Project no.	GZES2009028569V		
Client :	Portable Solar LLC		
Product Name :	Hybrid Inverter	Hybrid Inverter	Hybrid Inverter
Testing Location :	~~In-house Lab /~~ TMP ~~/ Others:~~		
Class :	I ~~/ II / III /~~ ~~Not classified~~	Movability :	Fixed installation
Rating :	**Sol-Ark-12K-P** AC side: AC Voltage@120/240V: 240V(211V-264V), 37.5A, 9000W(L-L) / 4800W(L-N), 60Hz, AC Voltage@120/208V: 208V(183V-229V), 40.0A, 9000W(L-L) / 4800W(L-N), 60Hz PV side: 150dc-500Vdc (MPPT range:175Vdc-425Vdc), 20A/20A Battery side: 48Vdc(41Vdc-59Vdc), 190A **Sol-Ark-9k-48-ST** AC side: AC Voltage@120/240V: 240V(211V-264V), 37.5A, 9000W(L-L) / 4800W(L-N), 60Hz, AC Voltage@120/208V: 208V(183V-229V), 40.0A, 9000W(L-L) / 4800W(L-N), 60Hz PV side: 150dc-500Vdc (MPPT range:175Vdc-425Vdc), 18A/18A Battery side: 48Vdc(41Vdc-59Vdc), 190A **Sol-Ark-8k-48-ST** AC side: AC Voltage@120/240V: 240V(211V-264V), 33.0A, 8000W(L-L) / 4800W(L-N), 60Hz, AC Voltage@120/208V: 208V(183V-229V), 38.5A, 8000W(L-L) / 4800W(L-N), 60Hz PV side: 150dc-500Vdc (MPPT range:175Vdc-425Vdc), 18A/18A Battery side: 48Vdc(42Vdc-61Vdc), 190A **Sol-Ark-5k-48-ST** AC side: AC Voltage@120/240V: 240V(211V-264V), 20.8A, 5000W(L-L) / 3500W(L-N), 60Hz, AC Voltage@120/208V: 208V(183V-229V), 24.0A, 5000W(L-L) / 3500W(L-N), 60Hz PV side: 150dc-500Vdc (MPPT range:175Vdc-425Vdc), 10A/10A		

	Battery side: 48Vdc(42Vdc-61Vdc), 120A -25 ºC to 55 ºC, NEMA type 1, Software revision COMM: f23b MCU: Ver1585
Standard(s) :	☒ **UL 1741 (April 20, 2010 Ed.2) CRD issued on March 8, 2019, Subject: Power Control Systems(PCS)**
Remarks: 1) The equipment list is detail in the attached appendix bearing the same project number.	

Retest List :

Retest clauses	Retest date	Result
/	/	/

Tested By	Hugo Zhang	Tested Period :	2020-11-01 to 2020-11-23
Checked By:	Reynolds	Date:	2020-11-21

Section Number:	Test Description:	Test Result:
203.5	Step Change in Load Test	P
203.6	Step Change in Generation Test	P
204	Optional Test	N/A
205	Abnormal Tests	P

203 Normal Operating Tests

203.1 Normal Operating Tests record and characterize the performance of the PCS during normal operation. These tests monitor currents flowing in PCS controlled conductors in response to step changes in load with generation held constant and in response to step changes in generation with load held constant.
203.2 For testing any required overcurrent devices shall be installed as required in the PCS instructions for the end application. During all tests in Section 203 the EUT shall not result in the opening of any overcurrent protective device. Ratings of overcurrent protective devices used during the testing shall be as specified in the manufacturer's instructions.
203.3 No specific pass / fail criteria currently exist for the temporal response of the PCS. Until standardized temporal requirements are developed, the maximum open loop response shall be less than or equal to 30 seconds. Faster PCS response times are allowed and may be required to meet specific utility requirements.
203.4 The Normal Operation Tests shall use the test setup shown in Figure 203.1 for AC coupled systems or Figure 203.2 for DC coupled systems. For hybrid systems which are capable of combined AC and DC coupled systems the EUT shall be evaluated both as an AC coupled system and as a DC coupled system.

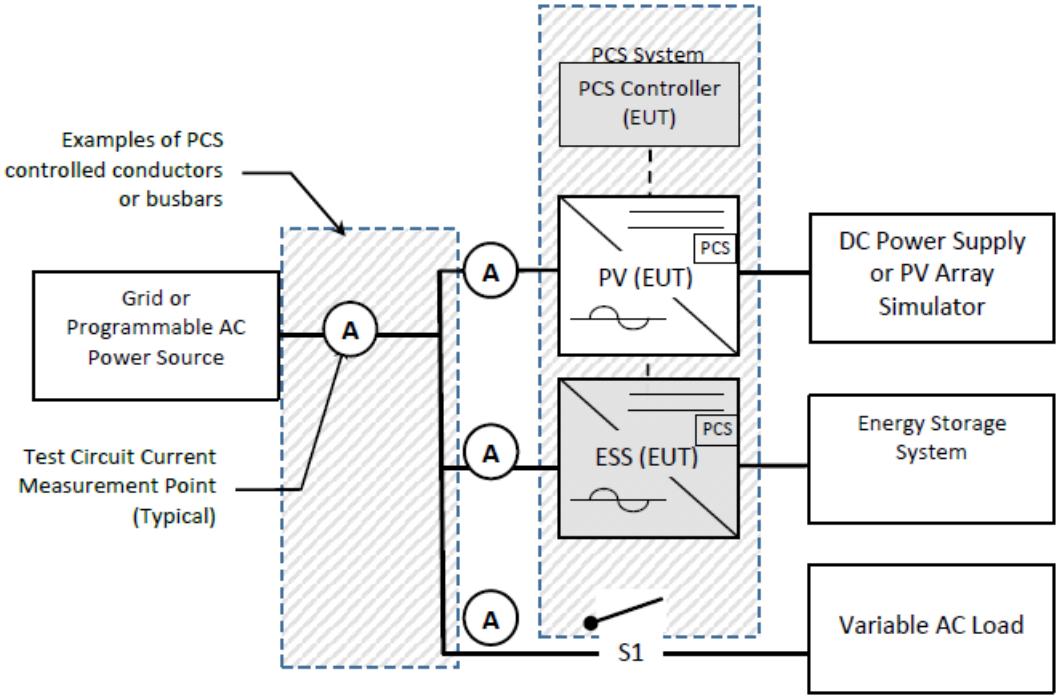

Figure 203.1 – Test Circuit AC Coupled System

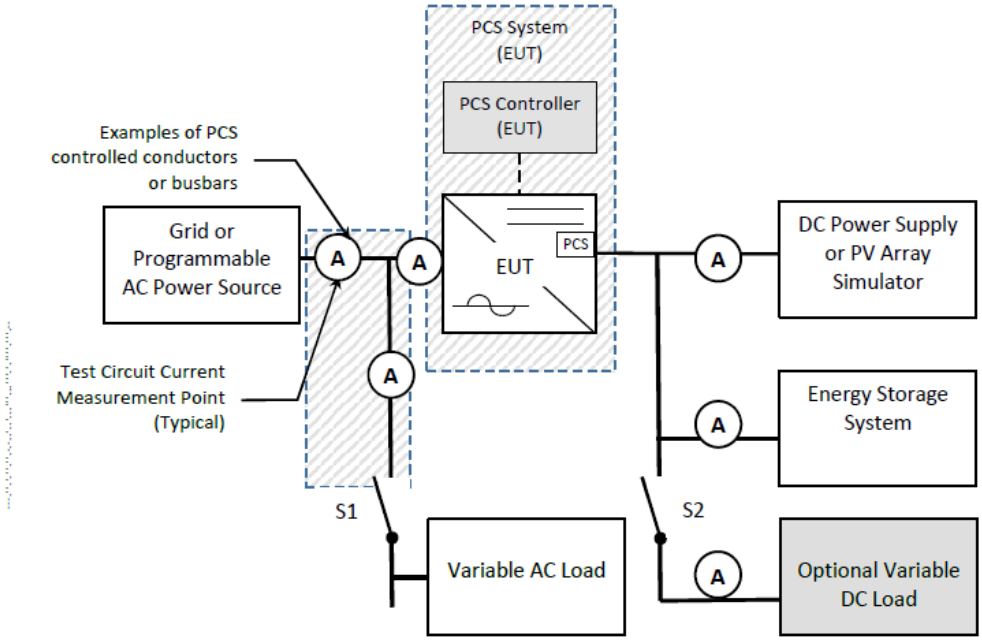

Figure 203.2 – Test Circuit Setup DC Coupled System

203.5 Step Change in Load Test

203.5.1 This procedure uses the step change test signal (step function) defined in Figure 203.3. These tests shall be performed at the terminals of the EUT and/or at an external reference point where the current is controlled. Signal injection test methods may be used for evaluation of Supplemental PCS but shall not be permitted for evaluation of Branch Circuit PCS.

203.5.2 The step change in test loads records the behavior of the PCS to variations in parallel connected loads when operating at constant generation levels. The test may be performed at any convenient voltage and frequency within the continuous operating region. The EUT(s) shall be connected in accordance with the relevant test circuit in Figure 203.1 or 203.2, and in accordance with the manufacturer's instructions.

a) Set the EUT operating parameters to nominal.
b) Record the state and settings of any grid support functions of the EUT(s)
c) Set EUT output current level to rated current, 100% +/- 5%
d) Close Switch S1 and adjust the variable load to draw EUT power output at 100% +/- 2%. Record the value of the current flowing to the grid or programmable ac power supply
e) Open Switch S1 and wait for the grid current to reach a new steady state value at EUT rated current. Record the currents flowing in all test circuit current sensors.
f) Close Switch S1 and wait for the grid current to reach a new steady state value at EUT rated current. Record the currents flowing in all test circuit current sensors. Repeat steps e) and f) two times for a total of three samples. The timing of the step transitions used in steps e) and f), shown as Th1 and Th2 in Figure 203.3, shall be selected to achieve steady state conditions in all current sensors.
g) Repeat steps d) through f) with load tuned to 66% +/- 5% and 33% +/- 5% of EUT output current.
h) Repeat steps d) through g) with the EUT output limit set to:
    i. 50% +/- 5% and 0% + 5%/-0% of namepalate current rating, and;
    ii. Optionally, at the maximum negative range of current supported by the system 1.
i) For three phase units repeat steps c) through h) opening switch S1 on only one phase and again with two phases simultaneously.
j) For single phase units connected line to line, repeat steps c) through h) opening switch S1 on only one line.

Test result :

Step	Input Side			Output of Inverter			Grid side			Load Side		
	V_input	I_input	P_input	V_invt	I_invt	P_invt	V_grid	I_grid	P_gird	V_load	I_load	P_load
EUT output 100% +/- 5%Pn → Variable load 100% +/- 2% Pn												
Sample 1												
e	423.8	19.7	8360.5	243.2	33.1	8044.3	242.1	33.1	7984.8	242.4	0.2	0.7
f	423.8	19.8	8368.4	240.6	33.5	8045.9	239.7	2.2	-6.1	239.7	33.4	8008.1
Sample 2												
e	420.7	19.8	8325.0	243.2	33.1	8035.5	242.1	33.0	7980.3	242.4	0.2	0.7
f	420.7	19.8	8322.2	240.6	33.5	8034.0	239.7	2.1	-74.2	239.7	33.5	8038.5
Sample 3												
e	420.7	19.8	8320.2	243.2	33.1	8043.6	242.1	33.1	8002.0	242.5	0.2	0.7
f	420.7	19.8	8320.9	240.6	33.5	8040.6	239.7	2.2	-54.3	239.7	33.5	8025.7
EUT output 100% +/- 5%Pn → Variable load 66% +/- 5% Pn												
Sample 1												
e	422.8	19.8	8360.5	242.1	33.3	8034.0	241.0	33.3	7980.6	241.3	0.2	0.8
f	422.8	19.8	8357.7	240.4	33.5	8038.7	239.4	11.6	2699.6	239.5	22.1	5296.5
Sample 2												
e	420.7	19.9	8367.0	242.1	33.3	8024.9	241.0	33.4	8015.5	241.3	0.1	0.6
f	420.7	19.9	8373.4	240.7	33.5	8023.0	239.7	14.6	3416.2	239.8	19.2	4590.5
Sample 3												
e	420.7	20.0	8390.3	242.1	33.3	8029.6	241.0	33.3	7998.9	241.3	0.1	0.6
f	420.7	20.0	8392.2	240.6	33.5	8026.9	239.6	13.2	3092.1	239.7	20.5	4912.3
EUT output 100% +/- 5%Pn → Variable load 33% +/- 5% Pn												
Sample 1												
e	422.8	19.8	8354.9	241.1	33.4	8030.4	240.0	33.4	7989.4	240.3	0.1	0.6
f	422.8	19.8	8356.2	240.3	33.5	8026.9	239.3	22.5	5339.3	239.4	11.1	2655.9
Sample 2												
e	421.8	19.8	8361.5	241.2	33.4	8028.7	240.1	33.4	7991.8	240.4	0.1	0.6
f	421.9	19.8	8361.1	240.3	33.5	8034.4	239.3	22.6	5352.6	239.5	11.1	2652.4
Sample 3												
e	420.7	19.8	8341.1	241.2	33.4	8022.0	240.1	33.4	7996.1	240.4	0.1	0.6
f	420.9	19.8	8340.7	240.4	33.5	8023.6	239.3	22.5	5352.1	239.5	11.1	2652.2
EUT output 50% +/- 5%Pn → Variable load 100% +/- 2% Pn												
Sample 1												
e	399.8	10.4	4161.4	243.1	16.6	4002.4	242.6	16.6	3998.0	242.8	0.1	1.0
f	399.8	10.4	4152.0	240.4	16.8	4000.5	240.0	16.8	-3998.0	240.0	33.5	8042.2
Sample 2												
e	399.8	10.4	4154.3	243.1	16.6	4003.2	242.6	16.6	3991.6	242.8	0.1	1.0
f	399.8	10.4	4164.6	240.4	16.8	4002.5	240.0	16.8	-3989.3	240.0	33.4	8015.8
Sample 3												
e	399.8	10.4	4153.4	243.1	16.6	4002.4	242.6	16.6	4000.6	242.8	0.1	1.0
f	399.8	10.4	4160.7	240.4	16.8	4001.8	240.0	16.8	-3996.6	240.0	33.4	8020.8
EUT output 50% +/- 5%Pn → Variable load 66% +/- 5% Pn												
Sample 1												
e	399.7	10.4	4158.5	240.9	16.7	4000.6	240.4	16.7	3983.5	240.6	0.1	1.0
f	399.7	10.4	4150.3	239.2	16.8	4000.6	238.8	5.8	-1279.8	238.8	22.0	5266.0
Sample 2												
e	399.8	10.4	4158.2	240.9	16.7	4000.8	240.4	16.8	3990.4	240.6	0.1	1.0
f	399.8	10.4	4148.2	239.2	16.8	4000.0	238.8	5.8	-1282.3	238.9	22.1	5278.9

Sample 3												
e	399.8	10.4	4160.6	240.9	16.7	4001.9	240.4	16.7	3985.3	240.7	0.1	1.0
f	399.8	10.4	4152.4	239.2	16.8	4000.1	238.8	5.8	-1280.1	238.9	22.2	5298.3
EUT output 50% +/- 5%Pn → Variable load 33% +/- 5% Pn												
Sample 1												
e	399.8	10.4	4150.6	240.9	16.7	4000.9	240.4	16.7	3987.6	240.6	0.1	1.0
f	399.8	10.4	4153.2	240.1	16.8	4002.2	239.6	5.9	1330.1	239.7	11.1	2668.9
Sample 2												
e	399.8	10.4	4151.7	240.9	16.7	3999.1	240.4	16.7	3981.8	240.6	0.1	1.0
f	399.8	10.4	4150.7	240.1	16.8	4001.0	239.6	5.9	1327.2	239.7	11.1	2668.5
Sample 3												
e	399.8	10.4	4161.1	240.9	16.7	4001.2	240.4	16.8	3998.9	240.6	0.1	1.0
f	399.8	10.4	4150.8	240.1	16.8	4000.4	239.6	5.9	1333.3	239.7	11.1	2659.6
EUT output 0% + 5%/-0%Pn → Variable load 100% +/- 2% Pn												
Sample 1												
e	399.8	0.1	21.9	243.0	0.0	0.0	243.0	0.6	-5.0	243.2	0.1	1.3
f	399.8	0.1	21.8	240.1	0.0	0.0	240.3	33.2	-7970.7	240.2	33.2	7969.8
Sample 2												
e	399.8	0.1	21.8	243.0	0.0	0.0	243.0	0.6	-4.7	243.2	0.1	1.5
f	399.8	0.1	21.8	240.1	0.0	0.0	240.3	33.2	-7979.5	240.2	33.2	7971.4
Sample 3												
e	399.9	0.0	16.4	243.0	0.0	0.0	243.0	0.6	-5.1	243.2	0.1	1.4
f	399.9	0.0	16.1	240.1	0.0	0.0	240.3	33.3	-8008.9	240.2	33.3	8008.9
EUT output 0% + 5%/-0%Pn → Variable load 66% +/- 5% Pn												
Sample 1												
e	399.8	0.0	0.6	243.0	0.0	0.0	243.0	0.0	-0.3	243.2	0.1	1.4
f	399.8	0.0	0.6	241.2	0.0	0.0	241.3	21.9	-5284.7	241.2	21.9	5280.2
Sample 2												
e	399.8	0.0	0.6	243.0	0.0	0.0	243.0	0.0	-0.3	243.2	0.0	1.5
f	399.8	0.0	0.6	241.2	0.0	0.0	241.3	21.9	-5292.6	241.2	21.9	5293.8
Sample 3												
e	399.8	0.0	0.6	243.0	0.0	0.0	243.0	0.0	-0.3	243.2	0.1	1.4
f	399.8	0.0	0.6	241.2	0.0	0.0	241.3	21.9	-5293.0	241.2	21.9	5291.0
EUT output 0% + 5%/-0%Pn → Variable load 33% +/- 5% Pn												
Sample 1												
e	399.8	0.0	0.6	241.1	0.0	0.0	241.1	0.0	-0.3	241.2	0.1	1.3
f	399.8	0.0	0.6	240.2	0.0	0.0	240.2	11.0	-2651.1	240.3	11.0	2649.3
Sample 2												
e	399.8	0.0	0.6	241.1	0.0	0.0	241.1	0.0	-0.3	241.2	0.1	1.4
f	399.8	0.0	0.6	240.2	0.0	0.0	240.2	11.0	-2653.4	240.3	11.0	2650.3
Sample 3												
e	399.8	0.0	0.7	241.1	0.0	0.0	241.1	0.0	-0.3	241.2	0.1	1.4
f	399.8	0.0	0.7	240.2	0.0	0.0	240.2	11.1	-2654.2	240.3	11.0	2650.2

Each step test at least 3min

TEST RESULT: **PASS** ~~**FAIL**~~

Equipment Used: No.1, No.2, No.3, No.4, No.5, No.6, No.7

T. amb.: 25.1ºC ***R.H. Amb.: 50.6%***

203.6 Step Change in Generation Test

203.6.1 This procedure uses the step change test signal (step function) defined in Figure 203.3. These tests shall be performed at the terminals of the EUT or an external reference point where the current is controlled. Signal injection test methods may be used.

203.6.2 The step change in generation test records the behavior of the PCS to variations in generation levels when connected in parallel with constant loads. For a PCS which includes an ESS device the step change in generation tests do not apply to the ESS source. The step change in generation test shall be applied only for variable input power sources, e.g. PV or Wind.

203.6.3 The test may be performed at any convenient near nominal voltage and frequency within the continuous operating region. Connect the EUT(s) in accordance with the relevant test circuit in Figure 203.1 or 203.2. and following the manufacturers supplied instructions

a) Set or verify that the EUT operating parameters are set to nominal.
b) Record the state and settings of any grid support functions of the EUT(s)
c) Set EUT output current level to rated current, 100% +/- 5%
d) Close Switch S1 and tune the variable load to 33% +/- 2% of EUT nameplate active current output rating. Record the apparent currents flowing in all test circuit current sensors.
e) Reduce the current of the DC source to a level which results in an EUT active output current between 5% and 10% of EUT's nameplate current rating. Record the currents flowing in all test circuit current sensors.
f) Increase the DC source to full power and record the value of the current flowing to the grid or programmable ac power supply.
g) Repeat steps e) and f) two times for a total of three samples.
h) Repeat steps e) through g) with the reduced value of the dc source set to a level which results in an EUT active output current between 33% and 66%of EUT nameplate rating. Record the currents flowing in all test circuit current sensors.
i) Repeat e) through h) with the EUT output current level set to 66% +/-5% and 33% +/-5% of EUT nameplate rating. Record the currents flowing in all test circuit current sensors. The timing of the step transitions used in steps e) through h) shown as Th1 and Th2 in Figure 203.3, shall be selected to achieve steady state conditions in all current sensors.

Test result :

Step	Input Side			Output of Inverter			Grid side			Load Side		
	V_input	I_input	P_Output	V_invt	I_invt	P_invt	V_grid	I_grid	P_gird	V_load	I_load	P_load
EUT output 100% +/- 5%Pn → Variable load 33% +/- 2% Pn, Reduce DC source to 5%-10%Pn → Increase to Full Power												
Sample 1												
e	419.8	2.0	594.6	234.5	2.5	534.6	234.5	8.7	-2032.0	234.5	11.0	2570.4
f	424.6	19.6	8291.5	240.2	33.5	8025.9	239.2	22.6	5383.8	239.4	11.0	2641.6
Sample 2												
e	420.7	1.9	589.1	234.5	2.5	537.7	234.5	8.7	-2029.1	234.5	11.0	2570.0
f	425.5	19.5	8285.7	240.2	33.5	8023.7	239.2	22.6	5381.7	239.4	11.0	2641.3
Sample 3												
e	422.7	2.0	611.2	234.5	2.5	534.0	234.5	8.7	-2036.8	234.5	11.0	2571.8
f	426.0	19.5	8262.6	240.2	33.4	8009.9	239.2	22.5	5370.4	239.4	11.0	2642.9
EUT output 100% +/- 5%Pn → Variable load 33% +/- 2% Pn, Reduce DC source to 33%Pn → Increase to Full Power												
Sample 1												
e	424.8	6.3	2661.8	236.1	11.0	2573.6	235.9	1.3	-12.0	235.9	11.0	2590.2
f	426.3	19.4	8276.9	240.2	33.4	8004.4	239.2	22.5	5363.0	239.4	11.0	2641.2
Sample 2												
e	424.7	6.4	2644.9	236.2	11.0	2576.8	235.9	1.3	-8.4	235.9	11.0	2589.7

f	424.8	19.5	8254.6	240.3	33.5	8023.6	239.2	22.6	5380.5	239.4	11.0	2641.0
Sample 3												
e	424.8	6.3	2646.9	236.2	11.0	2575.3	235.9	1.3	-9.5	235.9	11.0	2589.1
f	423.8	19.6	8271.4	240.3	33.5	8022.7	239.3	22.6	5378.2	239.4	11.0	2640.5
EUT output 100% +/- 5%Pn → Variable load 33% +/- 2% Pn, Reduce DC source to 66%Pn → Increase to Full Power												
Sample 1												
e	425.6	12.5	5287.9	238.1	21.6	5130.1	237.5	10.7	2516.7	237.6	11.0	2613.4
f	425.7	19.5	8291.2	240.3	33.5	8019.3	239.2	22.6	5376.4	239.4	11.0	2640.0
Sample 2												
e	425.9	12.4	5260.9	238.1	21.6	5128.8	237.5	10.7	2512.7	237.6	11.0	2612.8
f	426.0	19.4	8249.1	240.3	33.4	8017.0	239.3	22.5	5369.9	239.4	11.0	2639.7
Sample 3												
e	426.0	12.5	5289.8	238.1	21.7	5147.3	237.5	10.8	2529.2	237.6	11.0	2612.6
f	423.1	19.6	8276.4	240.3	33.4	8016.8	239.3	22.5	5367.6	239.5	11.0	2639.4
EUT output 66% +/- 5%Pn → Variable load 33% +/- 2% Pn, Reduce DC source to 5%-10%Pn → Increase to Full Power												
Sample 1												
e	421.7	1.6	605.7	236.5	2.5	538.2	236.4	8.9	-2092.2	236.5	11.0	2598.6
f	424.9	19.8	8421.8	242.1	33.2	8028.8	241.1	22.5	5401.8	241.3	11.1	2669.7
Sample 2												
e	422.7	1.9	601.8	236.5	2.5	541.4	236.4	8.9	-2087.1	236.5	11.0	2598.3
f	423.8	19.9	8409.6	242.2	33.2	8028.1	241.1	22.5	5398.9	241.3	11.1	2669.8
Sample 3												
e	423.4	1.9	599.1	236.5	2.5	540.3	236.4	8.9	-2087.2	236.5	11.0	2598.1
f	425.2	19.8	8401.1	242.2	33.2	8027.7	241.1	22.5	5397.1	241.3	11.1	2669.7
EUT output 66% +/- 5%Pn → Variable load 33% +/- 2% Pn, Reduce DC source to 33%Pn → Increase to Full Power												
Sample 1												
e	424.9	6.4	2663.8	238.1	10.9	2561.0	237.8	1.3	-65.6	237.9	11.0	2618.4
f	424.5	19.8	8387.1	242.1	33.2	8016.8	241.1	22.4	5386.4	241.3	11.1	2669.5
Sample 2												
e	424.8	6.4	2661.1	238.1	10.9	2560.9	237.8	1.3	-65.7	237.9	11.0	2618.2
f	424.5	19.8	8387.4	242.1	33.2	8023.1	241.1	22.5	5393.1	241.3	11.1	2669.2
Sample 3												
e	424.6	6.3	2664.4	238.1	10.9	2561.3	237.8	1.3	-68.1	237.8	11.0	2624.5
f	425.3	19.6	8339.3	242.2	33.1	8008.0	241.2	22.1	5307.3	241.3	11.1	2675.4
EUT output 66% +/- 5%Pn → Variable load 33% +/- 2% Pn, Reduce DC source to 66%Pn → Increase to Full Power												
Sample 1												
e	425.3	12.4	5270.5	240.1	21.4	5127.7	239.4	10.4	2463.8	239.6	11.1	2648.2
f	424.8	19.5	8263.5	242.2	33.2	8016.6	241.2	22.1	5313.8	241.4	11.1	2674.9
Sample 2												
e	424.9	12.5	5296.8	240.1	21.5	5139.7	239.4	10.4	2474.0	239.5	11.1	2647.4
f	424.9	19.5	8295.4	242.3	33.1	8008.6	241.3	22.1	5303.1	241.4	11.1	2674.6
Sample 3												
e	424.8	12.5	5296.4	240.1	21.5	5139.3	239.4	10.4	2472.4	239.6	11.1	2646.9
f	425.8	19.5	8301.6	242.2	33.1	8007.4	241.2	22.1	5301.0	241.4	11.1	2673.5
EUT output 33% +/- 5%Pn → Variable load 33% +/- 2% Pn, Reduce DC source to 5%-10%Pn → Increase to Full Power												
Sample 1												
e	421.8	1.5	601.4	238.6	2.9	542.0	238.6	9.0	-2106.8	238.6	11.0	2626.1

f	425.0	19.9	8443.0	244.1	33.0	8023.5	243.1	21.8	5278.4	243.2	11.1	2692.7
Sample 2												
e	423.8	1.5	599.3	238.6	2.9	542.1	238.6	9.0	-2104.3	238.6	11.0	2625.1
f	425.2	19.8	8420.4	244.0	33.0	8024.3	243.0	21.8	5277.9	243.2	11.1	2691.8
Sample 3												
e	422.1	1.5	596.2	238.6	2.9	541.7	238.6	9.0	-2103.7	238.6	11.0	2624.8
f	425.6	19.8	8406.9	244.0	33.0	8023.9	243.0	21.8	5276.5	243.2	11.1	2691.6
EUT output 33% +/- 5%Pn → Variable load 33% +/- 2% Pn, Reduce DC source to 33%Pn → Increase to Full Power												
Sample 1												
e	424.9	6.3	2667.7	240.1	10.8	2562.9	239.8	1.7	-108.4	239.9	11.0	2643.2
f	424.4	19.9	8427.1	244.0	32.9	8013.4	243.0	21.8	5269.5	243.2	11.1	2691.7
Sample 2												
e	424.9	6.3	2650.8	240.0	10.8	2562.8	239.8	1.7	-107.7	239.8	11.0	2642.8
f	425.5	19.7	8365.2	244.0	33.0	8023.4	243.0	21.9	5281.6	243.1	11.1	2690.8
Sample 3												
e	425.0	6.4	2647.4	240.0	10.8	2553.9	239.8	2.0	-119.0	239.8	11.0	2646.8
f	427.3	19.4	8270.8	244.0	33.0	8014.1	243.0	21.9	5273.6	243.1	11.1	2694.8
EUT output 33% +/- 5%Pn → Variable load 33% +/- 2% Pn, Reduce DC source to 66%Pn → Increase to Full Power												
Sample 1												
e	425.2	12.6	5310.0	241.9	21.5	5161.7	241.3	10.4	2457.8	241.4	11.1	2674.2
f	426.7	19.4	8266.2	244.0	33.0	8011.0	243.0	21.9	5269.8	243.2	11.1	2699.6
Sample 2												
e	425.1	12.6	5309.9	241.9	21.4	5143.1	241.3	10.4	2438.7	241.4	11.1	2668.5
f	426.2	19.6	8325.1	244.0	33.0	8012.6	243.0	21.9	5270.6	243.2	11.1	2694.3
Sample 3												
e	425.6	12.5	5276.4	241.9	21.3	5122.7	241.3	10.3	2418.0	241.4	11.1	2668.2
f	426.3	19.5	8300.0	244.0	33.0	8012.0	243.0	21.9	5269.1	243.2	11.1	2693.9

Note : Following grid support functions had been active

SA9	L/HVRT Low and High Voltage Ride-Through	X
SA10	L/HFRT Low and High Frequency Ride-Through	X
SA11	RR – Normal Ramp Rate and SS – Soft-Start Ramp Rate	X
SA12	SPF – Specified Power Factor	X
SA13	Volt/VAr Mode (Q(V))	X
SA14	Frequency-Watt (FW) – Optional	X
SA15	Volt-Watt (VW) – Optional	X

Each step test at least 3min

TEST RESULT: **PASS** ~~**FAIL**~~

Equipment Used: No.1, No.2, No.3, No.4, No.5, No.6, No.7

T. amb.: 25.1ºC ***R.H. Amb.: 50.6%***

204 Optional Tests

204.1 A PCS may optionally be evaluated to control current exchange with the Area EPS at an external reference point of applicability such as the point of common coupling. The PCS may limit current flow from sources to the Area EPS (exporting) or limit current flow from the Area EPS to loads (importing).

During these optional tests the current measured at any external reference point shall not cause the PCS to exceed any current limits as defined in Section 201.9. A PCS shall be considered in compliance if the current conducted to any optional external reference point(s) does not result in a steady state current on any PCS controlled conductor greater than the limits set in tests 203.5 and 203.6. The following optional tests shall be conducted as applicable for functionality and system configurations specified by the manufacturer.

Note: These requirements do not presently evaluate the ability of a PCS to comply with the Prioritization of DER Responses contained in IEEE Standard 1547, 2018. Following publication of IEEE P1547.1 these requirements will be revised to align with the 1547.1 testing protocols that are expected to include requirements for active and reactive power control functions for the PCS controlled conductors except where the active or reactive power control function could cause a PCS controlled current to exceed the limits of protected conductors or bus bars.

204.1.1 Export limiting from all sources
204.1.1 Where the PCS uses external current sensors to limit currents at an external reference point, such as at the point of common coupling, repeat the test sequence in 203.5 and 203.6 at the following conditions:
a) Install the external current sensors in accordance with the instructions supplied by the manufacturer.
b) Perform test 203.5 and 203.6 and measure current flows, including current flow to the external reference point such as the Area EPS or programmable ac power source. The timing of the step transitions shown as Th1 and Th2 in Figure 203.3, shall be selected to achieve steady state conditions in all current sensors, including the external current sensor at the external refence point.
c) Repeat step b) above with external current limit set to 50% (+/- 5%) and 0% (+/- 5%) of EUT nameplate rating. If the manufacturer also elects to support a minimum import function, repeat tests 203.5 and 203.6 at the minimum import setting which results in maximum current flow from the Area EPS or programmable ac power source (i.e. at the maximum setting of minimum import limit - Example: -50% or -100% of EUT nameplate rating).
204.1.2 An EUT shall be considered in compliance if the current conducted to any optional external reference point(s) does not result in a steady state current on any PCS controlled conductor greater than the limits set in tests 203.5 and 203.6.

204.2 ESS Operating Modes

204.2.1 General - Some utility requirements restrict current exchanges between the Area EPS and the energy storage sub-system (ESS). This section includes the requirements for ESS that perform PCS functionality. For example: It may be permissible to export active power from the ESS to the Area EPS but the ESS may not be allowed to import active power from the Area EPS.

204.2.2 ESS is rated to perform PCS control active power exchanges between the Area EPS and the energy storage sub-system (ESS), the manufacturer shall specify which optional functions and ESS operating modes are supported by the PCS. Each supported mode shall be evaluated using the relevant tests described in this Section.

204.2.3 The following terminology shall be used in the test report to identify operating modes which limit the steady state active power flows between the ESS and the Area EPS supported by the PCS.
a) **Unrestricted Mode** – The ESS may import active power from Area EPS while charging and may export active power to the Area EPS while discharging.
b) **Export Only Mode** – The ESS may export active power to the Area EPS during discharging but shall not import active power from the Area EPS for ESS charging purposes.
c) **Import Only Mode** – The ESS may import active power from the Area EPS for charging purposes but shall not export active power from the ESS to the Area EPS.
d) **No Exchange Mode** – The ESS shall not exchange active power with the Area EPS for charging or discharging purposes.

204.2.4 A description of all supported ESS PCS modes of operation shall be included in the documentation supplied by the manufacturer in accordance with requirements in in Section 208.

204. 3 ESS Operating Mode Selection
204.3.1The manufacturer shall document all field accessible PCS configuration methods such as but not limited to; display menus, dip swithes, jumpers, remote configuration tools, etc. The field accessible PCS configuration methods shall be reviewed during the evaluation to verify that none of the field accessible configuration methods can result in a change of ESS Operating Mode. The field accessible PCS configuration method(s) shall be documented in the installation instructions.

204.3.2 The selection of ESS Operating modes defined in Section 204.2 shall be made using one of the following methods:

a) The ESS Operating Mode may be fixed by the manufacturer using software, firmware or hardware and shall not be changeable in the field. Where the ESS Operating Mode is fixed in software or firmware the revision number and checksum of the firmware or software shall be recorded in the test report.
b) The ESS Operating Mode may be selected via an EUT or PCS configuration file. Where the ESS Operating Mode is selected via a configuration file, the ESS Operating Mode shall not be changeable in the field, other than by selection of a different EUT or PCS configuration file. The manufacturer shall provide a clear means to identify each configuration file and it's associated ESS Operating Mode. The configuration file identifier and associated operating modes shall be described in the manufacturer's instructions provided with the EUT.
c) The ESS Operating Mode may be configured using a password protected menu structure. The manufacturer shall document the PCS password structure including identification of read and write privileges associated with each type of password. The password for the ESS Operating Mode selection parameters shall be restricted to the manufacturer or the manufacturer's authorized representatives only and the ESS Operating Mode shall not be changeable using installer or end user level passwords.
Exception: The ESS Operating Mode may be configured by the installer or end user using a single use password supplied by the EUT or PCS manufacturer. Once configured or reconfigured, the ESS Operating Mode shall not be changeable by the installer or end user.
d) The ESS Operating mode may be selected by the installer or end user at the time of installation or commissioning. The selection may be made as part of an installation or commissioning process documented by the EUT or PCS

manufacturer or via a single use password supplied by the manufacturer. A fixed time period allowing unrestricted selection of the ESS Operating Mode shall be permitted during installation, commissioning or after entering a single use password. Once the ESS Mode is selected, including expiration of any optional fixed time periods, the ESS Operating Mode shall not be changeable by the installer or end user. Where reconfiguration of the ESS Operating Mode becomes necessary, the manufacture shall be permitted to provide a new single use password upon request from the installer or end user.
Note: Each method above is unique and it is acknowledged that the specified criteria for individual methods may include steps or requirements that conflict or contradict other methods.

204.4 Export limiting from Energy Storage Systems

204.4.1 Where the PCS includes ability to limit current flow from an ESS to the external reference point such as the point of common coupling to the Area EPS (i.e. ESS grid export limiting). Repeat the test sequence in 203.5 and 203.6 at the following conditions:
a) Install any external current sensors, if applicable, in accordance with the instructions supplied by the manufacturer.
b) For EUT's with multiple inputs, such as PV and ESS, set or verify the other, non ESS, inputs are set to 100% +/-5% of their nameplate ratings.
c) Set or verify that the ESS external export current limit is set to 0% to +5% of EUT nameplate rating.
d) Run test 203.5 and 203.6 and record current flows including current flow to the Area EPS or programmable ac power source and the output of the ESS. The timing of the step transitions shown as Th1 and Th2 in Figure 203.3, shall be selected to achieve steady state conditions in all current sensors, including the external current sensor at the external refence point and at the output of the ESS.
e) Where the PCS only supports zero export from the ESS steps f) and g) may be omitted.
f) Repeat steps c) through e) above with external current limit set to 66% +/- 5% and 33% +/- 5% of EUT nameplate rating.
g) For EUT's with multiple inputs, such as PV and ESS, repeat steps c) through g) with the other, non ESS, inputs set to 50% +/- 5% and 0% to +5% of their nameplate ratings

204.4.2 The EUT shall be considered in compliance if the steady state export current at the external reference point does not exceed the current from generation sources other than the ESS plus the current limit set for the ESS minus any local load.

204.4.3 For DC coupled systems the AC output current of the EUT shall be considered to be proportional to the to the relative DC current flows from each source divided by the sum of the DC current from all sources.

204.5 Import limiting to Energy Storage Systems

204.5.1 Where the PCS includes ability to limit current flow from the Area EPS to an Energy Storage System (ESS), i.e. ESS grid charge limiting, repeat the test sequence in 203.5and 203.6 at the following conditions:

a) Install any external current sensors, if applicable, in accordance with the instructions supplied by the manufacturer.

b) Set or verify that the ESS is at the lowest state of charge the ESS can support for the duration of the tests without causing damage or mis-operation. The lowest state of charge operating condition shall be specified by the manufacturer.

c) Set of verify that the Area EPS charge current limit is set to 0% to +5% of EUT nameplate rating.

d) For EUT's with multiple inputs, such as PV and ESS, set or verify the other, non ESS, inputs are set to 100% +/-5% of their nameplate ratings.

e) Where the PCS only supports zero charging from the Area EPS steps f) and g) may be omitted.

f) Run test 203.5 and 203.6 and record current flows including current flow from the Area EPS or programmable ac power source and the input of the ESS. The timing of the step transitions, Th1 and Th2, in Figure 203.3 shall be selected to achieve steady state conditions in all current sensors including the external current sensor at the external refence point and at the output of the ESS.

g) Repeat steps b) through d) above with external charge current limit set to 66%(+/- 5%) and 33%(+/- 5%) of EUT nameplate rating.

h) For EUT's with multiple inputs, such as PV and ESS, repeat steps c) through g) with the other, non ESS, inputs set to 50% +/- 5% and 0% +5% of their nameplate ratings

204.5.2 For EUT's with multiple inputs, such as PV and ESS, the EUT shall be considered in compliance if the steady state import current at the external reference point does not exceed the sum of the PV output current minus the input current limit set for the ESS minus any local load. For DC coupled systems the EUT input current, shall be considered to be proportional to the sum of the relative current flows of each source.

Test result :

This optional test is not test due to the requirement by manufactory.

205 Abnormal Tests

205.1 All Power Control Systems shall be tested as described in UL1741 Section 47 and comply with section 47.1.1 and 47.1.2 of UL 1741.
Exception: A PCS embedded into equipment that has already been evaluated to UL 1741, UL 60950, UL 9540, UL508, UL61010 is not required to repeat abnormal testing address in those Standards, other than as required in Section 205.
205.2 During all abnormal tests, automatic opening of a branch circuit rated overcurrent protective device shall be permitted to limit current flow. Rating of the overcurrent protective device used in abnormal testing shall be the maximum size specified in the manufacturer's instructions, in accordance with Section 41.5
205.3 If a device or conductor, (excluding a printed wiring board trace) internal to the EUT opens and interrupts the test the following shall apply. When the circuit is interrupted by opening of a component, the test is to be repeated two additional times using new components, as required. Opening of a suitably rated internal overcurrent protective device is considered as a compliant result and the test is not required to be repeated.

205.4 The PCS shall be evaluated for all the startup and abnormal operating test conditions contained in Table 205.1. Following completion of the tests in 205 EUT shall be subjected to and found to comply with the Dielectric Voltage Withstand test in Section 44.

Test result :

This test had been test in section 47 of UL 1741 in report

No	EQUIPMENT	MARK/MODEL	S/N	CALIBRATION DATE AND DUE DATE
1	True RMS Multimeter	15B+	43581337WS	2020/9/25 to 2021/9/24
2	Power analyzer	PW6001-16	150901722	2020/3/4 to 2021/3/3
3	Current probe	CT6863-05	150613621	2020/3/4 to 2021/3/3
4	Current probe	CT6863-05	150613626	2020/3/4 to 2021/3/3
5	Caliper	150mm	/	2020/7/2 to 2021/7/1
6	Chamber	OK-TH-1000	/	2020/9/21 to 2021/9/20
7	Current probe	CT6863-05	150613623	2020/3/4 to 2021/3/3