



NEP RSD



September, 2023
Rapid Shutdown Solutions
NEP CONFIDENTIAL



www.northernep.com



Who is NEP

Northern Electric Power Technology Inc (NEP) was founded in the USA and has a 13 year history of developing advanced solar power conversion solutions. We have shipped our microinverter and rapid shutdown MLPE products to customers in over 35 countries.

NEP has a relentless focus on safety, reliability, cost efficiency and customer focused innovation.

NEP is legally formulated in America as a Benefit Corporation striving for human and shareholder value.

*Silicon Valley, CA headquarters, advanced engineering, exec team, finance
Operations and product development in Asia*



Experienced Leadership Team

Ed, Jing, Fan; American and
majority owners of NEP



Ed Heacox
Board Member/ Co-Founder
eheacox@northernep.com

Ed brings 30 years of power electronics business development to NEP with history at GE Power Systems, Emerson Electric and Celestica Power Systems. He was VP-GM at Advanced Energy and created their inverter business unit, reaching #1 share in America. Most recently Ed co-created CPS America, building the business and team to a market leading position. He has a Stanford MS Management graduate degree.



Jing Wang
Chairman, Co-Founder
jwang@northernep.com

Jing is the original creator of NEP and the lead executive for customers, applications engineering and company operations. Jing's 30+ year career in power electronics provides the foundation for NEP including GE R & D in New York and Schneider/Xantrex in Asia and North America. He has a PH.D from the University of British Columbia.



Fan Wang
CTO, Co-Founder
fwang@northernep.com

Fan leads NEP product technology development in the USA and Asia bringing 10 years of Motorola R&D experience. Fan participated in 37 US patents and is an inverter and data-communications expert for NEP. Fan has a PH.D from Purdue University.



Jack Han
VP, Co-Founder
hanjiazhi@northernep.com

A long-time power electronics executive driving business development at industrial automation and renewable energy industries, and partnerships for NEP globally. Most recently Mr. Han has been a key executive for Chint Power Systems and prior role included business development for international companies, TMEIC from Japan, KEB and LTi from Germany.



Strong Cross-Functional USA Team

Est. 20 Staff in the USA



Jake LeVitre

General Manager of North America

Jake has experience in distribution knowledge in data structures. Jake strategies to optimize supply chain



John "Gino" Espino

Director of Commercial Sales

John is well-versed with many years development, strategic planning, and energy industry.



Mark Hudspeth

Regional Sales Manager South/Southeast

Mark has been in the Solar industry operations, project management, and their business by providing the best



Felicia Yang

Customer Operations Manager

Felicia has worked in customer in these areas, makes her



Wendy Yang

Customer Operations Associate

Wendy has worked in logistics years. Her experience and mission.



Sarah Li

Inside Sales & Marketing

Sarah has built up a wealth of cellular phone stores in her promotions makes her a



Jacob Benzaquen

Product Manager

Jacob has over 3 years of experience about helping customers transition products that make it easier for p



George Vuduc

Technical Support Lead

George has extensive experience UPS companies. Also, he has spent George was instrumental in building engineers.



Zach Kiebler

Technical Support Lead EC

Zach has 10 years of residential service excited to work with installers and RSD monitoring. In his downtime,



MLPE over 10
years

Microinverters



Residential
Single and Dual
Data monitoring
Global

Rapid Shutdown

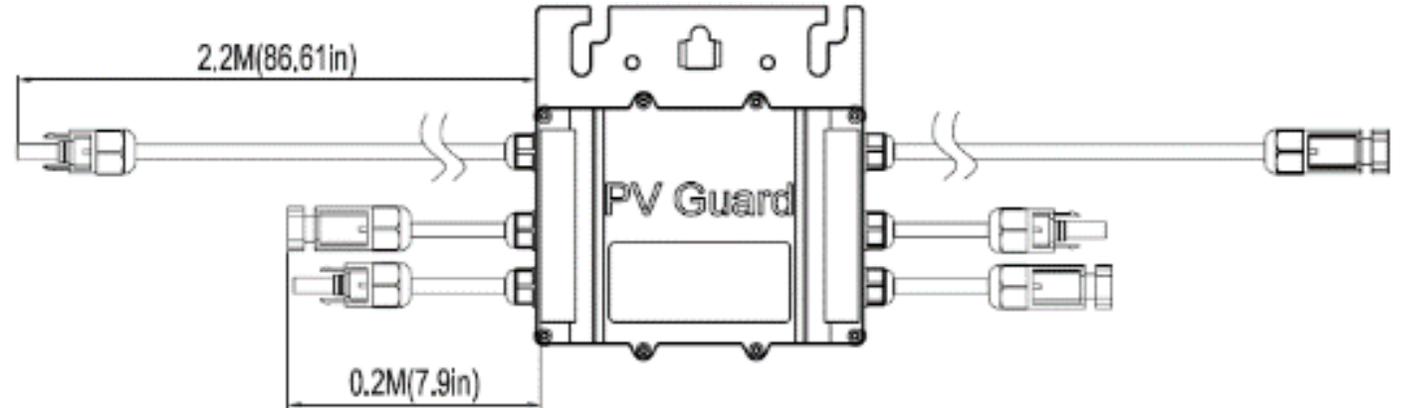


Residential, Commercial
Single, Dual, Triple
Data monitoring
USA and emerging markets

PVG-2-L
PVG-3-L



Specification eg. PVG-2-L



INPUT(DC)	Max DC Open Circuit Voltage per Input (Vdc)	90
	Max DC Current per input (A _{dc})	15 / 20
OUTPUT(DC)	Maximum Output Voltage (Vdc)	Voc * n (n=1/2/3/4)
SYSTEM	Maximum System Voltage (Vdc)	1500
MECHANICS	PV Cable	12AWG
	PV Connectors	Mc4 (Contact NEP for other connectors options)
	Size (not including PV cable)	5.12' x 4.73' x 1.14' (PVG-1) 5.90' x 5.71' x 1.00' (PVG-2)
	Protection Degree	NEMA 6
	Operating Ambient Temperature	-40°C--+85°C
	Mounting Method	Rail, Frame (option)
SIGNAL	Communications	DC Power Line
CERTIFICATION	Product Safety Compliance	UL 1741 CSA C22.2 No. 107.1 NEC 2014/2017 690.12 Canada CEC 2015 64-218



Comparisons



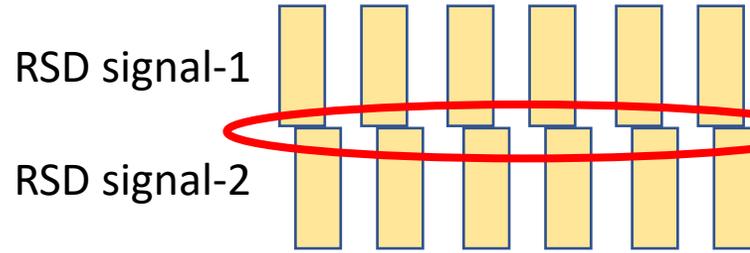
	NEP RSD	Other RSD
Communication	Two way PLC	One way
Crosstalk Avoidance	YES	NO
I-V Curve Test	YES	VERY DIFFICULT
Remote Trouble Shooting/Monitoring	YES	NO



PVG vs Optimizer

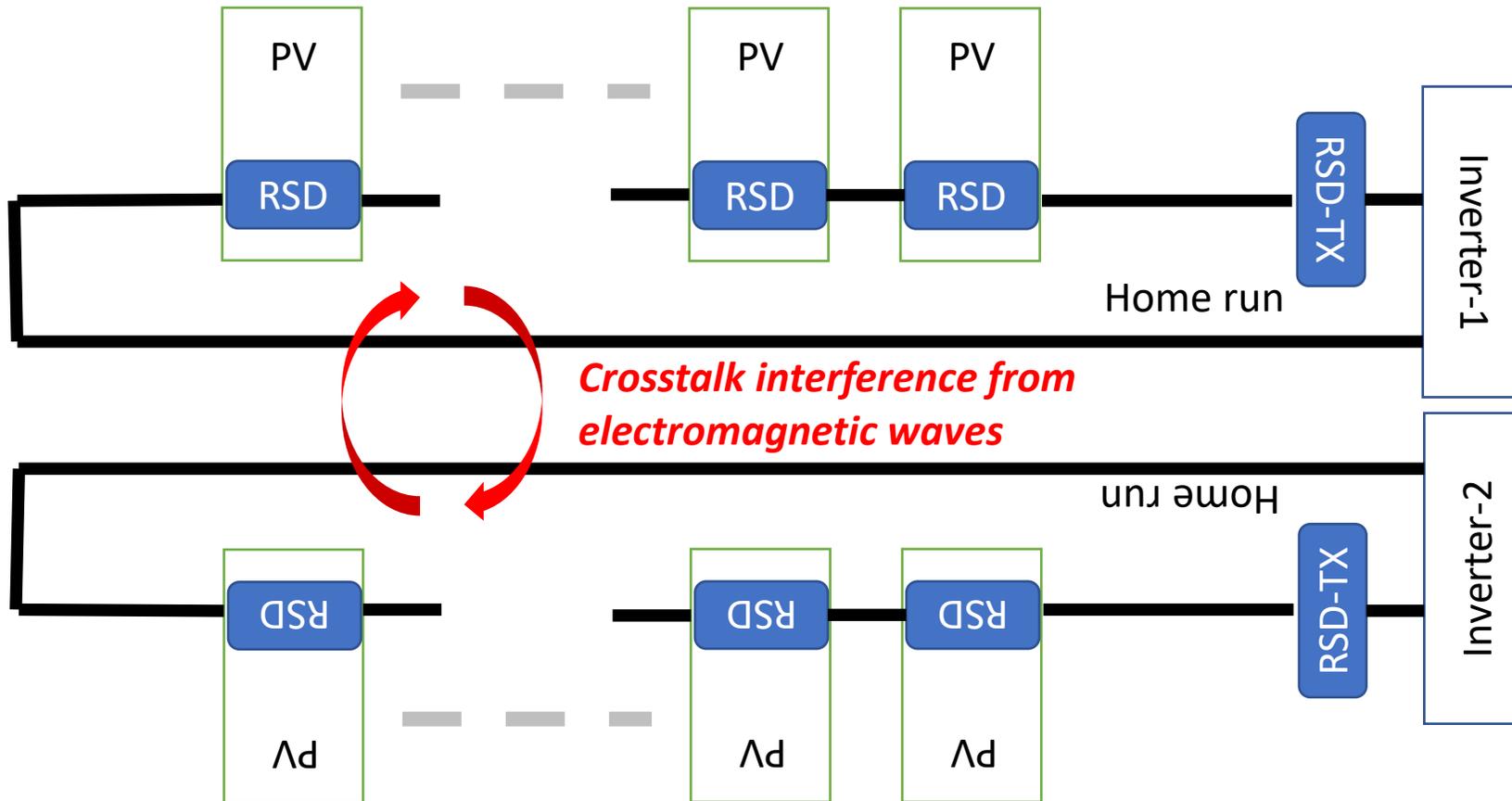
	NEP PVG	Optimizer
Communication	Two-way	Two-way
Module level monitoring	Yes	Yes
Component count	less	more
Mean Time Between Failure	better	worse
Over heating	almost no heat	Yes
Efficiency	> 99.8%	low
Reliability (topology complexity)	high	low
Module Level MPPT Function	No	Yes
Price	much lower	high
System flexibility	Yes	No

Crosstalk Root cause



*Crosstalk interference
jam the signal*

UNCONTROLLED on/off



Cross-Talk Challenge



Multi-Strings
In Conduits

Challenging
Application



Retrofit to NEP



Crosstalk Hazard

Our peers RSD has severe cross talk issue

- => Crosstalk interference can cause UNCONTROLLED on/off of PV panels
 - => Damaged RSD, Lower/unbalanced output
- => force installers to conduit one set of cables per inverter
- => many more steel pipes, much more space and much more expensive

Can RSD signal be synchronized?

- => Additional cable to connect all RSD transmitters requires more labors
- => Sync control signal delay due to transmission and processing
- => Most importantly, phase delay due to inductance of long PV cable can counter impact the synchronization of the transmitters

CONCLUSION: Simple 1-bit RSD signal cannot eliminate crosstalk

Crosstalk Avoidance

Unique protocol for crosstalk avoidance

Allows installers to put multiple sets of inverter cables into one conduit

Save space, save time and save money

Proprietary advanced signal processing and error control coding technique

No additional hardware. NEP 2-way communications between transmitter and RSD devices ensures a firm data/control 'handshake'

US patent pending



Retrofit to NEP
Duke Energy Site
Colorado



IV Curve Trace Mode

Unique function for IV Curve tracing
PVG switch can be set as open or closed
This function allows third party curve
tracer measurements
This function can save commissioning
time



Demonstration at AGT Site

Jointly with SEAWARD
Florida

US Patent Coverage



IV curve trace test

RSD System Device Level Monitoring

Cross talk avoidance

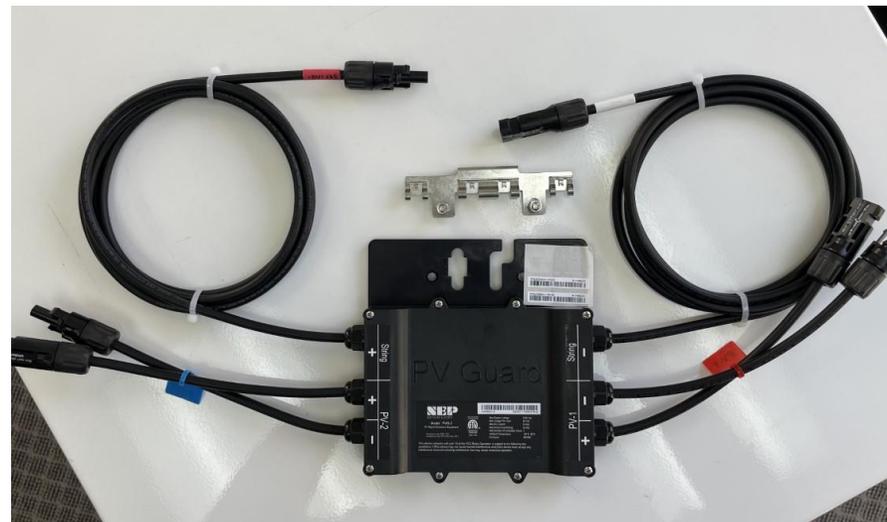

 US011133777B2

<p>(12) United States Patent Wang et al.</p> <hr/> <p>(54) SOLAR ARRAY COMMUNICATIONS</p> <p>(71) Applicants: Fan Wang, San Marino, CA (US); Jing Wang, Palo Alto, CA (US)</p> <p>(72) Inventors: Fan Wang, San Marino, CA (US); Jing Wang, Palo Alto, CA (US)</p> <p>(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.</p> <p>(21) Appl. No.: 17/024,563</p>	<p>(10) Patent No.: US 11,133,777 B2</p> <p>(45) Date of Patent: Sep. 28, 2021</p> <hr/> <p>(56) References Cited U.S. PATENT DOCUMENTS</p> <table border="0" style="width: 100%; font-size: small;"> <tr><td>5,327,892</td><td>A</td><td>7/1994</td><td>Nakamura</td></tr> <tr><td>8,274,172</td><td>B2</td><td>9/2012</td><td>Hadar</td></tr> <tr><td>8,653,689</td><td>B2</td><td>2/2014</td><td>Rozenboim</td></tr> <tr><td>9,112,379</td><td>B2*</td><td>8/2015</td><td>Sella H01L 31/02021</td></tr> <tr><td>9,524,832</td><td>B2</td><td>12/2016</td><td>Orr</td></tr> <tr><td>9,991,717</td><td>B1</td><td>6/2018</td><td>Rowe</td></tr> <tr><td>10,720,878</td><td>B2</td><td>7/2020</td><td>Ehlmann</td></tr> <tr><td>2004/0041665</td><td>A1</td><td>3/2004</td><td>Hode</td></tr> <tr><td>2004/0135676</td><td>A1</td><td>7/2004</td><td>Berkman</td></tr> <tr><td>2011/0261027</td><td>A1</td><td>10/2011</td><td>Lee</td></tr> <tr><td>2013/0009483</td><td>A1</td><td>1/2013</td><td>Kawate</td></tr> <tr><td>2013/0194706</td><td>A1</td><td>8/2013</td><td>Har-Shai</td></tr> <tr><td>2015/0028602</td><td>A1</td><td>1/2015</td><td>Makhtas</td></tr> </table>	5,327,892	A	7/1994	Nakamura	8,274,172	B2	9/2012	Hadar	8,653,689	B2	2/2014	Rozenboim	9,112,379	B2*	8/2015	Sella H01L 31/02021	9,524,832	B2	12/2016	Orr	9,991,717	B1	6/2018	Rowe	10,720,878	B2	7/2020	Ehlmann	2004/0041665	A1	3/2004	Hode	2004/0135676	A1	7/2004	Berkman	2011/0261027	A1	10/2011	Lee	2013/0009483	A1	1/2013	Kawate	2013/0194706	A1	8/2013	Har-Shai	2015/0028602	A1	1/2015	Makhtas
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Mounting

Rail or PV Frame(Clip) Mount



Fail Safe

PVEL test report is available



Extra protection for heat dissipation and protection over the plastic case

An RSD was subjected to a localized flame in order to observe the RSD's response to a flame. Throughout the test, the RSD continued to operate even while the plastic enclosure of the RSD was burning.

Upon removal the of the flame source, the plastic enclosure quickly stopped burning.

Third Party Evaluation

2 Test Plan Overview

This report outlines the TC200 reliability test and thermal shutdown validation test performed on the NEP PVG-2-L MLRSD. The testing sequence aims to validate the MLRSD's performance over the reliability and validation tests to better understand operational advantages, while providing design feedback and supporting data sets on design and performance deficiencies.

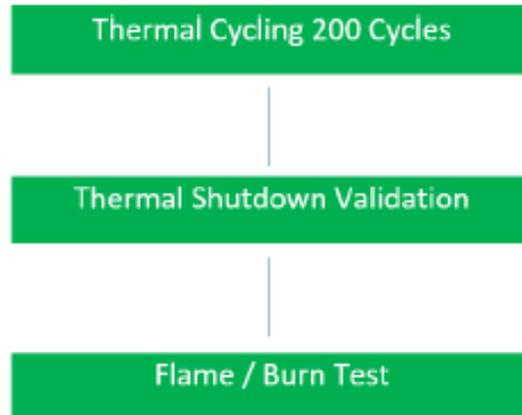


Figure 2-1: Test plan process diagram

This evaluation focuses on a series of indoor (laboratory) tests to monitor the RSDs' capability to remain operational throughout the thermal cycling accelerated age testing profile as well as to validate the RSDs' ability to shut down upon an over temperature event. An explanation of each test is provided along with a description of the setup, equipment used to evaluate the results, and a short analysis of the inverter's performance.



Final Engineering Report

Northern Electric Power Co.

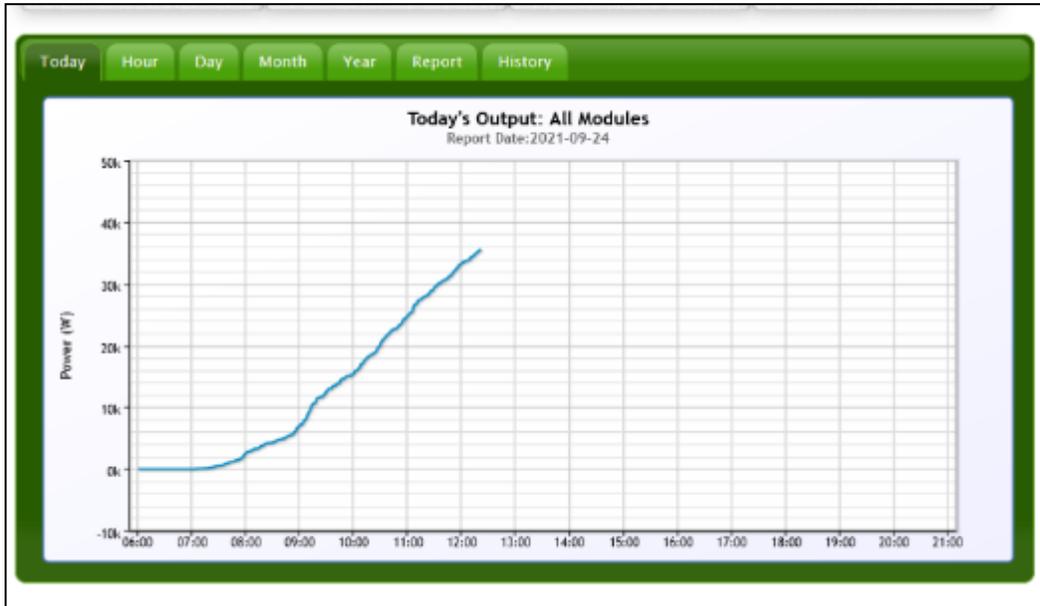
MLRSD Testing

Report No. RB271A-1
Date: 27 April 2022

Rigorous Testing
for Reliability



PVG Field Data



Zone: Zone 1

[1]	[2]	[3]	[4]	[5]			
445.4	391.4	378.4	386.0	210.5			
1.278	1.110	1.270	1.108	0.571			
[10]	[9]	[8]	[7]	[6]			
178.1	212.2	161.3	238.9	175.8			
0.813	0.823	0.224	1.202	0.526			
[11]	[12]	[13]	[14]	[15]			
407.7	121.4	435.4	370.0	194.9			
1.173	0.438	1.282	1.128	0.675			
[20]	[19]	[18]	[17]	[16]			
383.2	423.7	335.0	155.4	188.4			
1.198	1.245	1.182	0.668	0.599			
[21]	[22]	[23]	[24]	[25]	[26]		
289.3	388.7	227.6	210.7	421.6	326.5		
1.250	0.883	0.526	0.418	1.274	0.987		
[30]	[32]	[31]	[30]	[29]	[28]	[27]	
171.0	321.6	333.2	354.1	221.5	371.0	167.5	
0.482	1.049	0.261	1.142	0.248	0.975	0.422	
[24]	[25]	[26]	[27]	[28]	[29]	[30]	[31]
168.7	374.4	448.9	365.6	404.3	386.8	419.2	152.2
0.815	1.050	1.008	1.099	1.450	1.414	1.592	0.522
[47]	[46]	[45]	[44]	[43]	[42]	[41]	[40]
162.5	348.0	359.9	412.5	435.2	430.5	175.1	152.2
0.527	1.417	0.888	1.455	1.450	1.594	0.327	0.522
[48]	[49]	[50]	[51]	[52]	[53]	[54]	[55]
264.7	52.1	402.9	380.1	408.8	348.6	367.4	152.2
0.845	0.011	1.277	1.479	1.202	1.592	1.284	0.522
[61]	[60]	[59]	[58]	[57]	[56]	[55]	[54]
419.8	393.1	461.6	409.6	365.5	432.6	379.1	152.2
1.585	1.245	1.457	1.282	1.829	1.282	1.684	0.522
[62]	[63]	[64]	[65]	[66]	[67]	[68]	[69]
374.3	422.8	367.4	395.1	422.2	312.0	339.3	373.7
1.211	1.447	1.542	1.229	1.852	0.847	1.142	1.189
[77]	[76]	[75]	[74]	[73]	[72]	[71]	[70]
301.8	361.8	186.4	363.9	171.0	273.2	313.4	301.8
0.814	0.822	0.492	0.881	0.677	1.022	0.947	0.702
[76]	[79]	[80]	[81]	[82]	[83]	[84]	[85]
262.9	397.3	361.8	381.4	367.7	184.0	405.2	393.6
1.101	0.824	0.978	1.022	1.067	1.159	1.125	0.522
[92]	[92]	[91]	[90]	[89]	[88]	[87]	[86]
231.2	333.9	172.7	375.2	341.2	416.9	379.1	376.5
1.180	1.001	0.287	1.152	0.908	1.278	1.100	1.028
[94]	[95]	[96]	[97]	[98]	[99]	[100]	[101]
415.7	171.8	380.0	344.7	394.4	276.9	324.8	192.1
1.128	0.228	0.816	1.022	1.022	0.522	0.851	0.228
[106]	[107]	[108]	[109]	[104]	[103]	[102]	[101]
221.1	362.4	352.7	330.4	436.8	271.7	438.6	192.1
0.772	1.185	0.742	0.902	1.102	0.789	1.294	0.228



PVG-2

Field Data - Temperature

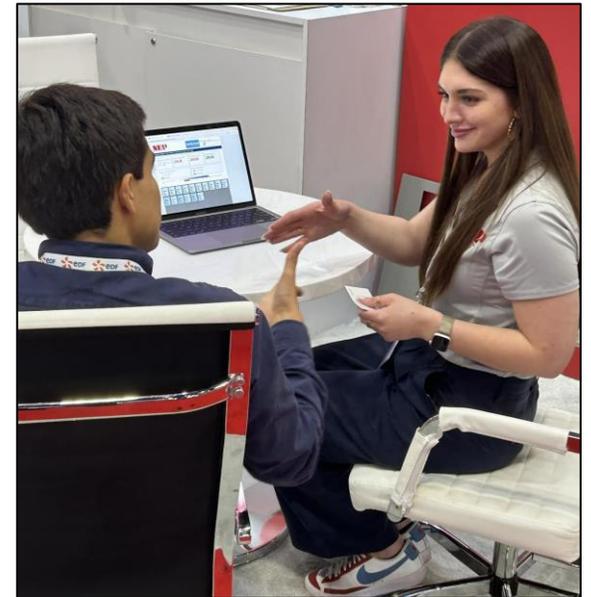
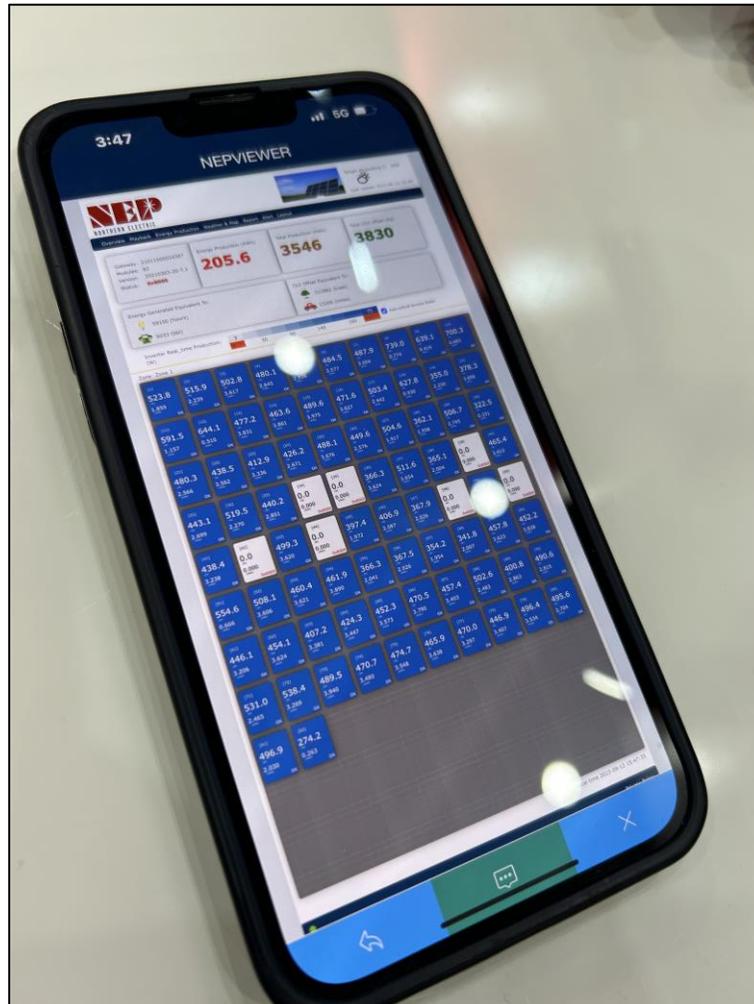
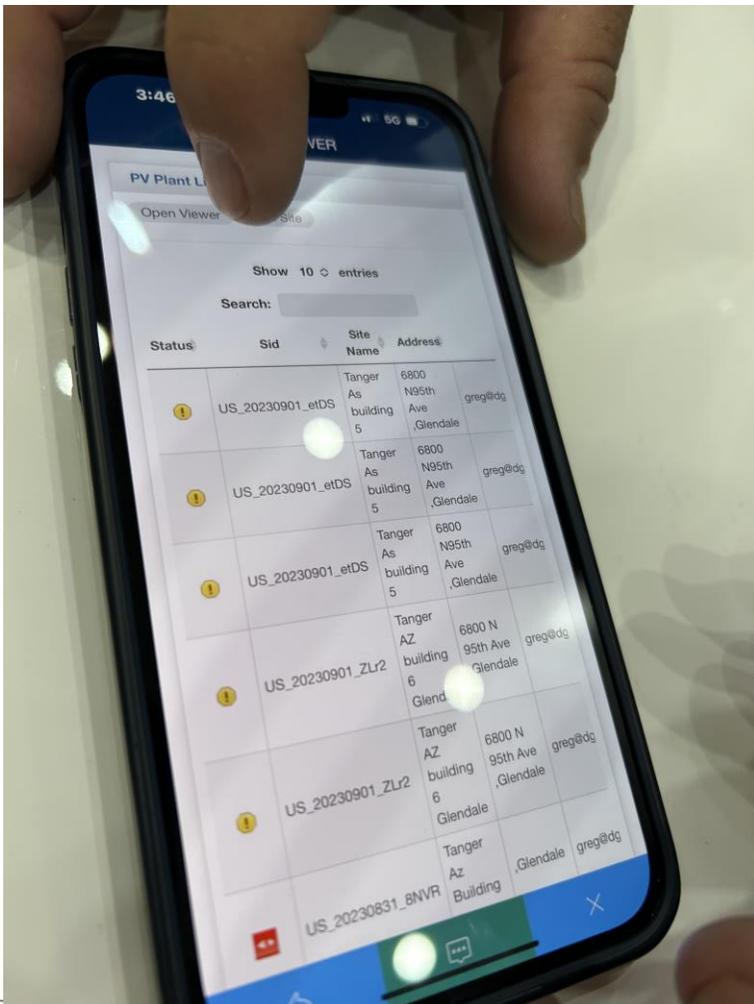
Panel Level monitoring

- Each panel real-time voltage
- String current
- Real-time Temperature
- Alert

Timestamp	Power (W)	Vdc-0	Vdc-1	Vdc-2	Vdc-3	A-DC (A)	TEMP (°C)	E-Today (kWh)	Status
2022-10-04 14:47	511.73	34.0	35.1	-	-	7.41	49	2.843	0
2022-10-04 14:48	511.73	34.0	35.1	-	-	7.41	49	2.843	0
2022-10-04 14:49	511.73	34.0	35.1	-	-	7.41	49	2.843	0
2022-10-04 14:50	501.22	34.0	34.7	-	-	7.30	50	2.896	0
2022-10-04 14:51	501.22	34.0	34.7	-	-	7.30	50	2.896	0
2022-10-04 14:52	501.22	34.0	34.7	-	-	7.30	50	2.896	0
2022-10-04 14:53	501.22	34.0	34.7	-	-	7.30	50	2.896	0
2022-10-04 14:54	501.22	34.0	34.7	-	-	7.30	50	2.896	0
2022-10-04 14:55	501.22	34.0	34.7	-	-	7.30	50	2.896	0
2022-10-04 14:56	493.67	34.0	34.7	-	-	7.19	50	2.946	0
2022-10-04 14:57	493.67	34.0	34.7	-	-	7.19	50	2.946	0
2022-10-04 14:58	493.67	34.0	34.7	-	-	7.19	50	2.946	0

Site and PV Data

Tools and People for site performance



People you can Count On



Challenge Us !



Supplements

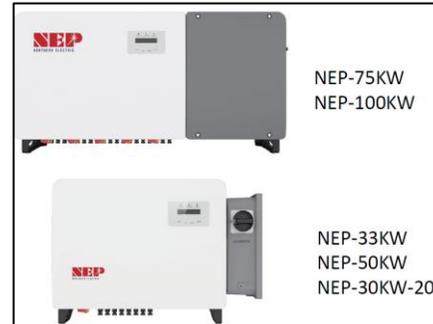
Supplements



See Also

NEPTUNE – 3-phase inverters

<https://northernep.com/products/3-phase-inverters/>



Galaxy – Data-comm for inverters and RSD

<https://northernep.com/wp-content/uploads/2023/09/NEP-NEPTUNE-Galaxy-Data-Comms-Solution-Sept-2023.pdf>

