

21080 Test Report: IEC TS 63209-1 Sequence 5 Potential Induced Degradation Testing on M390-D1FB Modules Produced by Mitrex

Report Number: 21080E-PR-E-001
Report Date: 2022-06-28
Test Period: 2022-02-07 to 2022-06-24
Project ID: 21060 (CFV), 000477 (Customer PO)
Customer: Hadi Khatibzadehazad/ Mitrex
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Report Prepared by:	Report Reviewed by:	Report Approved by:

Project Summary

CFV Labs conducted extended reliability testing on two **M390-D1FB** modules produced by **Mitrex** per IEC TS 63209-1 Sequence 5.

The modules were subjected to performance measurements and safety tests prior to stress testing. The modules were then subjected to 192 hours of PID stress (two modules per polarity), which was followed by post-stress performance and safety tests.

The average change in STC Pmp [W] from initial to the final post-stress testing was measured to be -3.05% and -47.91% for the positive and negative polarity test respectively. The modules passed all safety tests and all visual inspections.

This report is sub-report 21080E-PR-E-001 of project 21080. All test legs for this IEC TS 63209-1 project are summarized in report 21080-PR-E-001.

Project Test Flow

The figure below shows the overall test flow for this project.

Incoming Inspection	Seq_5 PID_Pos	Seq_5 PID_Neg
All samples	21080-014, 21080-020	21080-021, 21080-025
@Initial	@Seq5_Pos_Initial	@Seq5_Neg_Initial
Incoming Inspection	MQT 06.1 Performance at STC	MQT 06.1 Performance at STC
MQT 01 Visual Inspection	MQT 07 Performance at Low Irradiance	MQT 07 Performance at Low Irradiance
EL Imaging 1.0x Isc	@Seq5_Pos_Stabilization	@Seq5_Neg_Stabilization
EL Imaging 0.1x Isc	MQT 19 Stabilization - Outdoor Exposure (120 kWh/m ² , MPPT)	MQT 19 Stabilization - Outdoor Exposure (120 kWh/m ² , MPPT)
	@Seq5_Pos_Stabilized	@Seq5_Neg_Stabilized
	MQT 06.1 Performance at STC	MQT 06.1 Performance at STC
	MQT 07 Performance at Low Irradiance	MQT 07 Performance at Low Irradiance
	Bifacial Indoor I-V	Bifacial Indoor I-V
	EL Imaging 1.0x Isc	EL Imaging 1.0x Isc
	EL Imaging 0.1x Isc	EL Imaging 0.1x Isc
	MQT 03 Insulation	MQT 03 Insulation
	MQT 15 Wet Leakage Current	MQT 15 Wet Leakage Current
	@Seq5_Pos_PID	@Seq5_Neg_PID
	Positive PID (192 Hours)	Negative PID (192 Hours)
	MQT 01 Visual Inspection	MQT 01 Visual Inspection
	MQT 06.1 Performance at STC	MQT 06.1 Performance at STC
	MQT 07 Performance at Low Irradiance	MQT 07 Performance at Low Irradiance
	Bifacial Indoor I-V	Bifacial Indoor I-V
	EL Imaging 1.0x Isc	EL Imaging 1.0x Isc
	EL Imaging 0.1x Isc	EL Imaging 0.1x Isc
	MQT 03 Insulation	MQT 03 Insulation
	MQT 15 Wet Leakage Current	MQT 15 Wet Leakage Current

Test Flow Assignment

The modules utilized for this testing were supplied by the customer after they were inspected and sampled by PI Berlin for CFV Labs. The report, *CFV21080 Mitrex sample witness report 20220121_R2*, was provided separately to the customer.

These modules were free of obvious defects under visual inspection and electroluminescence imaging. The test flow assignment for each of the modules is provided in the table below. The modules were subjected to the test legs in the order listed.

Module ID	Serial Number	Test Leg(s)	Notes
21080-002	MIT21A04827	Incoming Inspection, Z_Control	-
21080-014	MIT22A00009	Incoming Inspection, Seq_5 PID Pos	-
21080-020	MIT21A04872	Incoming Inspection, Seq_5 PID Pos	-
21080-021	MIT21A04871	Incoming Inspection, Seq_5 PID Neg	-
21080-025	MIT21A04822	Incoming Inspection, Seq_5 PID Neg	-

Sample Information

Sample Dimensions

Module Manufacturer	Module Type	Length [m]	Width [m]	Thickness [mm]
Mitrex	M390-D1FB	2.03	0.99	40

Sample Nameplate Values

Module Type	Isc [A]	Voc [V]	Imp [A]	Vmp [V]	Pmp [W]	Max Sys Volt [V]	Fuse Rating [A]
M390-D1FB	9.76	47.3	9.29	42.07	390	1000	20

Sample Type Images

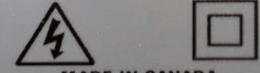
Module (M390-D1FB)




MITREX
 41 Racine Rd, Toronto, ON M9W 2Z4, Canada
 Tel: 1-416-497-7120
www.mitrex.com info@mitrex.com

MODULE TYPE	M390-D1FB
Maximum Power (P _{max})	390
Max Power Tolerance	± 5 %
Maximum Power Voltage (V _{mp})	42.0
Maximum Power Current (I _{mp})	9.29
Open Circuit Voltage (V _{oc})	47.3
Short Circuit Current (I _{sc})	9.76
Max. system Voltage	1000 V
Maximum overcurrent protection rating	20 A

All ratings at STC: E = 1000W/m² A = 1.5, T = 25°C
 Accuracy of other electrical values ± 5 %
WARNING / ELECTRICAL HAZARD
This module produces electricity when exposed to sunlight. Do not disconnect the module under load. Follow all applicable electrical safety precautions.


MADE IN CANADA



Results: Test Leg – Incoming Inspection

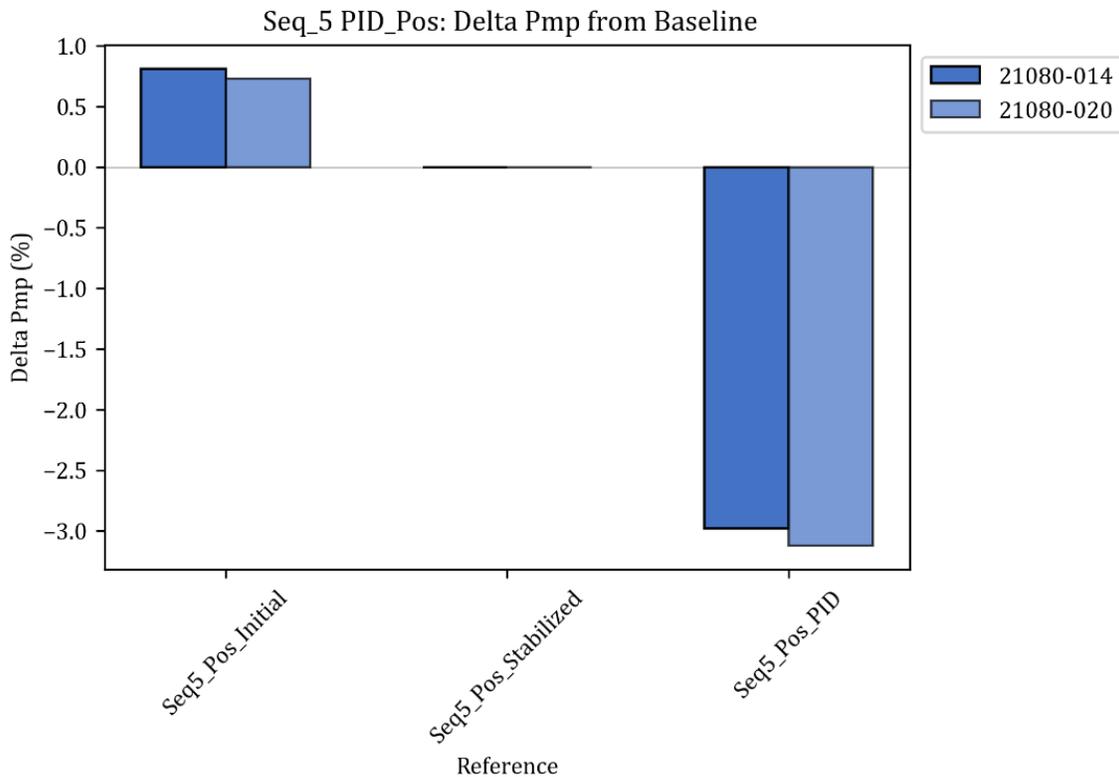
An incoming inspection report is provided separately to the customer. No issues were observed during the incoming inspection.

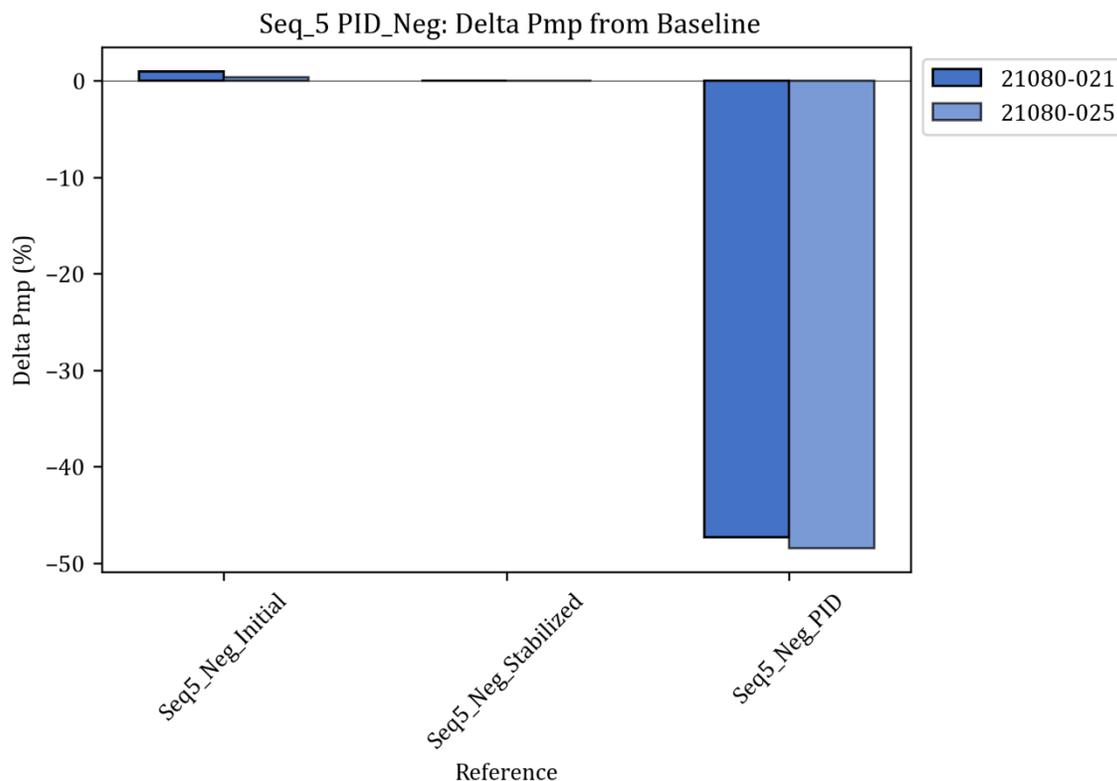
Results: Test Leg – Seq_5 PID_Pos/Neg

Results for both the positive (pos) and negative (neg) polarity tests are presented in this section.

Summary of Results – Performance at STC and Safety Testing

The plots below show the Performance at STC measurement values as a percentage change from the Stabilized values.





The tables below show the Performance at STC, Visual Inspection, and safety testing results per module. When required, more detail is provided in the section referenced in the “Notes” field.

Test Conditions

Irradiance [W/m ²]	Temperature [°C]
1000.0	25.0

Estimated Measurement Uncertainty

Technology	Isc	Voc	Imp	Vmp	Pmp
Si, Bifacial (k=2)	± 1.6 %	± 0.75 %	± 2.1 %	± 1.3 %	± 2.2 %

Module: 21080-014

Reference	Isc (A)	Voc (V)	Imp (A)	Vmp (V)	Pmp (W)	ΔPmp (%)	Visual Inspection	Wet Leakage	Insulation
Initial	9.984	49.10	9.473	40.29	381.68	+0.81	pass	pass	pass
Stabilized	9.958	49.12	9.422	40.18	378.60	-	pass	pass	pass
PID_Pos	9.821	48.78	9.230	39.80	367.30	-2.98	pass	pass	pass

Module: 21080-020

Reference	Isc (A)	Voc (V)	Imp (A)	Vmp (V)	Pmp (W)	ΔPmp (%)	Visual Inspection	Wet Leakage	Insulation
Initial	9.978	49.10	9.465	40.34	381.84	+0.73	pass	pass	pass
Stabilized	9.952	49.12	9.428	40.20	379.05	-	pass	pass	pass
PID_Pos	9.798	48.85	9.217	39.84	367.21	-3.12	pass	pass	pass

Module: 21080-021

Reference	Isc (A)	Voc (V)	Imp (A)	Vmp (V)	Pmp (W)	ΔPmp (%)	Visual Inspection	Wet Leakage	Insulation
Initial	9.996	49.21	9.479	40.43	383.30	+1.00	pass	pass	pass
Stabilized	9.972	49.05	9.428	40.25	379.51	-	pass	pass	pass
PID_Neg	9.782	41.65	7.315	27.32	199.84	-47.34	pass	pass	pass

Module: 21080-025

Reference	Isc (A)	Voc (V)	Imp (A)	Vmp (V)	Pmp (W)	ΔPmp (%)	Visual Inspection	Wet Leakage	Insulation
Initial	10.002	49.15	9.470	40.29	381.55	+0.38	pass	pass	pass
Stabilized	9.990	49.06	9.464	40.16	380.10	-	pass	pass	pass
PID_Neg	9.788	40.58	7.395	26.48	195.84	-48.48	pass	pass	pass

Performance at STC – Change from Stabilized

Module ID	Reference	Δ Isc [%]	Δ Voc [%]	Δ Imp [%]	Δ Vmp [%]	Δ Pmp [%]
21080-014	Initial	+0.25	-0.03	+0.54	+0.27	+0.81
	Stabilized	+0.00	+0.00	+0.00	+0.00	+0.00
	PID_Pos	-1.38	-0.68	-2.04	-0.96	-2.98
21080-020	Initial	+0.27	-0.04	+0.39	+0.34	+0.73
	Stabilized	+0.00	+0.00	+0.00	+0.00	+0.00
	PID_Pos	-1.55	-0.55	-2.24	-0.91	-3.12
21080-021	Initial	+0.24	+0.33	+0.54	+0.45	+1.00
	Stabilized	+0.00	+0.00	+0.00	+0.00	+0.00
	PID_Neg	-1.90	-15.09	-22.42	-32.13	-47.34
21080-025	Initial	+0.13	+0.19	+0.06	+0.32	+0.38
	Stabilized	+0.00	+0.00	+0.00	+0.00	+0.00
	PID_Neg	-2.02	-17.29	-21.87	-34.06	-48.48

Control Module Measurements (21060-024)

Module ID	Reference	Isc (A)	Voc (V)	Imp (A)	Vmp (V)	Pmp (W)
21080-002	Initial	9.981	49.19	9.476	40.33	382.22
	Stabilized	9.975	49.14	9.450	40.19	379.84
	PID	9.939	49.10	9.418	40.25	379.12

Bifacial Performance

Note: Front-side measurements are presented in Summary of Results – Performance and Safety Testing

Test Conditions

Irradiance [W/m ²]	Temperature [°C]
1000.0	25.0

Estimated Measurement Uncertainty

Technology	Isc	Voc	Imp	Vmp	Pmp
Si, Bifacial (k=2)	± 1.6 %	± 0.75 %	± 2.1 %	± 1.3 %	± 2.2 %

Measurements - Backside

Module ID	Reference	Isc [A]	Voc [V]	Imp [A]	Vmp [V]	Pmp [W]
21080-014	Stabilized	6.783	48.44	6.095	41.99	255.93
	PID_Pos	6.771	48.32	6.049	41.69	252.21
21080-020	Stabilized	6.823	48.45	5.962	42.45	253.13
	PID_Pos	6.772	48.24	5.921	42.03	248.86
21080-021	Stabilized	6.976	48.43	5.856	42.72	250.20
	PID_Neg	6.953	38.72	5.137	25.21	129.51
21080-025	Stabilized	7.010	48.46	5.476	43.37	237.49
	PID_Neg	7.024	37.90	5.132	25.08	128.70

Measurements - Bifaciality

Module ID	Reference	ϕ_{Isc} [%]	ϕ_{Voc} [%]	ϕ_{Imp} [%]	ϕ_{Vmp} [%]	ϕ_{Pmp} [%]
21080-014	Stabilized	68.11	98.63	64.69	104.49	67.60
	PID_Pos	68.94	99.06	65.54	104.77	68.67
21080-020	Stabilized	68.56	98.64	63.24	105.60	66.78
	PID_Pos	69.11	98.76	64.23	105.50	67.77
21080-021	Stabilized	69.95	98.74	62.12	106.14	65.93
	PID_Neg	71.08	92.99	70.23	92.28	64.81
21080-025	Stabilized	70.18	98.79	57.86	107.98	62.48
	PID_Neg	71.76	93.39	69.40	94.70	65.72

Performance at Low Irradiance

Test Conditions

Irradiance [W/m ²]	Temperature [°C]
200.0	25.0

Estimated Measurement Uncertainty

Technology	Isc	Voc	Imp	Vmp	Pmp
Si, Bifacial (k=2)	± 1.6 %	± 0.75 %	± 2.1 %	± 1.3 %	± 2.2 %

Measurements

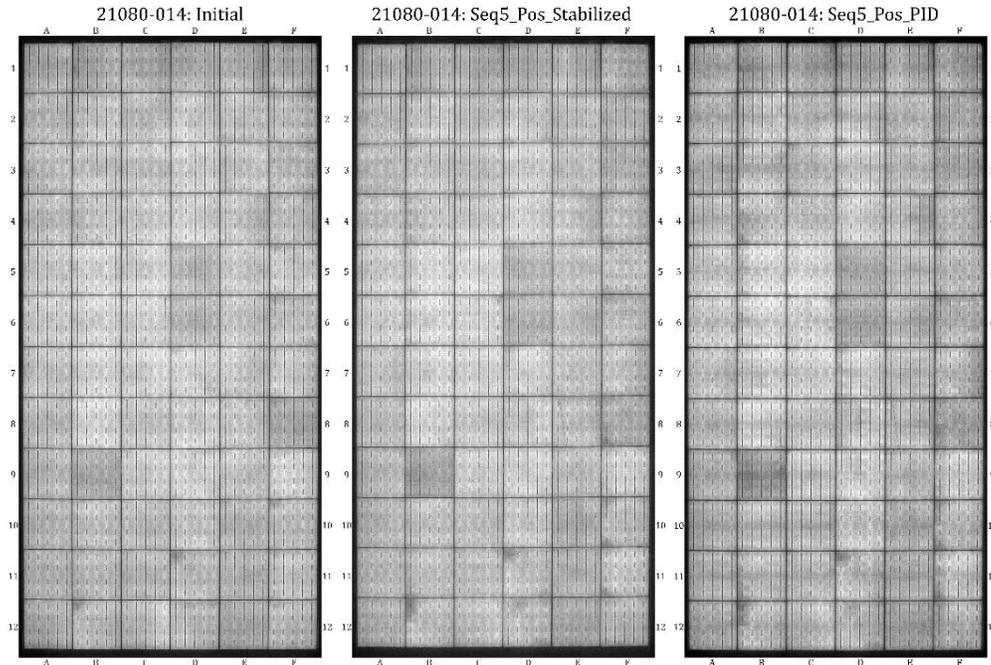
Module ID	Reference	Isc [A]	Voc [V]	Imp [A]	Vmp [V]	Pmp [W]
21080-014	Initial	1.995	46.03	1.887	39.40	74.36
	Stabilized	1.999	45.92	1.872	39.12	73.21
	PID_Pos	1.973	45.64	1.840	38.75	71.31
21080-020	Initial	1.988	46.01	1.886	39.41	74.32
	Stabilized	1.998	45.91	1.881	39.20	73.73
	PID_Pos	1.966	45.60	1.841	38.66	71.16
21080-021	Initial	2.000	46.09	1.890	39.47	74.61
	Stabilized	2.002	45.94	1.862	39.19	72.98
	PID_Neg	1.963	28.15	1.436	18.17	26.10
21080-025	Initial	1.999	46.13	1.888	39.45	74.47
	Stabilized	1.999	45.97	1.892	39.32	74.38
	PID_Neg	1.963	27.81	1.442	18.22	26.27

Stabilization

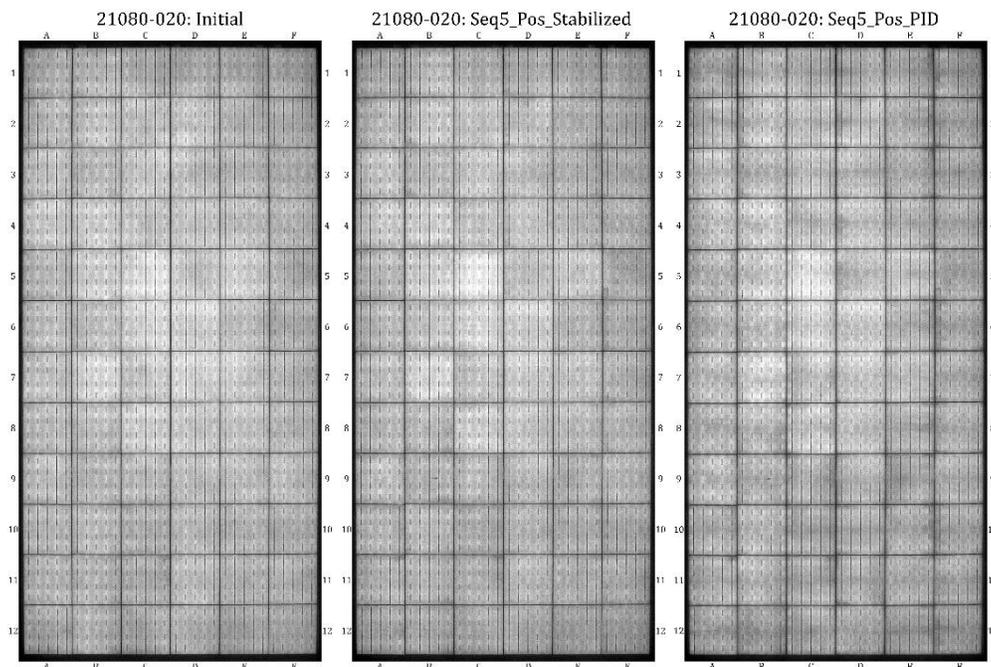
Modules were stabilized for a total dose of 145.78 kWh/m².

Electroluminescence Imaging

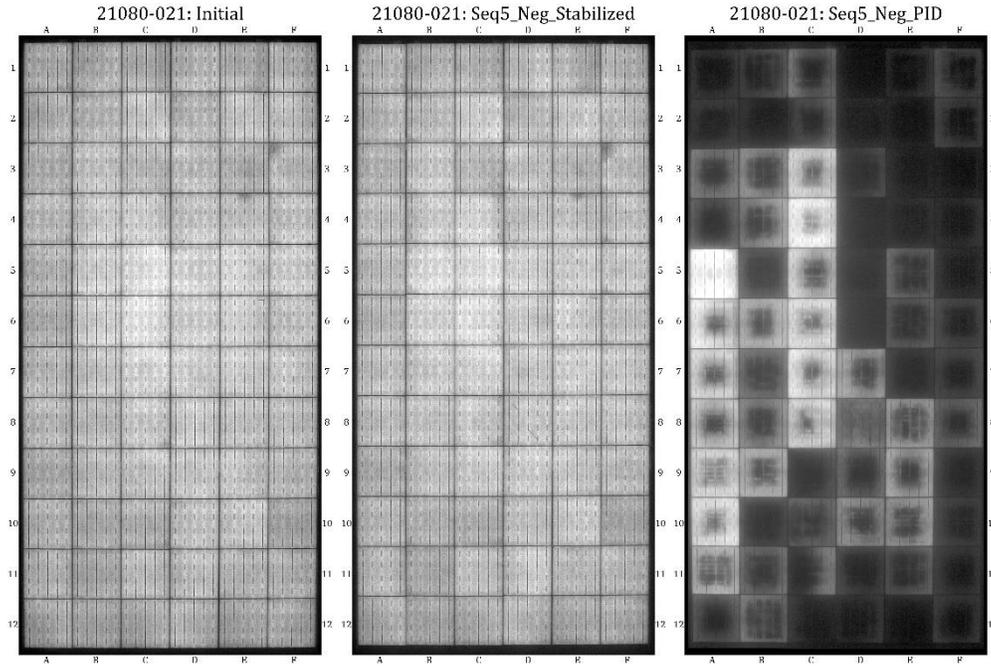
Module 21080-014 (Images taken at $0.1 \times I_{sc}$ are provided separately in digital format)



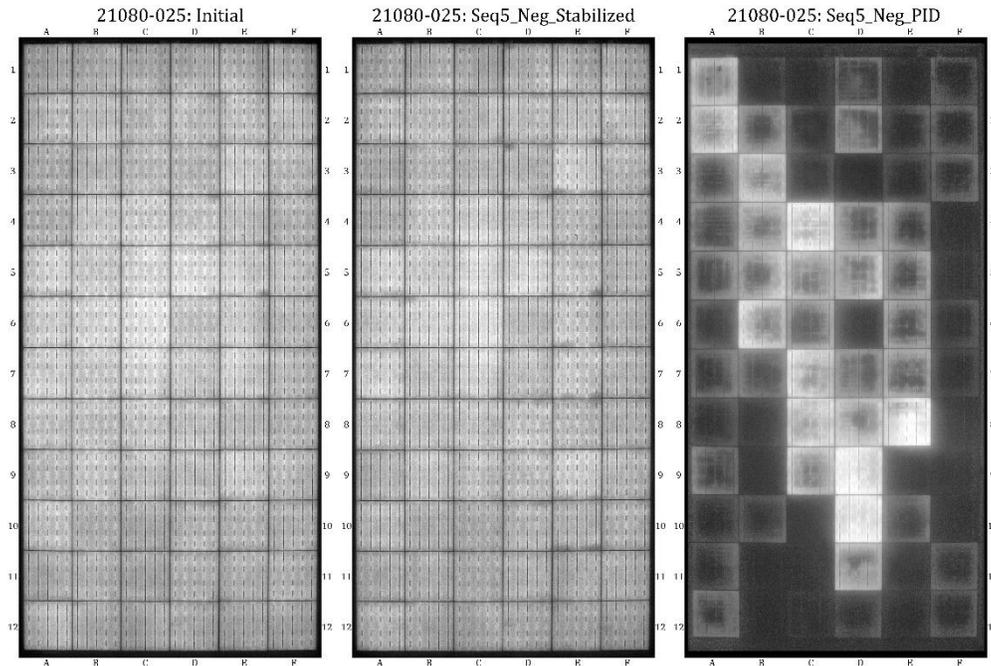
Module 21080-020 (Images taken at $0.1 \times I_{sc}$ are provided separately in digital format)



Module 21080-021 (Images taken at 0.1 x Isc are provided separately in digital format)



Module 21080-025 (Images taken at 0.1 x Isc are provided separately in digital format)



Potential Induced Degradation

Module	Reference	Hour Count	Applied Bias [V]	Temp [°C]	Humidity [% RH]
21080-014	Seq5_PID_Pos	192	+1000	85	85
21080-020	Seq5_PID_Pos	192	+1000	85	85
21080-021	Seq5_PID_Neg	192	-1000	85	85
21080-025	Seq5_PID_Neg	192	-1000	85	85

Procedures

The procedures for the testing contained in this report are summarized in the following table.

Test Name	Standard / Procedure	CFV Accreditation
Incoming Inspection	CFV	NA
Visual Inspection	IEC 61215-2:2016 MQT 01	ISO 17025
Electroluminescence Imaging	IEC TS 60904-13:2018	ISO 17025
*Stabilization	IEC 61215-2:2016 MQT 19	ISO 17025
Performance at STC	IEC 61215-2:2016 MQT 06.1	ISO 17025
Performance at Low Irradiance	IEC 61215-2:2016 MQT 07	ISO 17025
Bifacial Performance	IEC TS 60904-1-2:2019	ISO 17025
Wet Leakage Current	IEC 61215-2:2016 MQT 15	ISO 17025
Insulation	IEC 61215-2:2016 MQT 03	ISO 17025
Potential Induced Degradation	IEC TS 62804:2015	ISO 17025

Amendments to tests:

*IEC 61215-2:2016 MQT 19, requires that modules are operated with MPPT and are measured at multiple intervals during the light exposure to determine stability. For this project, three of the modules tested were measured according to the full MQT 19 protocol (21080-002, 21080-003, and 21080-008). However, the standard allows for the use of an alternative procedure that is validated against the full protocol. In this case, the remaining modules were exposed to the same total dose, but they were only measured before and after the total dose and were operated in open circuit.

Equipment Calibration Information

Equipment and Calibration information is available upon request.

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