



NEP RSD



April, 2024
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 14 year history of developing advanced solar power conversion solutions. We have shipped of 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*



MLPE for
12 years

Microinverters



Residential
Single, Dual and Quad
Data monitoring
Global

Rapid Shutdown

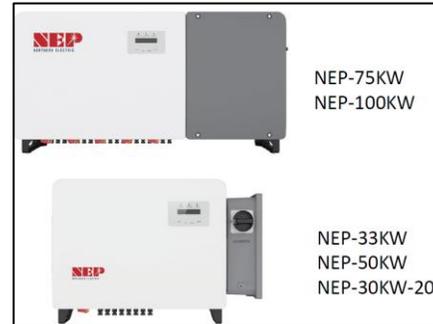


Residential, Commercial
Single, Dual, Triple
Data monitoring
USA and emerging markets

See Also

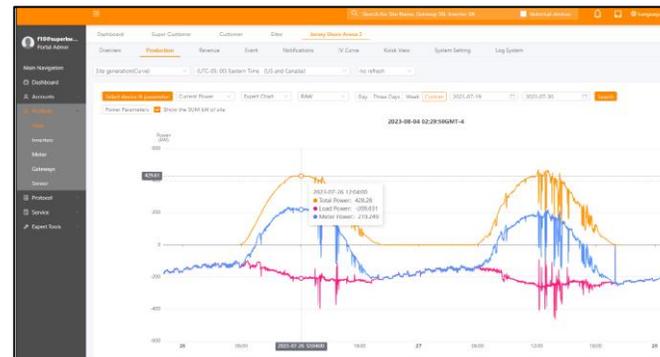
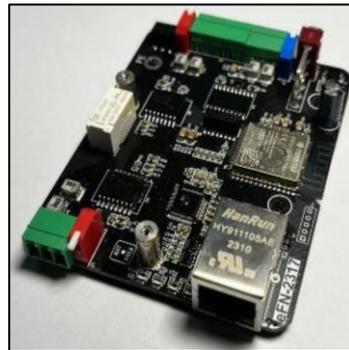
NEPTUNE – 3-phase inverters

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

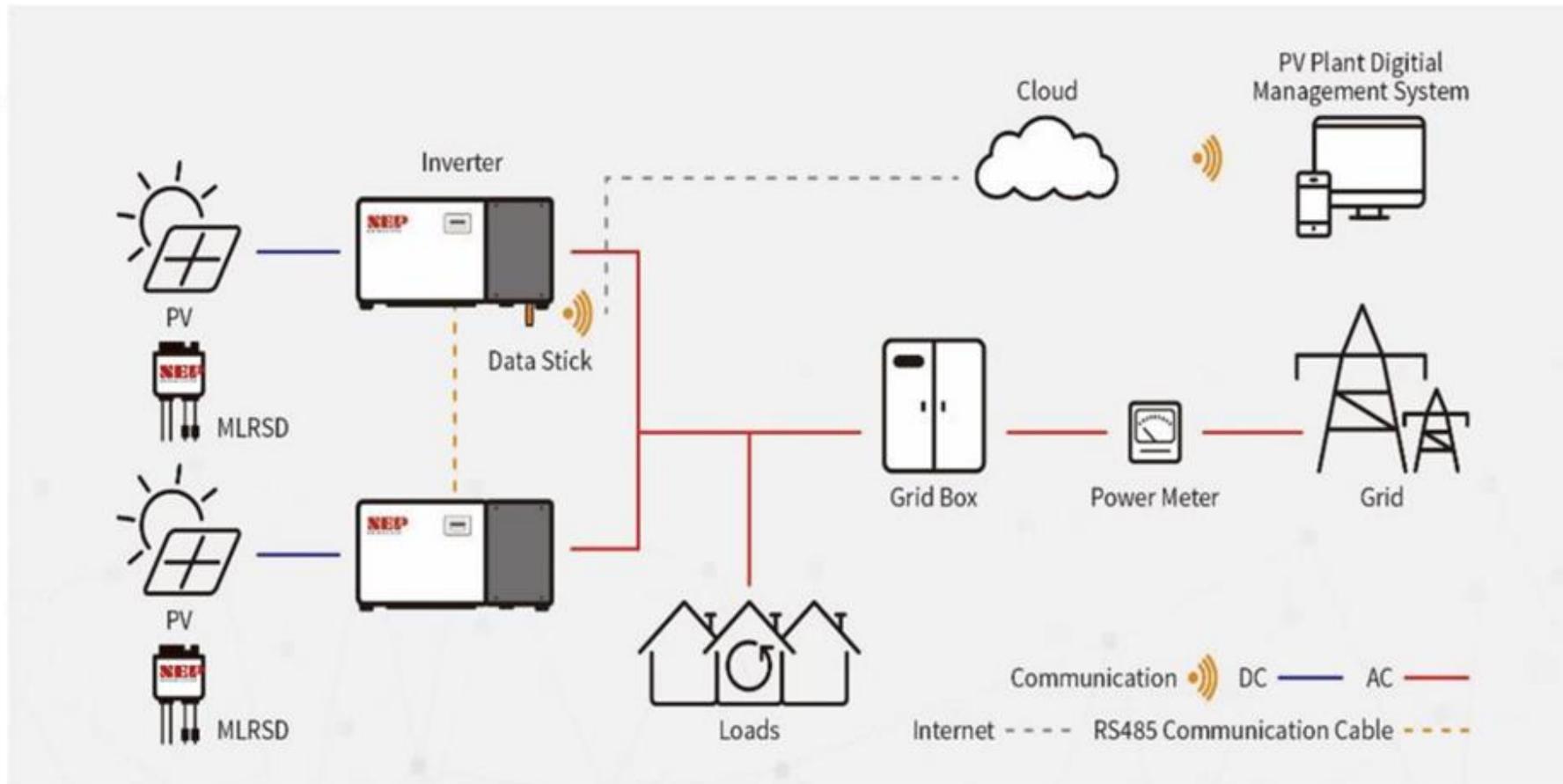


Galaxy – Data-comm for inverters and RSD

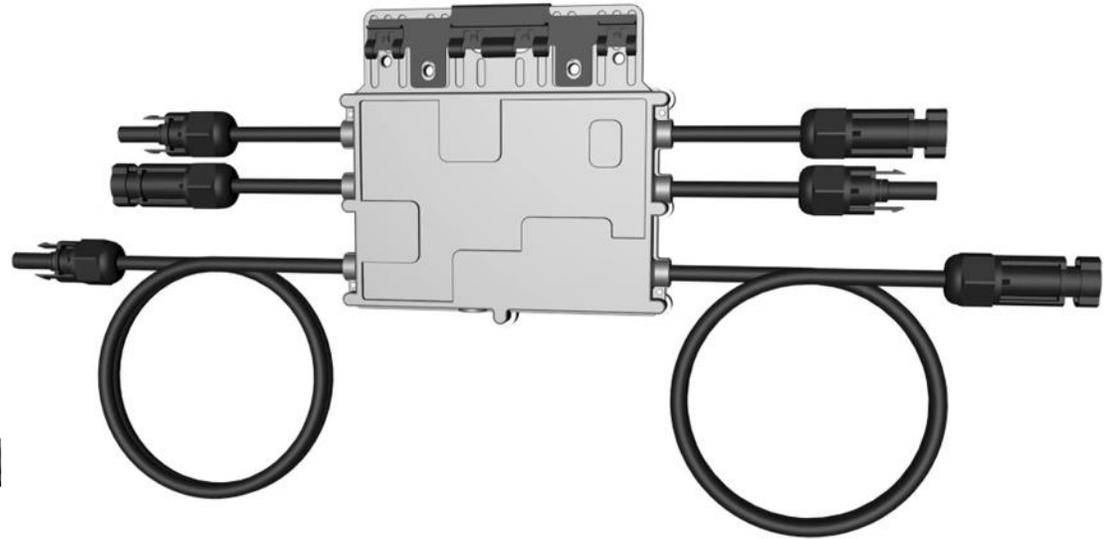
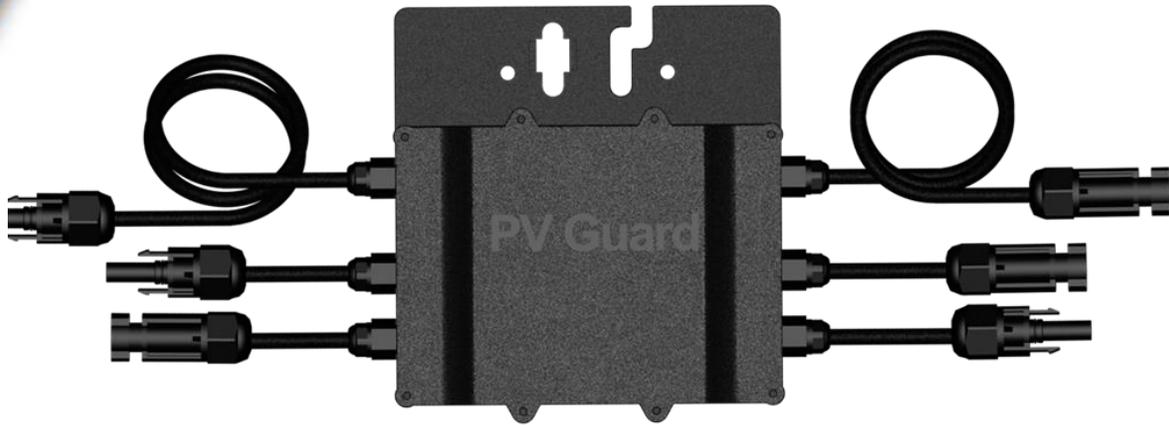
<https://northernep.com/wp-content/uploads/2023/09/NEP-NEPTUNE-Galaxy-Data-Comms-Solution-Sept-2023.pdf>



Complete RSD + Inverter + Data Solution... All from NEP



PVG-2-L
PVG-3-L



NEP RSD's work with NEP
and NON-NEP inverters

"PVG-O" provides the transmitter
and gateway for NON-NEP inverters



Counting on NEP



Bankability... on the bank

Safety... on the hospital

Reliability everywhere



Bank of America

WELLS
FARGO

SHARP



IKEA

citibank®

ExtraSpace
Storage

TANGER CITY MALL





Rapid Shutdown Solution - Data-sheet PVG-2, PVG-3



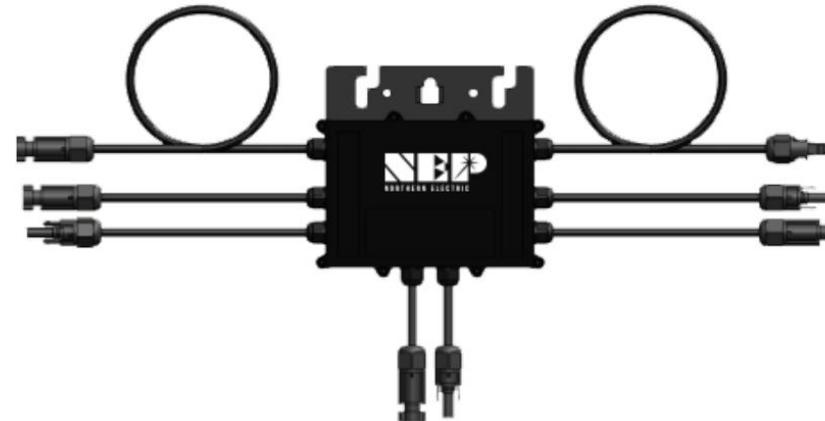
Features:

- Module level rapid shutdown: dual (2) and triple (3) modules
- Module level monitoring for commissioning, service diagnostics
- 1-minute PV data granularity for precise performance assessment
- Cellular, Wifi and Ethernet connectivity options
- Over temperature protection (auto-RSD function)
- PVRSS certified with multiple inverters and as independent system
- Zero cross talk interference through patented signaling design
- Optional customized cable/connector harness
- Staubli MC4 standard connectors
- IV Curve Trace Test mode for efficient commissioning
- String voltage test tool available
- Rail or module frame mount (optional PV mounting clip available)
- Multiple US patents

PVG-2-L



PVG-3-L



CE



PV-Guard, Panel Level Devices	PVG-2-L	PVG-3-L
Input/Output		
Input: Max DC Open Circuit Voltage per Input		90Vdc
Input: Max DC Current per Input		15/20 A
Output: Max Output Voltage	Voc(module)*2	Voc(module)*3
System Voltage Maximum		1500Vdc
Mechanical		
PV Cable	0.2m PV(2), 2.2m Homeruns (2)	12 AWG 0.2m PV, 2.2m PV(2), 3.5m Homeruns (2)
PV Connectors	MC4 Staubli (Custom configurations available)	
Size (PVG body)	5.9' x 5.7' x 1.0' (inches)	
Protection Degree	NEMA 6	
Operating Ambient Temperature	-40C - +85C	
Mounting Method	Rail via supplier MLPE hardware, PV Frame with optional NEP mounting clip	
Certifications	PVRSS Intertek, UL1741, CSA C22.2 No. 107.1, NEC 2017,2020 690.12, Canada CE 2015 64-218	
RSD Data Signal	Two-way, PLC Communications between PVG's and Transmitter	

20Amp is
With Metal
enclosure

Gateway Data Communications		
PVG-O	Enclosure with BDG-256 Gateway, PVG-C Transmitter	Used for full PV and PVG data access
PVG-M	Enclosure with BDG-256 Gateway, no Transmitter	Used for data and when transmitter resides in the inverter
Data Period	5 years data, website and smart phone application support included	
Internet Connectivity; 3 methods for connecting the NEP Gateway to the Internet		
a. Ethernet	Standard hard-wire connection to the NEP BDG-256 Gateway	
b. Wifi	Standard Wifi connection to the NEP BDG-256 Gateway	
c. Cellular	Optional cellular modem with USA sim card, includes 5 year data plan	
Power Supply	Power input 100-277Vac, 200mA, 50/60Hz	Power needed for Gateway and Transmitter
Transformer	Optional; for 480Vac to 277Vac	Used if only 480Vac is available, no neutral configuration
Enclosure Size	15.79' x 11.8' x 6.7'	
Protection	IP65	
Certifications	PVRSS, Intertek UL1741	





PVG-O Gateway + Transmitter Enclosure

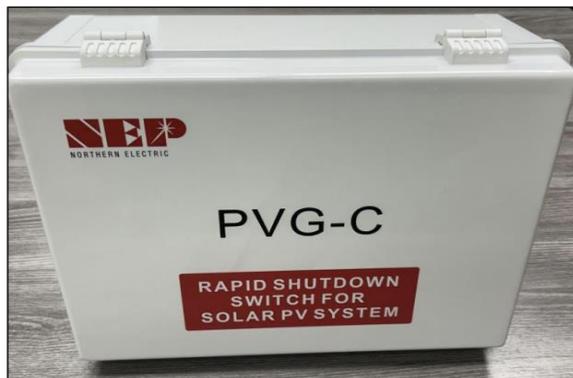
For Rapid Shutdown Implementation with Non-NEP Inverters

Features:

- NEP Rapid Shutdown Transmitter/Controller
- NEP Gateway installed
- Outdoor IP65 enclosure
- PLC Data communications system with two CT's
- Data collection from RSD devices (to Gateway)
- RSD activation and control via transmitters
- Two cores for more DC conductor capacity
- One PVG-O per inverter, recommended
- For C&I and Residential applications
- 4 units per carton, 54 units per pallet



NEP Part Number; NC0076 Product Name = PVG-O-D

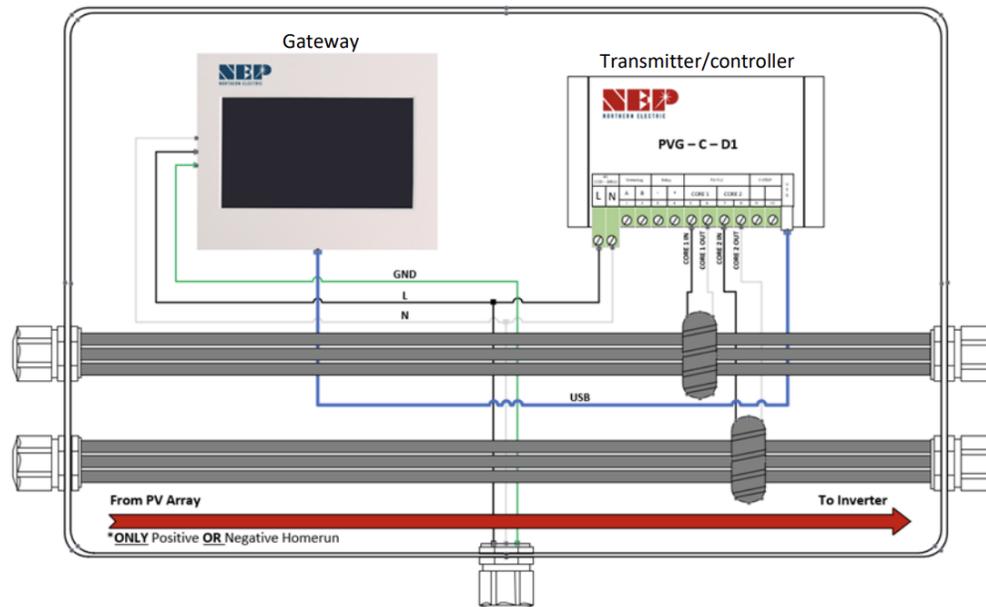


Transmitter enclosure for NON-NEP Inverters



PVG-O Gateway + Transmitter Enclosure

For Rapid Shutdown Implementation with Non-NEP Inverters



Power Supply	
	100-480 Vac.200mA, 50/60 HZ
Maximum System Voltage	
	1500 V
Mechanicals	
Size	15.79' x11.8' x 6.7'
Protection Degree	IP65
Operating Temperature	-20°C~+85°C
Monitoring	
	Module Level with BDG-256

Optional transformer is necessary for applications not having 100-277Vac available to power the gateway and transmitter. E.g., In case of a 480Vac inverter with no neutral. The NEP step down transformer can be installed in the PVG-O enclosure. NEP Part Number = XFMR-480/277/240



NEP RSD 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

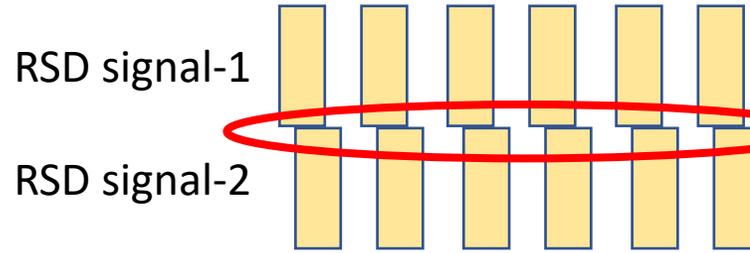


PVG vs Optimizer

NEP RSD has more features, less hassle

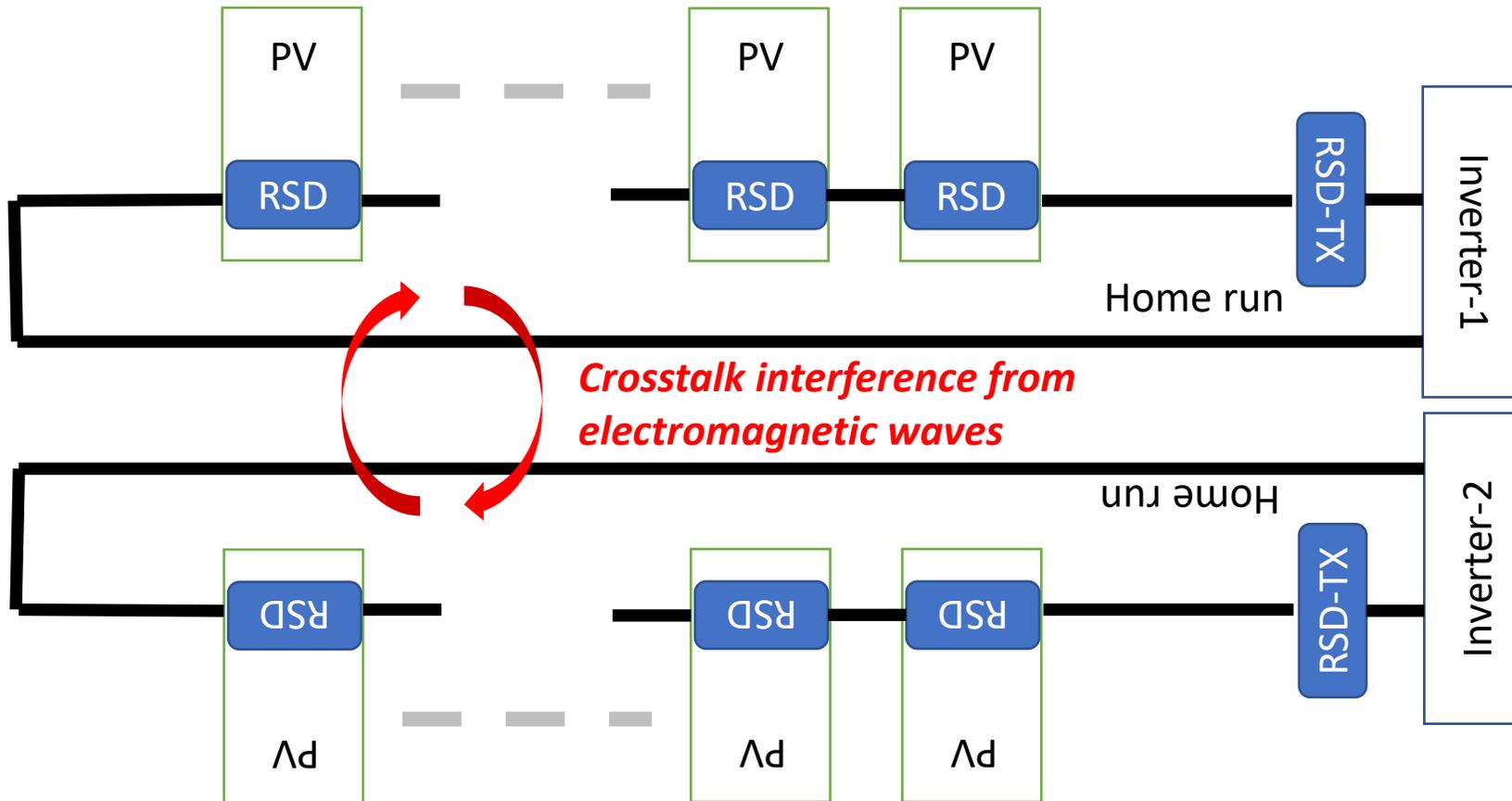
	NEP PVG	Optimizer
Communication	Two-way	Two-way
Module level monitoring	Yes	Yes
Component count	less	more
Mean Time Between Failure	better	worse
Over heating	almost no heat	Yes
Efficiency	> 99.8%	low
Reliability (topology complexity)	high	low
Module Level MPPT Function	No	Yes
Price	much lower	high
System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

Crosstalk Root cause



*Crosstalk interference
jam the signal*

UNCONTROLLED on/off



Cross-Talk Challenge



Retrofit to NEP
Is underway
Texas



Retrofit to NEP



Crosstalk Hazard

Peers RSD's have severe cross talk issues

- => 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
- => Importantly, phase delay due to inductance of long PV cable can counter impact the synchronization of the transmitters

CONCLUSION: 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>	<p>(10) Patent No.: US 11,133,777 B2 (45) Date of Patent: Sep. 28, 2021</p>																																																				
<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>(56) References Cited U.S. PATENT DOCUMENTS</p> <table border="0" style="width: 100%;"> <tr> <td style="width: 15%;">5,327,892 A</td> <td style="width: 15%;">7/1994</td> <td style="width: 15%;">Nakamura</td> <td style="width: 55%;"></td> </tr> <tr> <td>8,274,172 B2</td> <td>9/2012</td> <td>Hadar</td> <td></td> </tr> <tr> <td>8,653,689 B2</td> <td>2/2014</td> <td>Rozenboim</td> <td></td> </tr> <tr> <td>9,112,379 B2*</td> <td>8/2015</td> <td>Sella</td> <td>H01L 31/02021</td> </tr> <tr> <td>9,524,832 B2</td> <td>12/2016</td> <td>Orr</td> <td></td> </tr> <tr> <td>9,991,717 B1</td> <td>6/2018</td> <td>Rowe</td> <td></td> </tr> <tr> <td>10,720,878 B2</td> <td>7/2020</td> <td>Ehlmann</td> <td></td> </tr> <tr> <td>2004/0041665 A1</td> <td>3/2004</td> <td>Hode</td> <td></td> </tr> <tr> <td>2004/0135676 A1</td> <td>7/2004</td> <td>Berkman</td> <td></td> </tr> <tr> <td>2011/0261027 A1</td> <td>10/2011</td> <td>Lee</td> <td></td> </tr> <tr> <td>2013/0009483 A1</td> <td>1/2013</td> <td>Kawate</td> <td></td> </tr> <tr> <td>2013/0194706 A1</td> <td>8/2013</td> <td>Har-Shai</td> <td></td> </tr> <tr> <td>2015/0028602 A1</td> <td>1/2015</td> <td>Makhtas</td> <td></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



Extra protection for heat dissipation and protection over the plastic case

In 2024, NEP started shipping 20Amp metal enclosure RSD's

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.

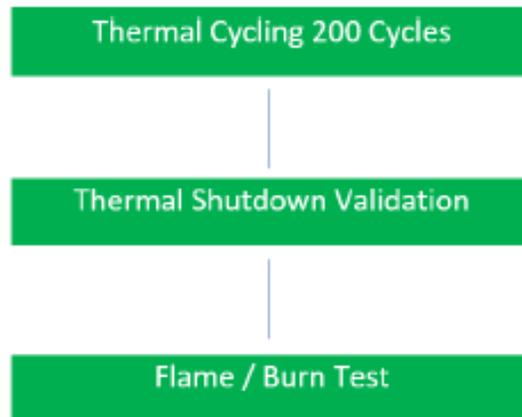
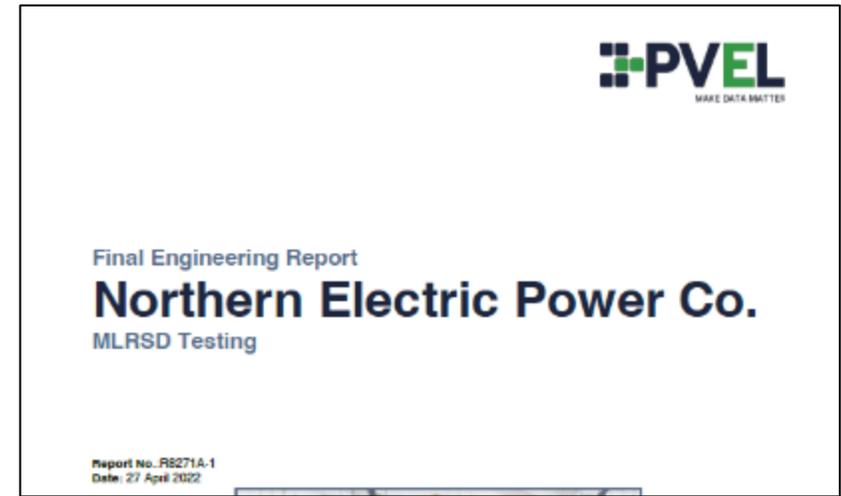


Figure 2-1: Test plan process diagram

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.

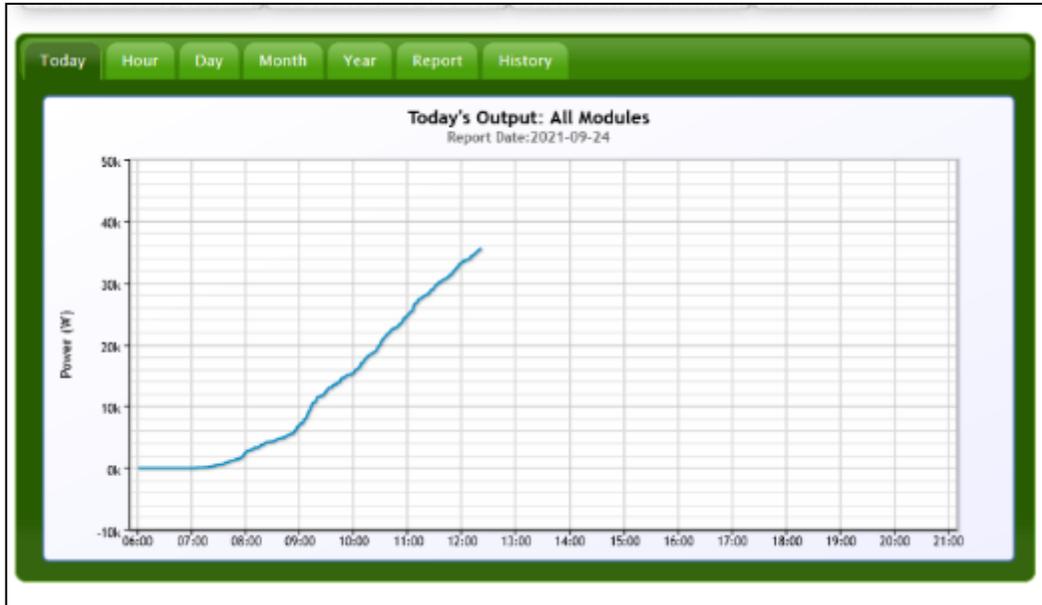


PVEL test report is available

Rigorous Testing
for Reliability



PV data granularity



To assure correct installation, day #1
 To assure proper function over time
 For site troubleshooting; strings, panels, RSD,
 ...shade, connectors, inverters etc.

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	0.638	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]	
168.7	374.4	448.9	365.6	404.3	386.8	419.2	
0.815	1.050	1.008	1.099	1.450	1.414	1.592	
[47]	[46]	[45]	[44]	[43]	[42]	[41]	
162.5	348.0	359.9	412.5	435.2	430.5	175.1	
0.527	1.417	0.888	1.455	1.450	1.594	1.227	
[48]	[49]	[50]	[51]	[52]	[53]	[54]	
264.7	52.1	402.9	380.1	408.8	348.6	367.4	
0.845	0.011	1.277	1.479	1.202	1.592	1.284	
[61]	[60]	[59]	[58]	[57]	[56]	[55]	
419.8	393.1	461.6	409.6	365.5	432.6	379.1	
1.585	1.245	1.457	1.282	1.829	1.292	1.684	
[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	1.342	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	0.820	0.492	0.881	0.677	1.023	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	0.523
[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	1.026
[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	1.025	1.022	0.522	0.851	0.208
[106]	[107]	[108]	[109]	[104]	[103]	[102]	
221.1	362.4	352.7	330.4	436.8	271.7	438.6	
0.772	1.185	0.742	0.902	1.102	0.789	1.294	



PVG-2

Field Data - Temperature

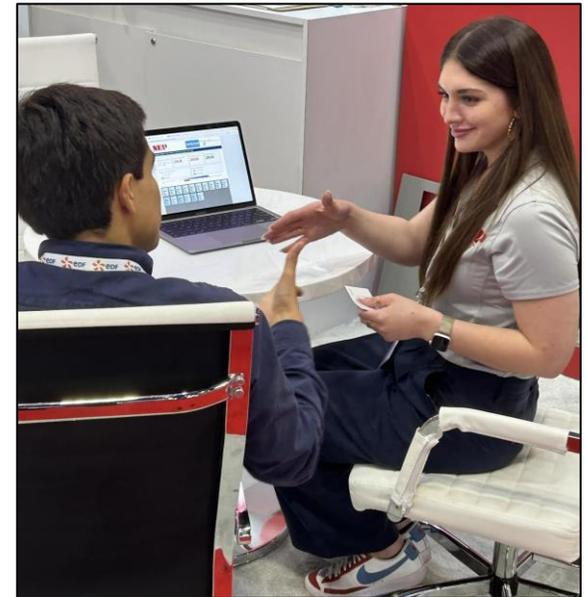
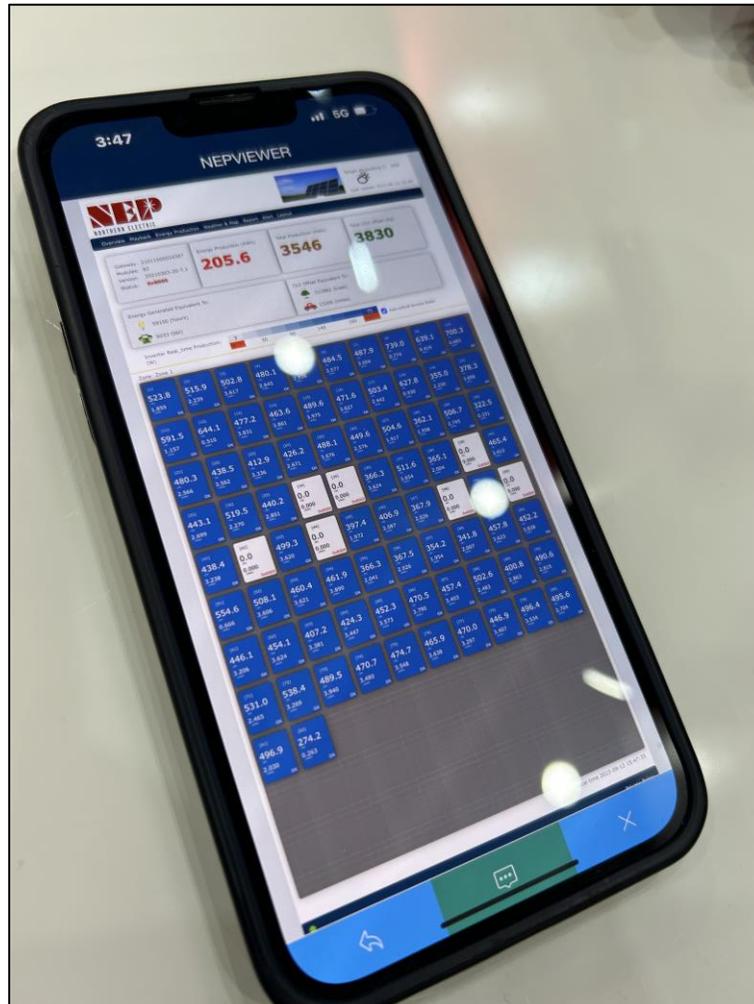
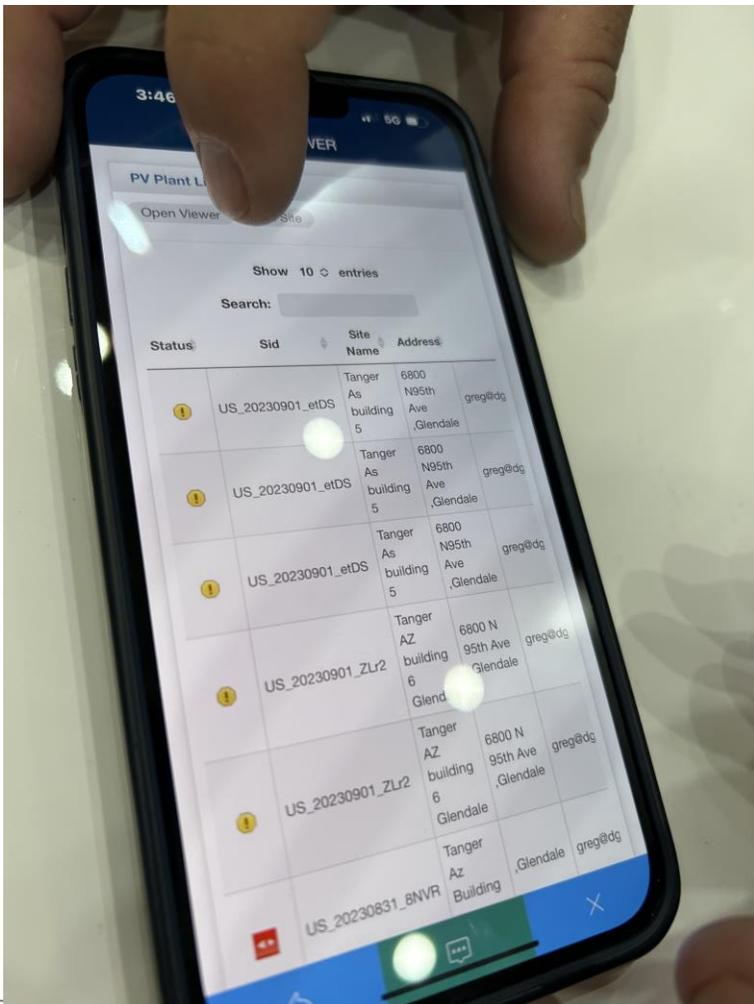
Panel Level monitoring

- Each panel real-time voltage
- String current
- Real-time Temperature
- Alert
- 1 minute data granularity

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



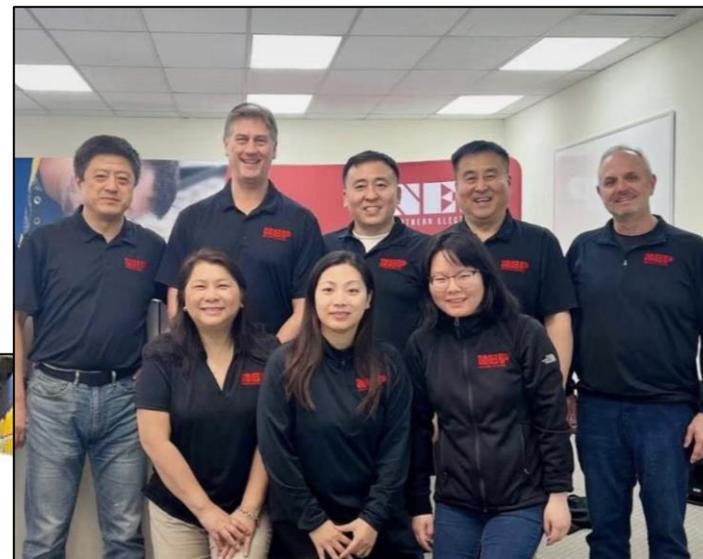
Mystery Challenge?

What is going on in this photo?

Clue: those are not NEP RSD's in the NEP cartons!



People you can
Count On



Supplements

Supplements

