracy in Varhour.

Voltage & Phase Angle

Amps	120 90°Lag	120 30°Lag	240 90°Lag	240 30°Lag	480 90°Lag	480 30°Lag	600 90°Lag	600 30°Lag
0.25	0.010	0.011	0.003	0.005	0.002	0.004	0.005	0.007
0.5	0.008	0.002	0.002	0.000	0.001	-0.006	0.000	-0.001
1.0	0.009	0.008	0.003	0.003	0.003	0.003	0.001	0.003
2.0	0.005	0.001	0.002	-0.004	-0.001	-0.007	-0.001	-0.004
2.5	0.004	0.005	0.002	0.003	0.000	-0.003	0.001	0.001
3.0	0.006	0.005	0.001	0.003	0.000	-0.001	0.000	-0.001
5.0	0.007	0.010	0.002	0.005	0.003	0.003	0.004	0.005
10.0	0.004	0.002	0.001	0.000	-0.001	-0.002	0.001	-0.002
12.0	0.005	0.002	0.002	-0.003	0.002	-0.002	0.002	-0.001
15.0	0.004	0.005	0.001	0.000	0.002	-0.001	0.002	0.000
20.0	0.002	0.002	0.002	0.000	0.001	0.000	0.002	0.001
25.0	0.005	0.001	0.002	0.001	0.002	0.001	0.003	0.001
30.0	-0.002	-0.008	-0.002	-0.010	-0.002	-0.008	-0.002	-0.007
40.0	-0.001	-0.007	-0.003	-0.009	-0.003	-0.009	-0.002	-0.006
45.0	-0.003	-0.010	-0.002	-0.010	-0.002	-0.007	-0.002	-0.005
50.0	-0.001	-0.009	-0.001	-0.008	-0.002	-0.007	-0.001	-0.005
Average	**0.004**	**0.001**	**0.001**	**-0.002**	**0.000**	**-0.003**	**0.001**	**-0.001**
Minimum	-0.003	-0.010	-0.003	-0.010	-0.003	-0.009	-0.002	-0.007
Maximum	0.010	0.011	0.003	0.005	0.003	0.004	0.005	0.007

Overall	**90°Lag**	**30°Lag**
Average	0.001	-0.001
Minimum	-0.003	-0.010
Maximum	0.010	0.011

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Radian Research, Inc.

Power and Energy Measurement Specialists

Calibration Report

RM-11-07 Metronic Primary Watthour Standard

Mode.....Qhour 60 Hertz

Date..... 16-Mar-01

Serial Number..... 5216

The following data was collected by an RS703A Syntron Automated Calibration System. The RS-703A Qhour Calibration is derived directly from the (NIST) Watthour Calibration by the use of ultra low distortion synthesis and digital delay. Uncertainty is .005% for Qhour. Calibration temperature is 23 degrees Centigrade. Test time is 15 seconds per point with a 5 second stabilization time between points. Timing is done by gating the pulse output. For for lagging power factors, current lags voltage. All readings are in percent error. RM-11 Qhour accuracy is +/-.05% (worst case). The RS-703A has a (10) times greater accuracy in Qhour.

Voltage & Phase Angle

Amps	120 60°Lag	120 Unity	240 60°Lag	240 Unity	480 60°Lag	480 Unity	600 60°Lag	600 Unity
0.25	-0.007	0.008	-0.007	0.007	-0.007	0.008	-0.004	0.009
0.5	-0.010	0.004	-0.008	0.000	-0.011	0.002	-0.008	0.001
1.0	-0.008	0.009	-0.008	0.005	-0.007	0.004	-0.005	0.005
2.0	-0.008	0.003	-0.010	0.000	-0.011	-0.001	-0.010	0.001
2.5	-0.008	0.003	-0.009	0.002	-0.010	0.000	-0.009	0.003
3.0	-0.007	0.007	-0.009	0.003	-0.009	0.001	-0.008	0.003
5.0	-0.006	0.007	-0.007	0.004	-0.008	0.006	-0.006	0.005
10.0	-0.009	0.002	-0.010	-0.001	-0.010	0.000	-0.008	0.000
12.0	-0.008	0.003	-0.010	0.000	-0.009	0.002	-0.006	0.003
15.0	-0.007	0.005	-0.009	0.004	-0.009	0.003	-0.007	0.003
20.0	-0.009	0.005	-0.009	0.000	-0.008	0.003	-0.007	0.005
25.0	-0.010	0.001	-0.008	0.006	-0.007	0.002	-0.006	0.005
30.0	-0.013	-0.004	-0.012	-0.006	-0.013	-0.003	-0.009	-0.001
40.0	-0.012	-0.007	-0.013	-0.004	-0.011	-0.003	-0.010	0.000
45.0	-0.012	-0.006	-0.012	-0.006	-0.011	-0.007	-0.010	0.000
50.0	-0.014	-0.007	-0.012	-0.006	-0.010	-0.001	-0.007	0.001
Average	**-0.009**	**0.002**	**-0.010**	**0.001**	**-0.009**	**0.001**	**-0.008**	**0.003**
Minimum	-0.014	-0.007	-0.013	-0.006	-0.013	-0.007	-0.010	-0.001
Maximum	-0.006	0.009	-0.007	0.007	-0.007	0.008	-0.004	0.009

	60°Lag	Unity
Average	-0.009	0.002
Minimum	-0.014	-0.007
Maximum	-0.004	0.009

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