Provisional Interconnection Study Report for PI-2024-02

11/01/2024

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1.0 Executive Summary

The PI-2024-02 project is a Provisional Interconnection Service (PIS)[1] request for a 400 MW Combustion Turbine Generating Facility with a Point of Interconnection (POI) at the Fort Saint Vrain 230 kV substation. This PIS request is associated with Generation Interconnection Request 5RSC-2024-02 in the 5RSC cluster.

The total estimated cost of the transmission system improvements required for PI-2024-02 to qualify for Provisional Interconnection Service is **$19.091** million (Table 7 and Table 8).

The initial maximum permissible output of PI-2024-02 Generating Facility is 400 MW. The maximum permissible output of the Generating Facility in the PLGIA[2] will be reviewed quarterly and updated if there are changes to the system conditions assumed in this analysis, to determine the maximum permissible output.

Security: PI-2024-02 is a request for Energy Resource Interconnection Service (ERIS). For ERIS requests, security shall estimate the risk associated with the Network Upgrades and the Interconnection Facilities and is assumed to be a minimum of $5 million.

In addition, the Interconnection Customer would assume all risk and liabilities with respect to changes between the PLGIA and the LGIA[3], including changes in output limits and Interconnection Facilities, Network Upgrades, Distribution Upgrades, and/or System Protection Facilities cost responsibility.

The Provisional Interconnection Service in and of itself does not convey transmission service.

2.0 Introduction

PI-2024-02 is the Provisional Interconnection Service request for a 400 MW Combustion Turbine Generating Facility located in Weld County, Colorado.

- The POI of this project is the Fort Saint Vrain 230 kV substation.

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[1] **Provisional Interconnection Service (PIS)** shall mean an Interconnection Service provided by Transmission Provider associated with interconnecting the Interconnection Customer's Generating Facility to Transmission Provider's Transmission System and enabling that Transmission System to receive electric energy and capacity from the Generating Facility at the Point of Interconnection, pursuant to the terms of the Provisional Large Generator Interconnection Agreement and, if applicable, the Tariff.

[2] **Provisional Large Generator Interconnection Agreement (PLGIA)** shall mean the interconnection agreement for Provisional Interconnection Service established between Transmission Provider and/or the Transmission Owner and the Interconnection Customer. The pro forma agreement is provided in Appendix 8 and takes the form of the Large Generator Interconnection Agreement, modified for provisional purposes.

[3] **Large Generator Interconnection Agreement (LGIA)** shall mean the form of interconnection agreement applicable to an Interconnection Request pertaining to a Large Generating Facility that is included in the Transmission Provider's Tariff.

- The Commercial Operation Date (COD) to be studied for PI-2024-02 as noted on the Provisional Interconnection Service request is May 31, 2027.

The geographical location of the transmission system near the POI is shown in Figure 1.

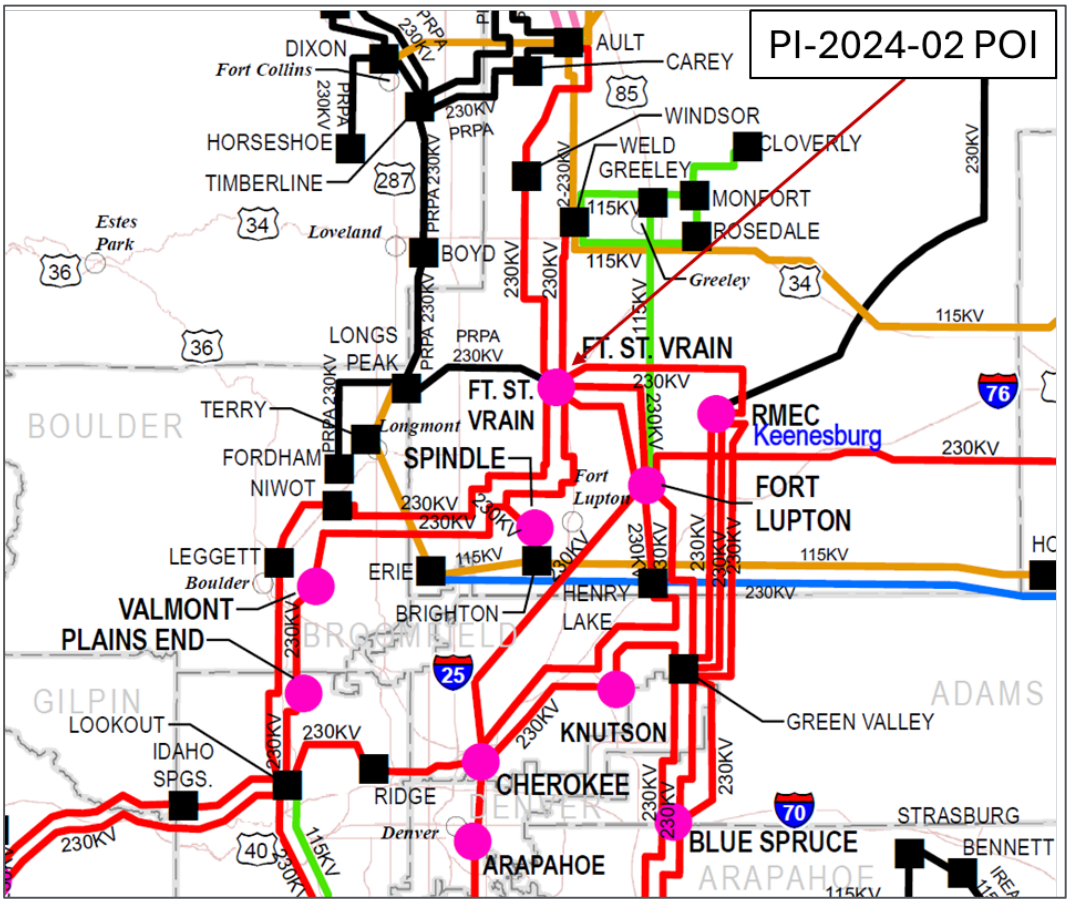


Figure 1: Point of Interconnection of PI-2024-02

3.0 Study Scope

The purpose of this study is to determine the impacts to the PSCo system and the Affected Systems from interconnecting PI-2024-02 for Provisional Interconnection Service. Consistent with the assumption in the study agreement, PI-2024-02 selected Energy Resource Interconnection Service (ERIS)[4].

[4] **Energy Resource Interconnection Service (ERIS)** shall mean an Interconnection Service that allows the Interconnection Customer to connect its Generating Facility to the Transmission Provider's Transmission system to be eligible to deliver the Generating Facility's electric output using the existing firm and non-firm capabilities of the Transmission Provider's Transmission System on an as available basis.

The scope of this report includes voltage and reactive capability evaluation, steady state (thermal and voltage) analysis, transient stability analysis, short-circuit analysis, and cost estimates for Interconnection Facilities and Station Network Upgrades. The study also identifies the estimated Security[5] and Contingent Facilities associated with the Provisional Service.

3.1 Steady-State Criteria

The following Criteria are used for the reliability analysis of the PSCo system and Affected Systems:

P0—System Intact conditions:

Thermal Loading: <=100% of the normal facility rating

Voltage range: 0.95 to 1.05 per unit

P1 & P2-1—Single Contingencies:

Thermal Loading: <=100% Normal facility rating

Voltage range: 0.90 to 1.10 per unit

Voltage deviation: <=8% of pre-contingency voltage

P2 (except P2-1), P4, P5 & P7—Multiple Contingencies:

Thermal Loading: <=100% Emergency facility rating

Voltage range: 0.90 to 1.10 per unit

Voltage deviation: <=8% of pre-contingency voltage

3.2 Transient Stability Criteria

The transient voltage stability criteria are as follows:

a. Following fault clearing, the voltage shall recover to 80% of the pre-contingency voltage within 20 seconds of the initiating event for all P1 through P7 events for each applicable Bulk Electric System (BES) bus serving load.
b. Following fault clearing and voltage recovery above 80%, voltage at each applicable BES bus serving load shall neither dip below 70% of pre-contingency voltage for more than 30 cycles nor remain below 80% of pre-contingency voltage for more than two seconds, for all P1 through P7 events.
c. For Contingencies without a fault (P2.1 category event), voltage dips at each applicable BES bus serving load shall neither dip below 70% of pre-contingency

[5] **Security** estimates the risk associated with the Network Upgrades and Interconnection Facilities that could be identified in the corresponding LGIA.

voltage for more than 30 cycles nor remain below 80% of pre-contingency voltage for more than two seconds.

The transient angular stability criteria are as follows:

a. P1—No generating unit shall pull out of synchronism. A generator being disconnected from the system by fault clearing action or by a special Protection System is not considered an angular instability.
b. P2–P7—One or more generators may pull out of synchronism, provided the resulting apparent impedance swings shall not result in the tripping of any other generation facilities.
c. P1–P7—The relative rotor angle (power) oscillations are characterized by positive damping (i.e., amplitude reduction of successive peaks) > 5% within 30 seconds.

3.3 Breaker Duty Analysis Criteria

Fault Current after PI addition should not exceed 100% of the Breaker Duty rating. PSCo can only perform breaker duty analysis on the PSCo system. Before the PI goes in service the Affected Systems may choose to perform a breaker duty analysis to identify breaker duty violations on their system.

3.4 Study Methodology

For PSCo and non-PSCo facilities, thermal violations attributed to the request include all new facility overloads with a thermal loading >100% and increased by 1% or more from the benchmark case overload post the Generator Interconnection Request (GIR) addition.

The voltage violations assigned to the request include new voltage violations which resulted in a further variation of 0.01 per unit.

Since the request is for Provisional Interconnection Service, if thermal or voltage violations are seen, the maximum permissible Provisional Interconnection before violations is identified. For voltage violations caused by reactive power deficiency at the POI, voltage upgrades are identified.

The Provisional Interconnection Service request should meet the transient stability criteria stated in Section 3.2. If the addition of the GIR causes any violations, the maximum permissible Provisional Interconnection Service before violations is identified.

3.5 Contingency Analysis

The transmission system on which steady state contingency analysis is run includes the WECC designated areas 70 and 73.

The transient stability analysis is performed for the following worst-case contingencies shown in Table 1.

Table 1 – Transient Stability Contingencies

Ref. No.	Fault Location	Fault Category	Outage(s)	Clearing Time (Cycles)
1	Ft St Vrain 345/230 kV transformer	P1	Ft St Vrain 345/230 kV transformer	5
2	Ft St Vrain - Fordham 230 kV Line	P1	Ft St Vrain - Fordham 230 kV Line	5
3	Ft St Vrain - Ft Lupton 230 kV Line	P1	Ft St Vrain - Ft Lupton 230 kV Line	5
4	Ft St Vrain - GI-2024-02 230 kV Line	P1	Ft St Vrain - GI-2024-02 230 kV Line	5
5	Ft St Vrain - Isabelle 230 kV Line	P1	Ft St Vrain - Isabelle 230 kV Line	5
6	Ft St Vrain - Keenesburg 230 kV Line	P1	Ft St Vrain - Keenesburg 230 kV Line	5
7	Ft St Vrain - Longs Peak 230 kV Line	P1	Ft St Vrain - Longs Peak 230 kV Line	5
8	Ft St Vrain - Spindle 230 kV Line	P1	Ft St Vrain - Spindle 230 kV Line	5
9	Ft St Vrain - Weld PS 230 kV Line	P1	Ft St Vrain - Weld PS 230 kV Line	5
10	Ft St Vrain - Windsor 230 kV Line	P1	Ft St Vrain - Windsor 230 kV Line	5
11	Ft St Vrain - Fordham 230 kV line	P4	○ Ft St Vrain - Windsor - Ault 230 kV line ○ Ft St Vrain - Fordham 230 kV line ○ Loads 'P1' and 'P2' at Windsor 230 kV	17
12	Ft St Vrain 230 kV bus	P4	Ft St Vrain unit 'ST' & GSU	17
13	Ft St Vrain - Longs Peak 230 kV Line	P4	○ Ft St Vrain - Longs Peak - Gateway 230 kV line ○ Longs Peak 230/115 transformers 1 & 2	17
14	Ft St Vrain - Ft Lupton 230 kV Line	P4	○ Ft St Vrain - Ft Lupton 230 kV Line ckt 2 ○ Ft St Vrain unit 2	17
15	Ft St Vrain - Keenesburg	P4	○ Ft St Vrain - Keenesburg 230 kV Line ○ Ft St Vrain unit 3	17
16	Ft St Vrain 230 kV bus	P4	○ Ft St Vrain unit 4 & GSU ○ Ft St Vrain 230 switched shunt	17
17	Ft St Vrain 230 kV bus	P4	○ Ft St Vrain unit 5 & GSU ○ Ft St Vrain 230 switched shunt	17
18	Ft St Vrain 230 kV bus	P4	○ Ft St Vrain unit 6 & GSU ○ Ft St Vrain 230 switched shunt	17
19	Ft St Vrain - Isabelle 230 kV Line	P7	○ Ft St Vrain - Isabelle 230 kV Line ○ Ft St Vrain - Spindle 230 kV Line	5

3.6 Study Area

The North study area includes WECC designated zone 706. As described in Section 3.11 of the BPM, this study pocket is comprised Northeast of Metro, North of Metro, and Northwest of Metro transmission systems. Below is the list of current generation comprising Pocket North:

- Northeast of Metro injecting at Keenesburg: Rocky Mountain Energy Center (RMEC) CC, Cedar Creek Wind, Blue Spruce
- North of Metro: Fort St Vrain, Fort Lupton, JM Shafer
- Northwest of Metro: Spindle, Valmont, Plains End, all generators within the North area

The study did not identify any impacts to Affected Systems.

4.0 Base Case Modeling Assumptions

The 2029HS2a WECC case released on May 3, 2023, was selected as the Starting Case. The 2027 Heavy Summer Base Case was created from the Starting Case by including the following modeling changes.

- Shortgrass to Goose Creek uprate to 1439 MVA – ISD TBD
- Poncha – San Luis Valley 115 kV L9811 uprate to 239 MVA – ISD 8/20/2025.
- Daniels Park-Prairie-Greenwood Uprate L5707 to 956 MVA – ISD 6/1/2026.
- Leetsdale-Monroe-Elati line 5283 uprate to 956 MVA – ISD 5/31/2026.
- Uprate Lines 6935/6936 69 kV from Alamosa - Mosca - San Luis Valley to 800 A, 95 MVA – ISD 5/15/2026.
- Daniels Park-Prairie-Greenwood Uprate L5111 to 956 MVA – ISD 10/21/2026.
- Additional Harvest Mile to Smoky Hill 230 kV Line – ISD 5/14/2027.
- Leetsdale to University Line 9338 – ISD 9/9/2026.
- Tollgate Load Shift – ISD 7/7/2026.
- New Arapahoe T6 230/115 kV, 272/319 MVA – ISD 2/10/2027.
- Cherokee-Federal Heights-Broomfield L9558 Line rebuild – ISD 11/18/2026.
- MidwayPS 230/115 T1 Transformer Replacement with 280 MVA – ISD 10/7/2026.

Additionally, the following segments of the Colorado Power Pathway (CPP) were included in the Base Case:

- Segment #1: Fort St. Vrain – Canal Crossing 345 kV Double Circuit
- Segment #2: Canal Crossing – Goose Creek 345 kV Double Circuit
- Segment #3: Goose Creek – May Valley 345 kV Double Circuit

The Base Case model includes the existing PSCo generation resources and all Affected Systems' existing resources.

While the higher-queued Network Resource Interconnection Service (NRIS) requests were dispatched at 100%, the higher-queued ERIS requests were modeled offline.

4.1 Benchmark Case Modeling

The Benchmark Case was created from the Base Case described in Section 4.0 by changing the study pocket generation dispatch to reflect heavy generation in the North pocket. This was accomplished by adopting the stressed generation dispatch given in Table 2.

Table 2 – Generation Dispatch Used to Create the North Pocket Benchmark Case (MW is Gross Capacity)

Generator Bus No.	Name	kV	ID	Pgen (MW)	Pmax (MW)
70188	FT_LUPTN_12	13.8	G1	41.31	45.90
70188	FT_LUPTN_12	13.8	G2	40.32	44.80
70409	ST.VRAIN	22	ST	286.02	317.80
70406	ST.VR_2	18	G2	147.33	163.70
70407	ST.VR_3	18	G3	140.40	156.00
70408	ST.VR_4	18	G4	156.22	173.58
70950	ST.VR_5	18	G5	140.85	156.50
70951	ST.VR_6	18	G6	139.05	154.50
70588	RMEC1	15	G1	132.39	147.10
70589	RMEC2	15	G2	140.49	156.10
70591	RMEC3	23	ST	288.72	320.80
70448	VALMNT6	13.8	G6	41.94	46.60
70557	VALMNT7	13.8	G7	36.63	40.70
70558	VALMNT8	13.8	G8	37.62	41.80
70487	JMSHAFR4	13.8	G5	29.70	33.00
70487	JMSHAFR4	13.8	G4	31.77	35.30
70490	JMSHAFR3	13.8	G3	34.02	37.80
70490	JMSHAFR3	13.8	ST	40.50	45.00
70493	JMSHAFR2	13.8	ST	42.48	47.20
70495	JMSHAFR1	13.8	G1	32.67	36.30
70495	JMSHAFR1	13.8	G2	31.50	35.00
700151	GI_2021_6	34.5	S1	203.30	203.30
70562	SPRUCE1	18	G1	122.85	136.50
70563	SPRUCE2	18	G2	121.95	135.50

Generator Bus No.	Name	kV	ID	Pgen (MW)	Pmax (MW)
70580	PLNENDG1_1	13.8	G0	4.86	5.40
70580	PLNENDG1_1	13.8	G1	4.86	5.40
70580	PLNENDG1_1	13.8	G2	4.86	5.40
70580	PLNENDG1_1	13.8	G3	4.86	5.40
70580	PLNENDG1_1	13.8	G4	4.86	5.40
70580	PLNENDG1_1	13.8	G5	4.86	5.40
70580	PLNENDG1_1	13.8	G6	4.86	5.40
70580	PLNENDG1_1	13.8	G7	4.86	5.40
70580	PLNENDG1_1	13.8	G8	4.86	5.40
70580	PLNENDG1_1	13.8	G9	4.86	5.40
70587	PLNENDG1_2	13.8	G0	4.86	5.40
70587	PLNENDG1_2	13.8	G1	4.86	5.40
70587	PLNENDG1_2	13.8	G2	4.86	5.40
70587	PLNENDG1_2	13.8	G3	4.86	5.40
70587	PLNENDG1_2	13.8	G4	4.86	5.40
70587	PLNENDG1_2	13.8	G5	4.86	5.40
70587	PLNENDG1_2	13.8	G6	4.86	5.40
70587	PLNENDG1_2	13.8	G7	4.86	5.40
70587	PLNENDG1_2	13.8	G8	4.86	5.40
70587	PLNENDG1_2	13.8	G9	4.86	5.40
70585	PLNENDG2_1	13.8	G1	7.29	8.10
70585	PLNENDG2_1	13.8	G2	7.29	8.10
70585	PLNENDG2_1	13.8	G3	7.29	8.10
70585	PLNENDG2_1	13.8	G4	7.29	8.10
70585	PLNENDG2_1	13.8	G5	7.29	8.10
70585	PLNENDG2_1	13.8	G6	7.29	8.10
70585	PLNENDG2_1	13.8	G7	7.29	8.10
70586	PLNENDG2_2	13.8	G1	7.29	8.10
70586	PLNENDG2_2	13.8	G2	7.29	8.10
70586	PLNENDG2_2	13.8	G3	7.29	8.10
70586	PLNENDG2_2	13.8	G4	7.29	8.10
70586	PLNENDG2_2	13.8	G5	7.29	8.10
70586	PLNENDG2_2	13.8	G6	7.29	8.10
70586	PLNENDG2_2	13.8	G7	7.29	8.10
70593	SPNDLE1	18	G1	128.76	143.07
70594	SPNDLE2	18	G2	126.53	140.59
70823	CEDARCK_1A	34.5	W1	176.00	220.00
70824	CEDARCK_1B	34.5	W2	64.00	80.00
70825	CEDAR2_W1	0.66	W1	100.00	125.00
70826	CEDAR2_W2	0.69	W2	80.64	100.80

Generator Bus No.	Name	kV	ID	Pgen (MW)	Pmax (MW)
70827	CEDAR2_W3	0.66	W3	20.00	25.00
Total (MW)				**3355.23**	**3766.64**

4.2 Study Case Modeling

A Study Case was created from the Benchmark Case by turning on the PI-2024-02 generation. The additional 400 MW output from PI-2024-02 was balanced against PSCo generation outside of the North study pocket.

4.3 Short-Circuit Modeling

This request is for the Interconnection of two new gas combustion turbine generators (PI-2024-2) to the Fort Saint Vrain 230 kV substation. The requested capacity at POI is 400 MW.

This project will add two (2) GE 7FA63 combustion turbines to the Fort St. Vrain 230 kV Substation, with a COD of 5/31/2027. A separate position in the substation has been requested for each generating unit. Two 230/19 kV main GSU transformers rated at 171/227 MVA step the voltage up from the generator voltage to the POI voltage. An approximately 0.2-mile-long generation tie line connects the project to the Fort Saint Vrain 230 kV switchyard.

All connected generating facilities were assumed capable of producing maximum fault current. As such, all generation was modeled at full capacity, whether NRIS or ERIS is requested. Generation is modeled as a separate generating resource in PSS CAPE and included at full capacity in the short circuit study, regardless of any limitations to the output that would be imposed otherwise. Provisional Interconnection Service Analysis

5.0 Provisional Interconnection Service Analysis

5.1 Voltage and Reactive Power Capability Evaluation

Per Section 4.1.1.1 of the BPM, the following voltage regulation and reactive power capability requirements are applicable to non-synchronous generators:

- Xcel Energy's OATT requires all non-synchronous generator Interconnection Customers to provide dynamic reactive power within the power factor range of 0.95 leading to 0.95 lagging at the high side of the generator substation. Furthermore, Xcel Energy requires every Generating Facility to have dynamic voltage control capability to assist in maintaining the POI voltage schedule specified by the Transmission Operator.
- It is the responsibility of the Interconnection Customer to determine the type (switched shunt capacitors and/or switched shunt reactors, etc.), the size (MVar), and the locations (on the Interconnection Customer's facility) of any additional static reactive power compensation needed within the generating plant in order to have adequate reactive capability to meet the +/- 0.95 power factor at the high side of the main step-up transformer.
- It is the responsibility of the Interconnection Customer to compensate their generation tie-line to ensure minimal reactive power flow under no load conditions.

Per Section 4.1.1.2 in the BPM, the following voltage regulation and reactive power capability requirements are applicable to synchronous generators.

- Xcel Energy's OATT requires all synchronous Generator Interconnection Customers to provide dynamic reactive power within the power factor range of 0.95 leading to 0.95 lagging at the POI.
- The reactive power analysis performed in this report is an indicator of the reactive power requirements at the POI and the capability of the generator to meet those requirements. The Interconnection Customer is required to demonstrate to the satisfaction of PSCo Transmission Operations prior to the commercial in-service date of the generating plant that it can safely and reliably operate within the required power factor and the regulating voltage of the POI.

Per Section 4.4.1 in the BPM, the following steps shall be followed to perform the reactive power capability evaluation for synchronous generators:

a. The reactive power evaluation of the Synchronous generators is done by dispatching the generator at Pmax and changing the POI voltage till Qmax and Qmin are reached.
b. This step is repeated for Pmin.
c. The POI voltage and power factor for the two evaluations are noted. If the POI power factor of 0.95 is reached and the POI voltage stays under the voltage guidance values noted (1-1.04 p.u. for the 230 kV system, 1-1.05 for the 345 kV system and 1-1.03 for

115 kV system), the GIR is considered to meet reactive power requirements. If not, additional dynamic reactive support would be identified.

All proposed reactive devices in customer provided models are switched favorably to provide appropriate reactive compensation in each test, therefore identified deficiencies are in addition to any proposed reactive compensation.

All summary tables representing GIRs' Voltage and Reactive Power Capability tests adhere to the following color formatting representing the different aspects of the tests:

- Values highlighted in red indicate a failed reactive power requirement.
- Voltages outside the following ranges are highlighted in yellow to provide additional information.
    - 1.00 – 1.03 for 115 kV system
    - 1.00 – 1.04 for 230 kV system
    - 1.00 – 1.05 for 345 kV system

The PI-2024-02 GIR is modeled as follows:

Generator gross capacity: Pmax = 413.2 MW, Pmin = 100 MW, Qmax = 291.8 MVAr, Qmin = -291.8 MVAr

The summary for the Voltage and Reactive Power Capability Evaluation for PI-2024-02 is:

- The GIR is capable of meeting 0.95 lagging pf at the POI at either operating point. However, the POI voltage exceeds the limit of 1.04 p.u. during each lagging pf test.
- The GIR is capable of meeting 0.95 leading pf at the POI while maintaining an adequate POI bus voltage, at either operating point.

The Voltage and Reactive Power Capability tests performed for PI-2024-02 are summarized in Table 3.

Table 3 – Reactive Capability Evaluation for PI-2024-02

Test	POI			
	P (MW)	Q (Mvar)	V (p.u.)	PF
Pmax - Lagging	400.0	240.4	1.049	0.86
Pmax - Leading	400.0	-360.2	1.024	-0.74
Pmin - Lagging	87.2	268.0	1.050	0.31
Pmin - Leading	87.2	-323.0	1.026	-0.26

5.2 Steady-State Analysis

Contingency analysis was performed on the North study pocket using the Study Case model.

- System Intact analysis showed no thermal or voltage violations attributed to PI-2024-02.
- Single Contingency analysis:

  Thermal results: Table 4 lists overloads attributed to PI-2024-02 for contingency conditions. All identified violations in Table 4 were alleviated through generation redispatch. The maximum allowable output of this project, without requiring system network upgrades, is 400 MW.

  Voltage results: No voltage violations attributed to PI-2024-02 were identified.

- Multiple Contingency analysis:

  Thermal results: Table 5 lists overloads attributed to PI-2024-02. Multiple contingency overloads are mitigated using system adjustments, including generation redispatch and/or operator actions. None of the multiple contingency overloads are attributed to this project.

  Please note one P7 contingency (ID: P7_167, tower outage of May Valley – Sandstone 345 kV ckts 1 & 2) was divergent in the Benchmark case but not in the Study case. The divergence is not caused by PI-2024-02. Also diverged multiples will be mitigated using system adjustments, including generation redispatch and/or operator actions.

  Voltage results: No voltage violations attributed to this project were identified.

Table 4 – Single Contingency Thermal Overloads

Ref. No.	Monitored Facility	Contingency Name	kVs	Areas	Rate Cont (MVA)	Benchmark Case Loading (%)	Study Case Loading (%)	Loading Difference (%)	DFAX for PI-2024-2
1	Sky Ranch (70392) - Spruce (70528) 230 kV ckt 1	Green Valley - Spruce (#5270)	230	70	484	96.74	103.78	7.04	0.04
2	GI_2021_6 (700155) - Sky Ranch (70392) 230 kV ckt 1	Green Valley - Spruce (#5270)	230	70	484	98.23	105.25	7.02	0.04

Table 5 – Multiple Contingency Thermal Overloads

Ref. No.	Monitored Facility	Contingency Name	kVs	Areas	Rate Cont (MVA)	Benchmark Case Loading (%)	Study Case Loading (%)	Loading Difference (%)	DFAX for PI-2024-2
1	Ft St Vrain (70410) - Long Peak (78105) 230 kV ckt 1	Ft St Vrain - Ault/Fordham #5308	230	70	476	100.20	104.45	4.25	0.17
2	Green Valley (70048) - Spruce (70528) 230 kV ckt 1	Lines: 5525 5277 5759 5275	230	70	717	104.87	111.29	6.42	0.07
3	Green Valley (70048) - Keenesburg (70820) 230 kV ckt 2	Lines: 5279 5271	230	70	717	106.42	111.80	5.38	0.06
4	Green Valley (70048) - Keenesburg (70820) 230 kV ckt 1	Lines: 5271 5961	230	70	717	106.42	111.80	5.38	0.06
5	Green Valley (70048) - RMEC (70590) 230 kV ckt 1	Lines: 5279 5961	230	70	717	100.16	104.99	4.83	0.05
6	Clark (70112) - Jordan (70241) 230 kV ckt 1	Lines: 5167 5285	230	70	364	103.77	105.67	1.90	0.03

5.3 Transient Stability Results

Table 6 below summarizes the contingencies studied and their results. A total of ten P1s, eight P4s, and one P7 were simulated. Except for four P4 contingencies (Ref. No. 12, 16, 17, 18), all contingencies showed:

- ✓ No rotor angle instability
- ✓ No voltage violation
- ✓ Machine rotor angles displayed positive damping

For the four P4 contingencies that showed unstable results, the same issues were observed in the Benchmark Case. Multiple contingency violations including P4 and P7 are mitigated using system adjustments, including generation redispatch and/or operator actions. None of the multiple contingency issues are attributed to PI-2024-02 project.

Table 6 – Transient Stability Analysis Results

Ref. No.	Fault Location	Fault Category	Outage(s)	Clearing Time (Cycles)	Post-Fault Voltage Recovery	Angular Stability
1	Ft St Vrain 345/230 kV transformer	P1	Ft St Vrain 345/230 kV transformer	5	Stable	Stable
2	Ft St Vrain - Fordham 230 kV Line	P1	Ft St Vrain - Fordham 230 kV Line	5	Stable	Stable
3	Ft St Vrain - Ft Lupton 230 kV Line	P1	Ft St Vrain - Ft Lupton 230 kV Line	5	Stable	Stable
4	Ft St Vrain - GI-2024-02 230 kV Line	P1	Ft St Vrain - GI-2024-02 230 kV Line	5	Stable	Stable
5	Ft St Vrain - Isabelle 230 kV Line	P1	Ft St Vrain - Isabelle 230 kV Line	5	Stable	Stable
6	Ft St Vrain - Keenesburg 230 kV Line	P1	Ft St Vrain - Keenesburg 230 kV Line	5	Stable	Stable
7	Ft St Vrain - Longs Peak 230 kV Line	P1	Ft St Vrain - Longs Peak 230 kV Line	5	Stable	Stable
8	Ft St Vrain - Spindle 230 kV Line	P1	Ft St Vrain - Spindle 230 kV Line	5	Stable	Stable
9	Ft St Vrain - Weld PS 230 kV Line	P1	Ft St Vrain - Weld PS 230 kV Line	5	Stable	Stable
10	Ft St Vrain - Windsor 230 kV Line	P1	Ft St Vrain - Windsor 230 kV Line	5	Stable	Stable
11	Ft St Vrain - Fordham 230 kV line	P4	○ Ft St Vrain - Windsor - Ault 230 kV line ○ Ft St Vrain - Fordham 230 kV line ○ Loads 'P1' and 'P2' at Windsor 230 kV	17	Stable	Stable
12	Ft St Vrain 230 kV bus	P4	Ft St Vrain unit 'ST' & GSU	17	Unstable	Stable
13	Ft St Vrain - Longs Peak 230 kV Line	P4	○ Ft St Vrain - Longs Peak - Gateway 230 kV line ○ Longs Peak 230/115 transformers 1 & 2	17	Stable	Stable
14	Ft St Vrain - Ft Lupton 230 kV Line	P4	○ Ft St Vrain - Ft Lupton 230 kV Line ckt 2 ○ Ft St Vrain unit 2	17	Stable	Stable

Ref. No.	Fault Location	Fault Category	Outage(s)	Clearing Time (Cycles)	Post-Fault Voltage Recovery	Angular Stability
15	Ft St Vrain - Keenesburg	P4	○ Ft St Vrain - Keenesburg 230 kV Line ○ Ft St Vrain unit 3	17	Stable	Stable
16	Ft St Vrain 230 kV bus	P4	○ Ft St Vrain unit 4 & GSU ○ Ft St Vrain 230 switched shunt	17	Unstable	Unstable
17	Ft St Vrain 230 kV bus	P4	○ Ft St Vrain unit 5 & GSU ○ Ft St Vrain 230 switched shunt	17	Unstable	Unstable
18	Ft St Vrain 230 kV bus	P4	○ Ft St Vrain unit 6 & GSU ○ Ft St Vrain 230 switched shunt	17	Unstable	Unstable
19	Ft St Vrain - Isabelle 230 kV Line	P7	○ Ft St Vrain - Isabelle 230 kV Line ○ Ft St Vrain - Spindle 230 kV Line	5	Stable	Stable

5.4 Short-Circuit and Breaker Duty Analysis Results

A study was completed to determine whether any overstressed breakers resulted when several provisional interconnections (PIs) were added to the PSCo transmission system in the order of their Commercial Operation Date (COD). If the addition of the interconnection resulted in a requirement that one or more breakers be replaced in the Xcel system, it was considered that that customer would not be able to connect under a provisional interconnection agreement and it was removed from the study.

Taken into consideration were any existing plans for breaker replacement by Xcel Energy. Breakers that had already been assigned to projects were not considered as needing replacement by the interconnection customer.

The Short Circuit study on the PSCo transmission system did not identify any circuit breakers that became over-dutied because of adding the PI-2024-02. The fault currents at the POI for can be made available upon request by the customer.

5.5 Affected Systems

The study did not identify any impacts to Affected Systems.

5.6 Summary of Provisional Interconnection Analysis

All single contingency thermal violations were alleviated through generation redispatch, therefore, the maximum allowable output of the GIR without requiring any additional System Network Upgrades is 400 MW.

6.0 Cost Estimates

The total cost of the required upgrades for PI-2024-02 to interconnect for Provisional Interconnection Service at the Fort St Vrain 230 kV substation is estimated to be **$19.091** million.

- **Cost of Transmission Provider's Interconnection Facilities (TPIF) is $2.937 million** (Table 7)
- **Cost of Station Network Upgrades is $16.154 million** (Table 8)
- **Cost of System Network Upgrades is $0**

The list of improvements required to accommodate the Provisional Interconnection of PI-2024-02 are given in Table 9, and Table 10.

Since the POI is at an expansion of the existing Fort Saint Vrain 230 kV substation, a CPCN may be required to accommodate the interconnection.

Table 7 – Transmission Provider's Interconnection Facilities

Element	Description	Cost Est. (Million)
PSCo's Fort Saint Vrain 230 kV substation	Interconnection of 5RSC-2024-02 (PI-2024-2) at the Fort Saint Vrain 230 kV substation. The new equipment includes: • (2) 230 kV 3-phase arresters • (2) 230 kV 3-phase CTs for metering • (2) 230 kV 3-phase CCVTs • Dual fiber communication equipment • Associated electrical equipment, wiring and grounding • Associated foundations and structures • Associated transmission line communications, fiber, relaying and testing	$2.437
PSCo's Fort Saint Vrain 230 kV substation	Transmission Provider's new equipment for Gen No. 7 includes: • Transmission line into switch yard from the PCO at the Interconnection Customer's Gen No. 7 dead end structure. Transmission line equipment including single span, 3 conductors, insulators, hardware, jumpers and labor Transmission Provider's new equipment for Gen No. 8 includes: • (1) Monopole structure at the Point of Change of Ownership (PCO) outside the switch yard fence line • Transmission line into switch yard from the PCO including single span, 3 conductors, insulators, hardware, jumpers and labor	$0.500
Total Cost Estimate for Interconnection Customer-Funded, PSCo-Owned Interconnection Facilities		**$2.937**

Table 8 – Station Network Upgrades

Element	Description	Cost Est. (Million)
PSCo's Fort Saint Vrain 230 kV substation	Interconnection of 5RSC-2024-02 (PI-2024-02) at Fort Saint Vrain 230 kV substation. The new equipment includes: • (2) 230 kV dead end structures for line terminations • (2) 230 kV dead end structures for South bus tie • (2) 230 kV monopole structures for North bus tie masts • (4) 230 kV 3000 A SF6 circuit breakers • (14) 230 kV 3000 A disconnect switches • Associated electrical equipment, bus extensions, wiring and grounding • Associated foundations and structures	$15.359
PSCo's Fort Saint Vrain 230 kV substation	Install required communication in the EEE at the Fort Saint Vrain 230 kV Substation	$0.745
PSCo's Fort Saint Vrain 230 kV substation	Siting and Land Rights permitting	$0.050
Total Cost Estimate for PSCo-Funded, PSCo-Owned Interconnection Facilities		**$16.154**

PSCo has developed cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades required for the interconnection of PI-2024-02 for Provisional Interconnection Service. The estimated costs provided in this report are based upon the following assumptions:

- The estimated costs are in 2024 dollars with escalation and contingencies applied.
- Allowances for Funds Used During Construction (AFUDC) is not included.
- The estimated costs include all applicable labor and overheads associated with the siting, engineering, design, and construction of these new PSCo facilities.
- The estimated costs do not include the cost for any Customer owned equipment and associated design and engineering.
- Labor is estimated for straight time only—no overtime included.
- PSCo (or its Contractor) will perform all construction, wiring, testing, and commissioning for PSCo owned and maintained facilities.

The customer requirements include:

- Customer will install two (2) redundant fiber optic circuits (one primary circuit with a redundant backup) into the Transmission Provider's substation as part of its interconnection facilities construction scope.
- Power Quality Metering (PQM) will be required on the Customer's generation tie-line terminating into the POI.
- The Customer will be required to design, procure, install, own, operate and maintain a Load Frequency/Automated Generation Control (LF/AGC) RTU at their Customer substation. PSCo will be provided with indications, readings, and data from the LF/AGC RTU.
- The Interconnection Customer will comply with the most current version of the *Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater Than 20 MW*, as amended from time to time, and available at: Interconnection | Transmission | Corporate | Xcel Energy

6.1 Schedule

This section provides proposed milestones for the interconnection of PI-2024-02 to the Transmission Provider's Transmission System. The customer requested a back-feed date (In-Service Date for Transmission Provider Interconnection Facilities and Station Network Upgrades required for interconnection) for the Provisional Interconnection of January 29, 2027. This is not attainable by the Transmission Provider, based upon the current schedule developed for this interconnection request. The Transmission Provider proposes the milestones provided below in Table 9.

Table 9 – Proposed Milestones for PI-2024-02

Milestone	Responsible Party	Estimated Completion Date
LGIA Execution	Interconnection Customer and Transmission Provider	December 2024
In-Service Date for Transmission Provider Interconnection Facilities and Station Network Upgrades required for interconnection	Transmission Provider	March 25, 2027
In-Service Date & Energization of Interconnection Customer's Interconnection Facilities	Interconnection Customer	March 25, 2027

Initial Synchronization Date	Interconnection Customer	May 1, 2027
Begin trial operation & testing	Interconnection Customer and Transmission Provider	June 1, 2027
Commercial Operation Date	Interconnection Customer	July 31, 2027

Some schedule elements are outside of the Transmission Provider's control and could impact the overall schedule. The following schedule assumptions provide the basis for the schedule milestones:

- Construction permitting (if required) for new facilities will be completed within 12 months of LGIA execution.
- The Transmission Provider is currently experiencing continued increases to material lead times which could impact the schedule milestones. The schedule milestones are based upon material lead times known at this time.
- Availability of line outages to interconnect new facilities to the transmission system.

7.0 Summary of Provisional Interconnection Service Analysis

The total estimated cost of the PSCo transmission system improvements required for PI-2024-02 to qualify for Provisional Interconnection Service is **$19.091** million.

The initial maximum permissible output of PI-2024-02 Generating Facility is 400 MW. The maximum permissible output of the Generating Facility in the PLGIA will be reviewed quarterly and updated if there are changes to system conditions compared to the system conditions previously used to determine the maximum permissible output.

Security: PI-2024-02 is a request for Energy Resource Interconnection Service (ERIS). For ERIS requests, security shall estimate the risk associated with the Network Upgrades and the Interconnection Facilities and is assumed to be a minimum of $5 million.

The Provisional Interconnection Service in and of itself does not convey transmission service.

8.0 Contingent Facilities

The Contingent Facilities identified for PI-2024-02 include the breaker upgrades, TPIF, and Station Network Upgrades identified in Table 7 and Table 8.

9.0 Preliminary One-Line Diagram and General Arrangement for PI-2024-02

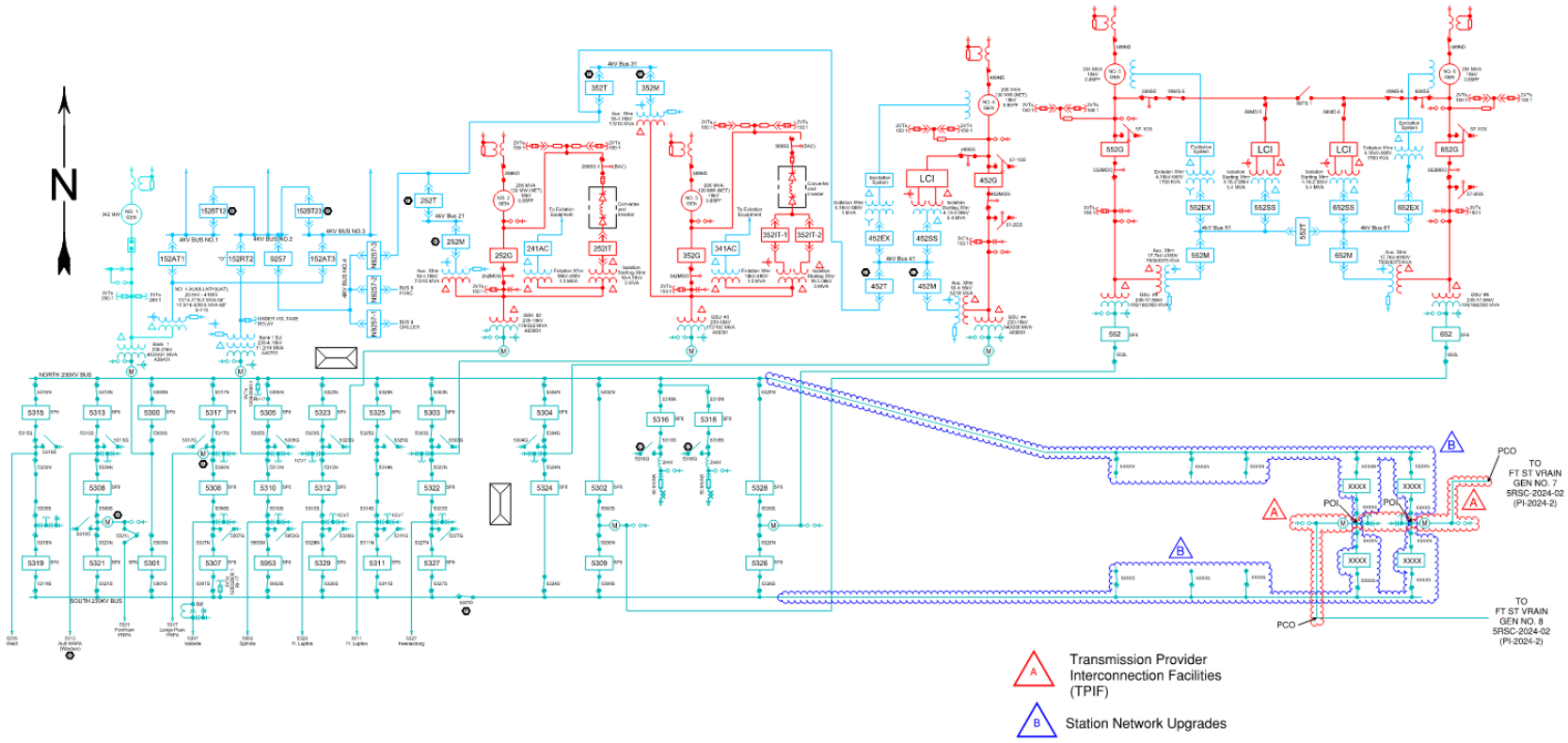


Figure 2: Preliminary One-Line of PI-2024-02 at the Fort St Vrain 230 kV substation

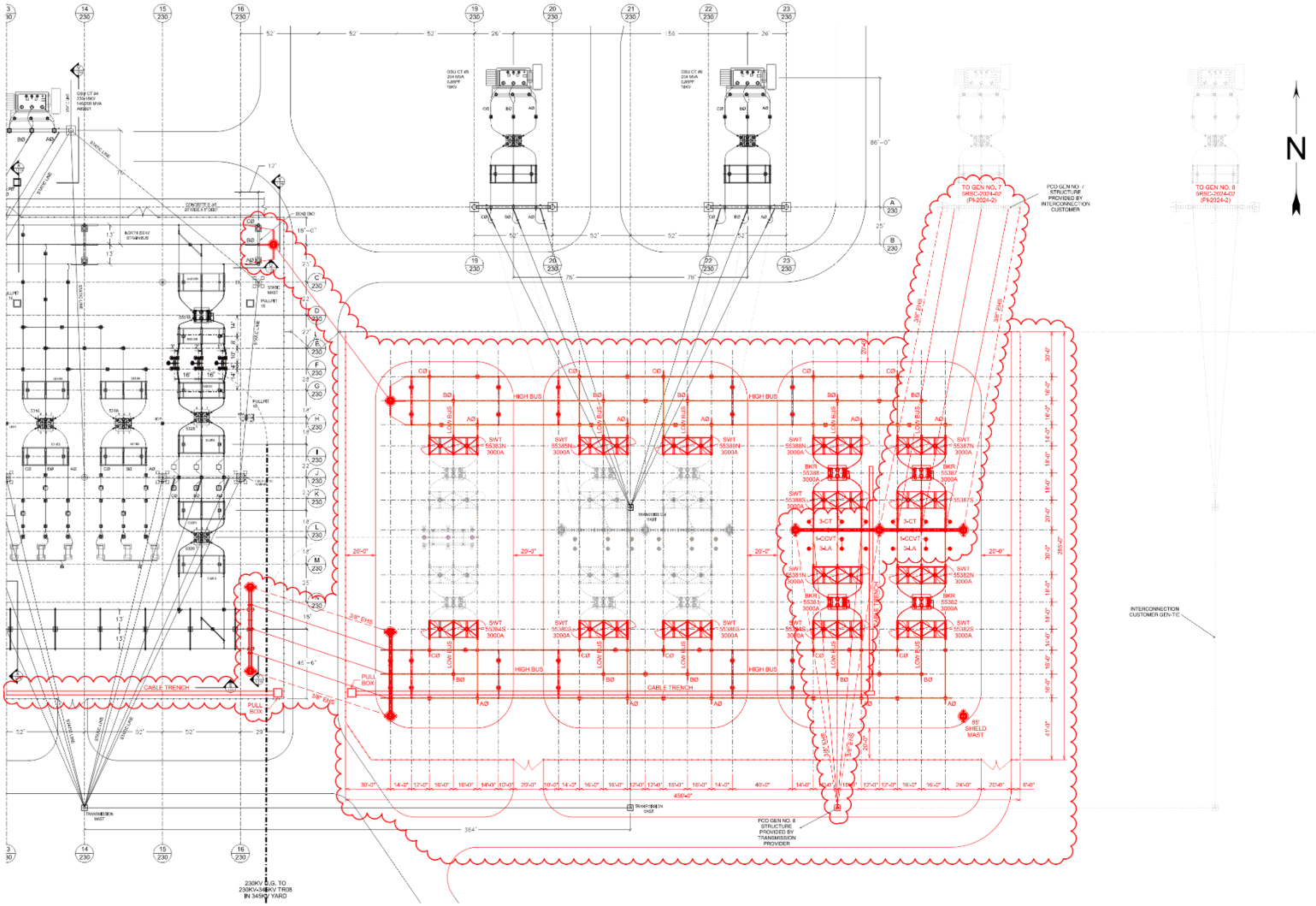
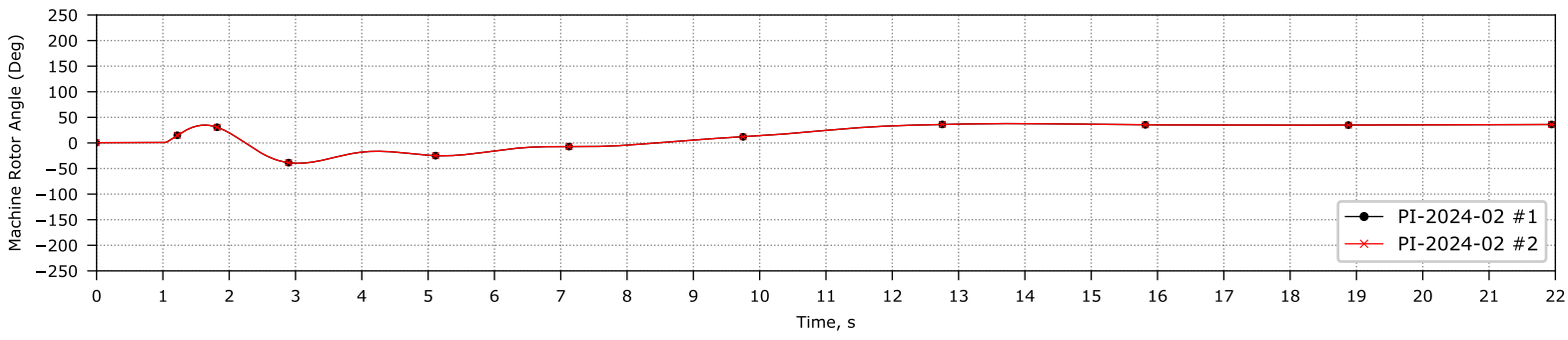


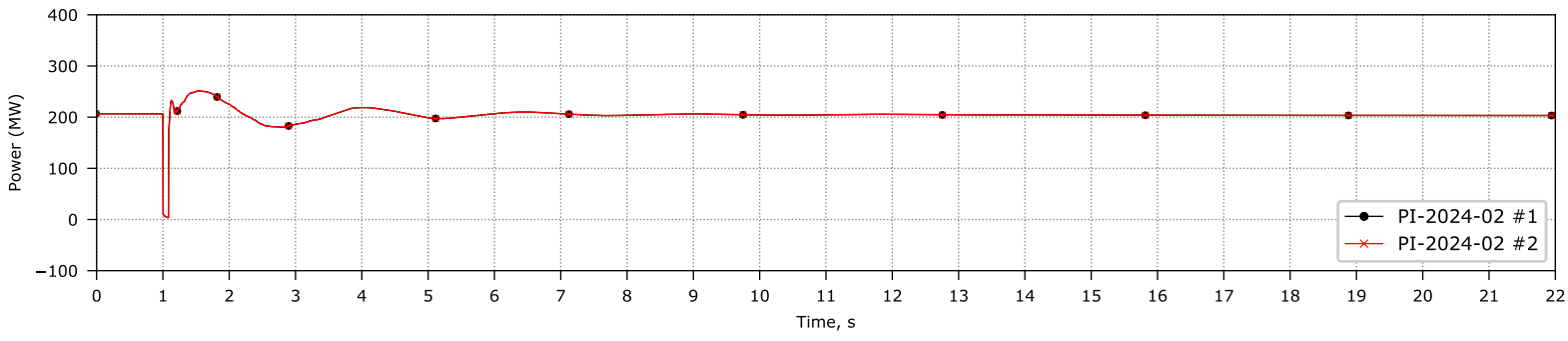
Figure 3: Preliminary General Arrangement for PI-2024-02 at the Fort St Vrain 230 kV Substation

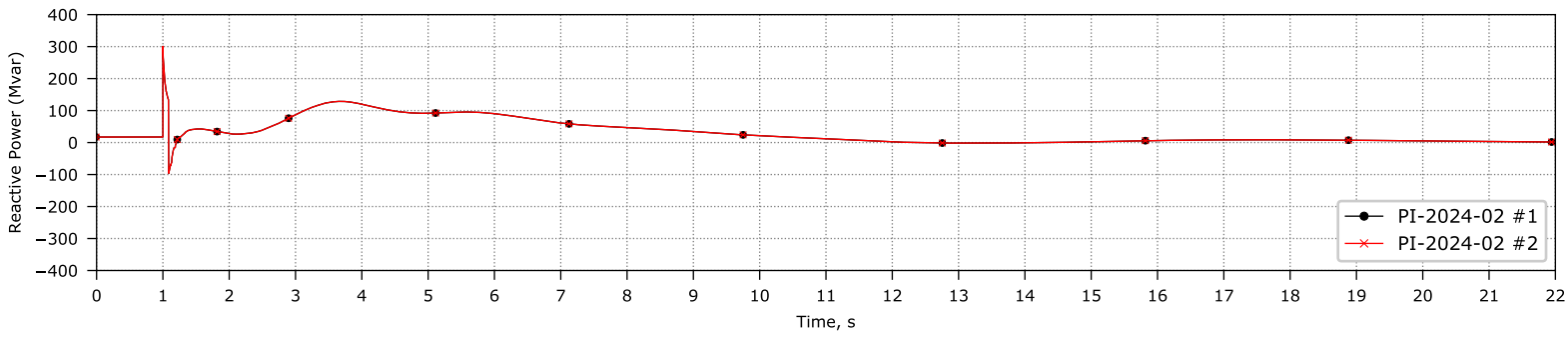
10.0 Appendices

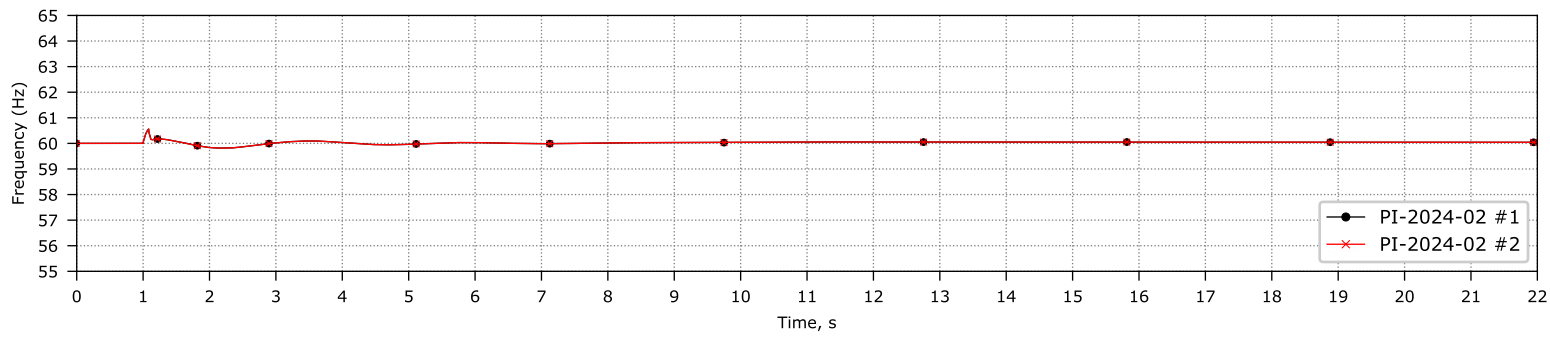
Appendix A: Transient Stability Plots	Appendix A - Transient Stability Plot

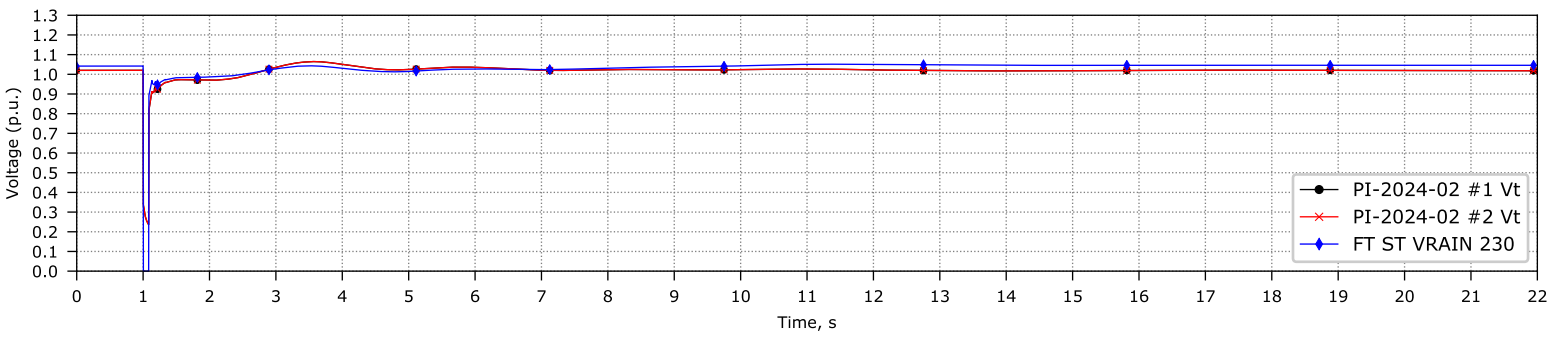
01_P1-Vrain-345TX

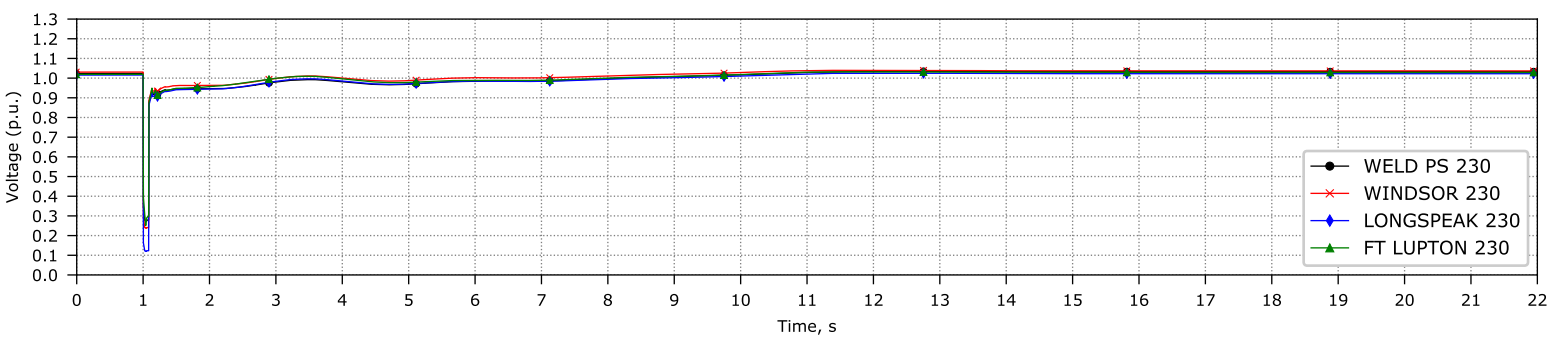


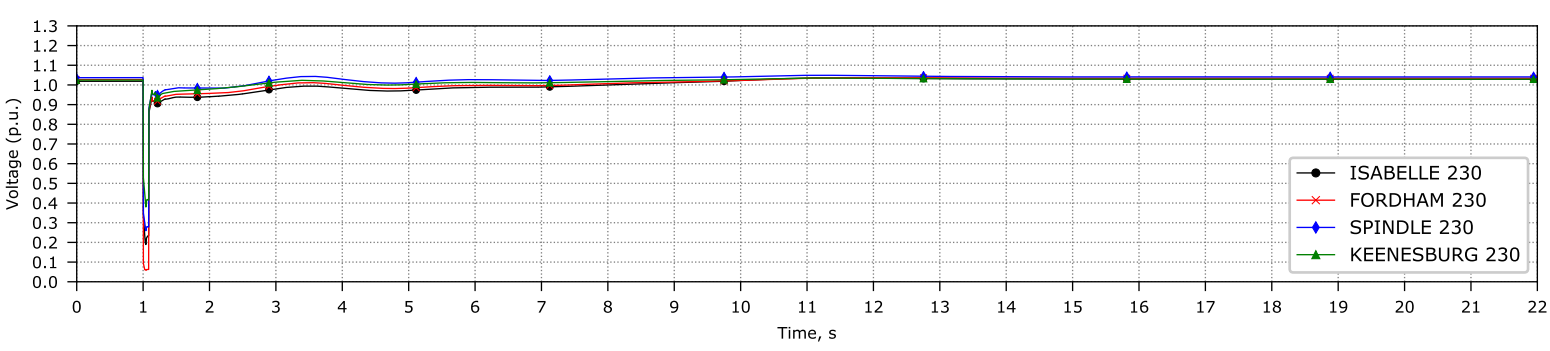


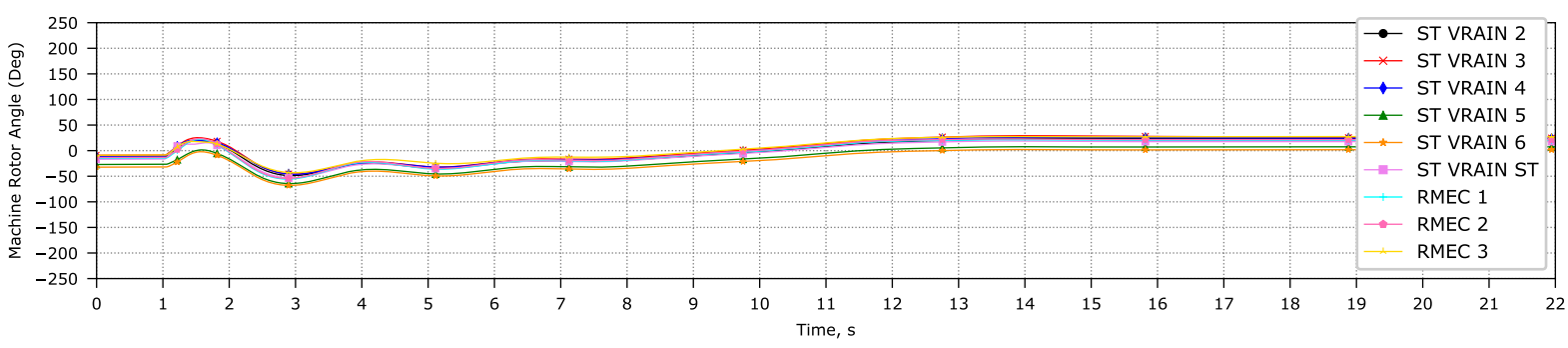


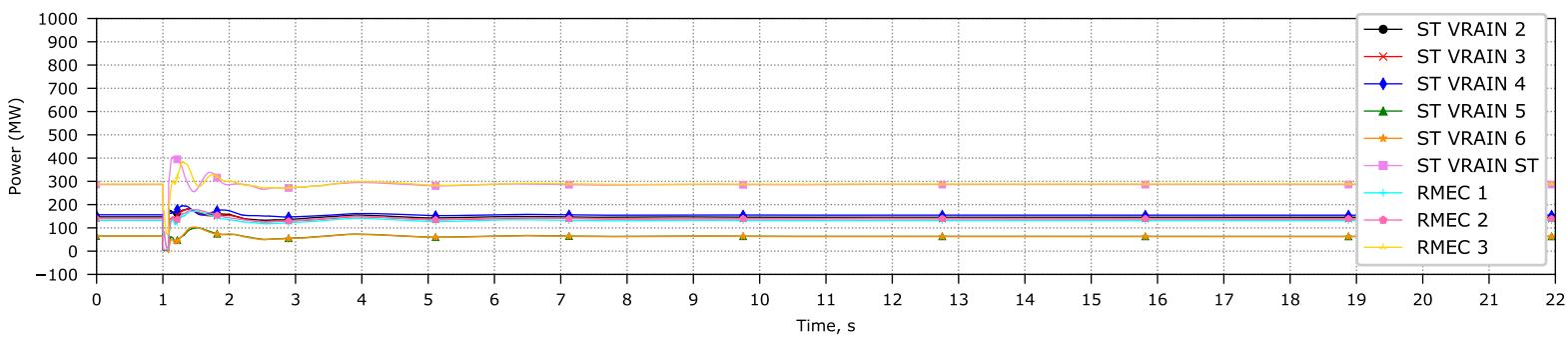




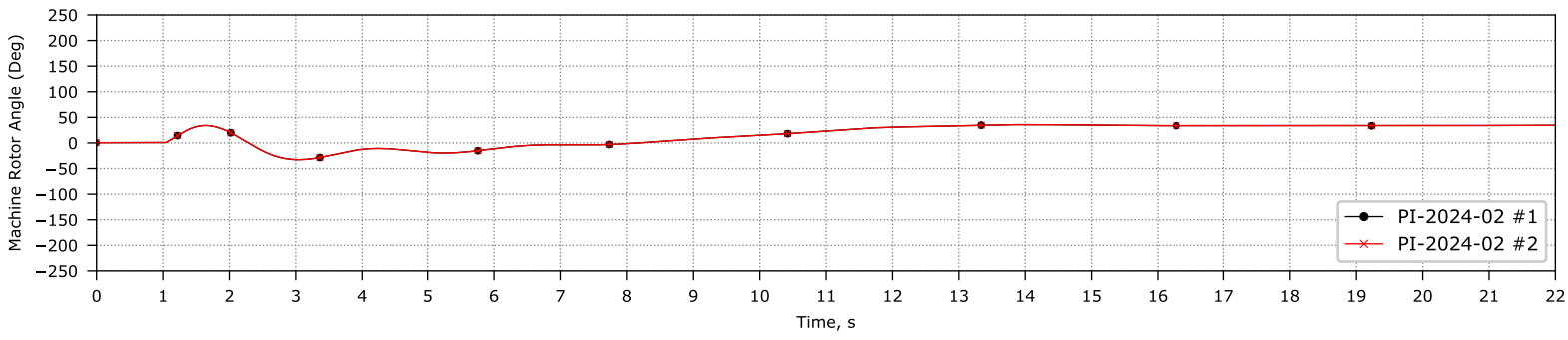


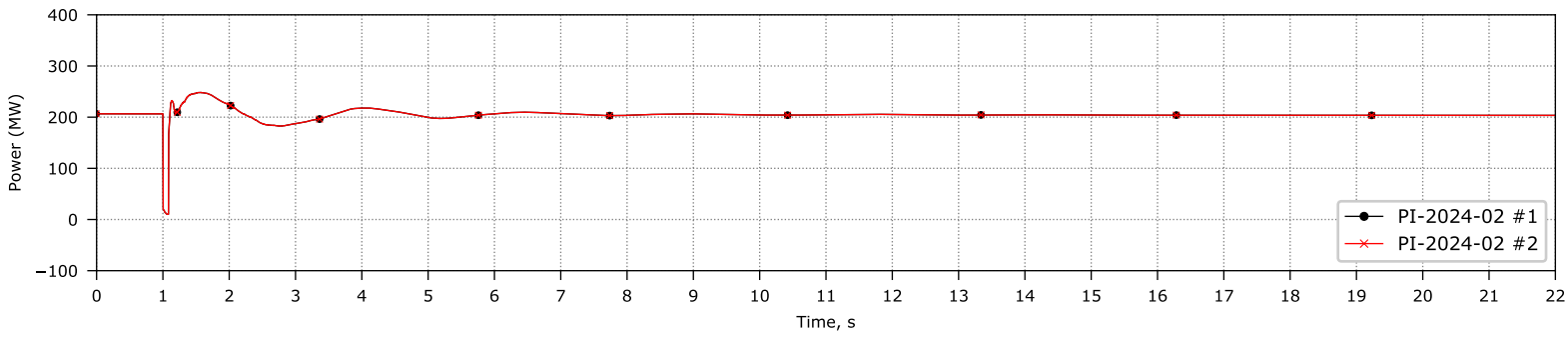


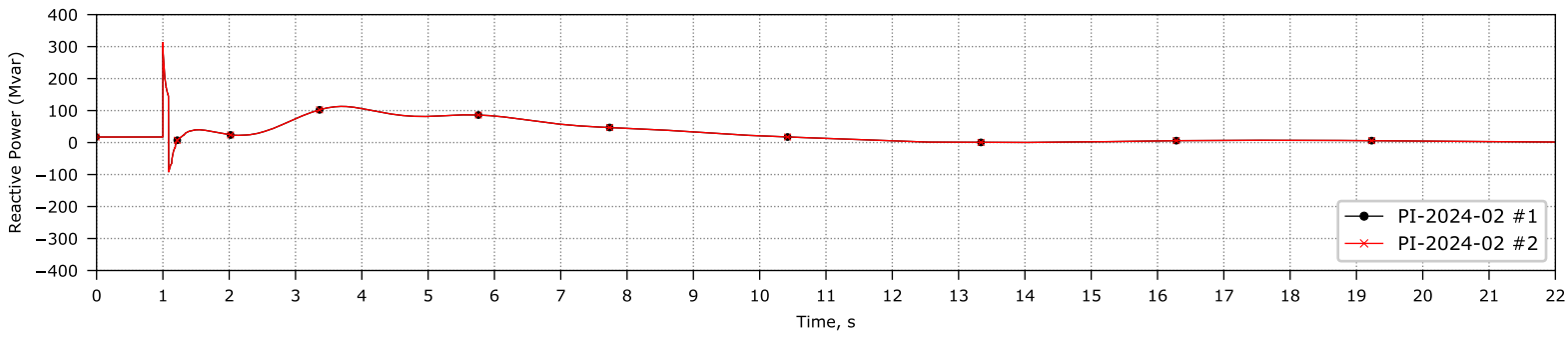


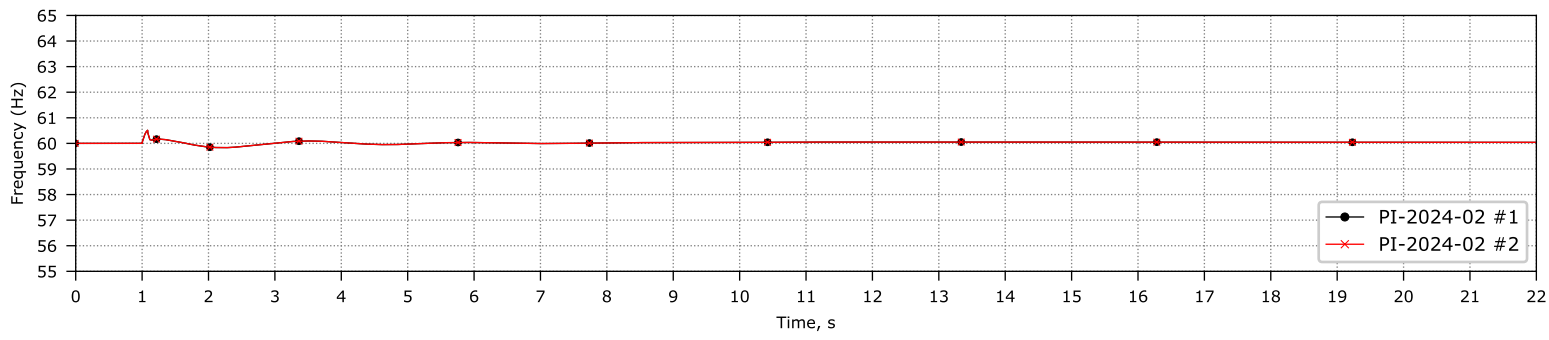


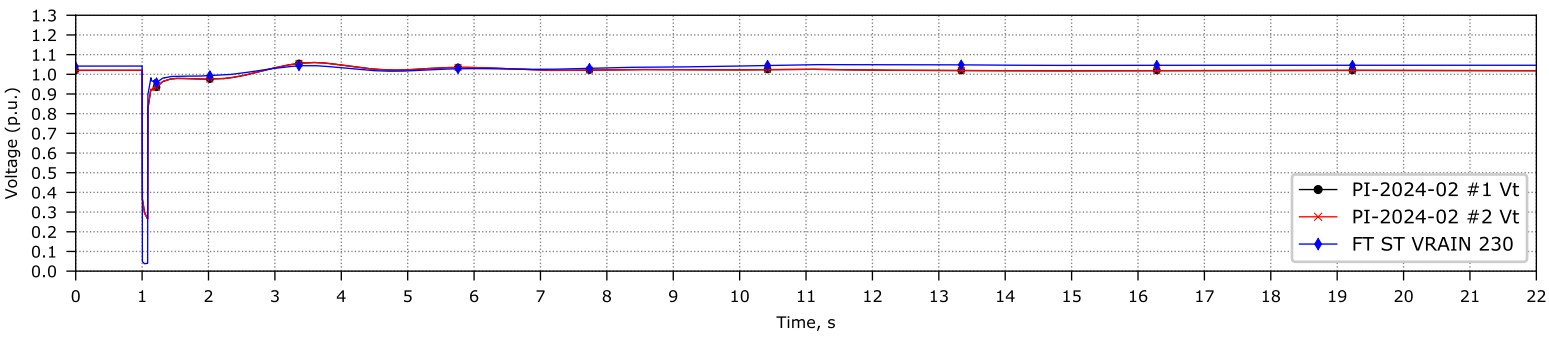
02_P1-Vrain-FORDHAM 230kV

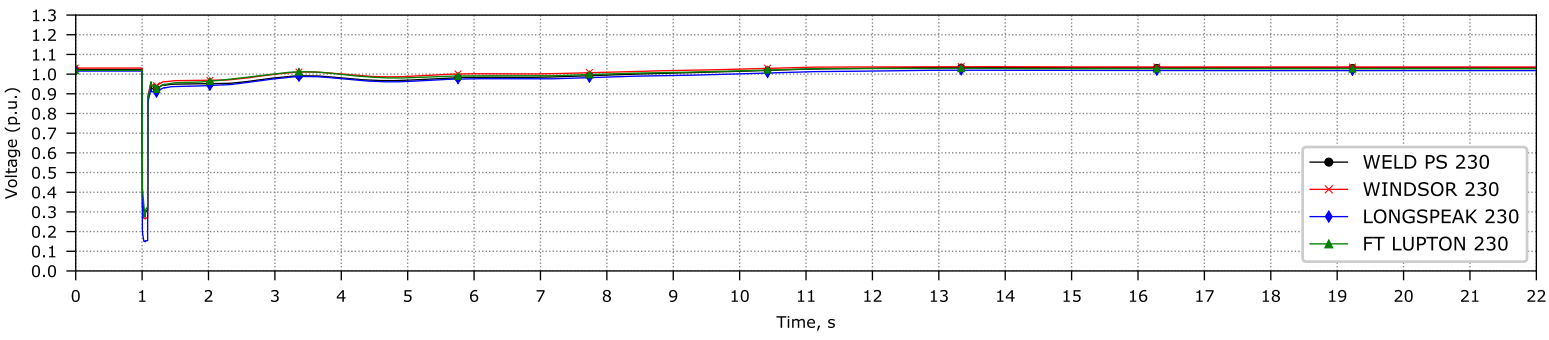


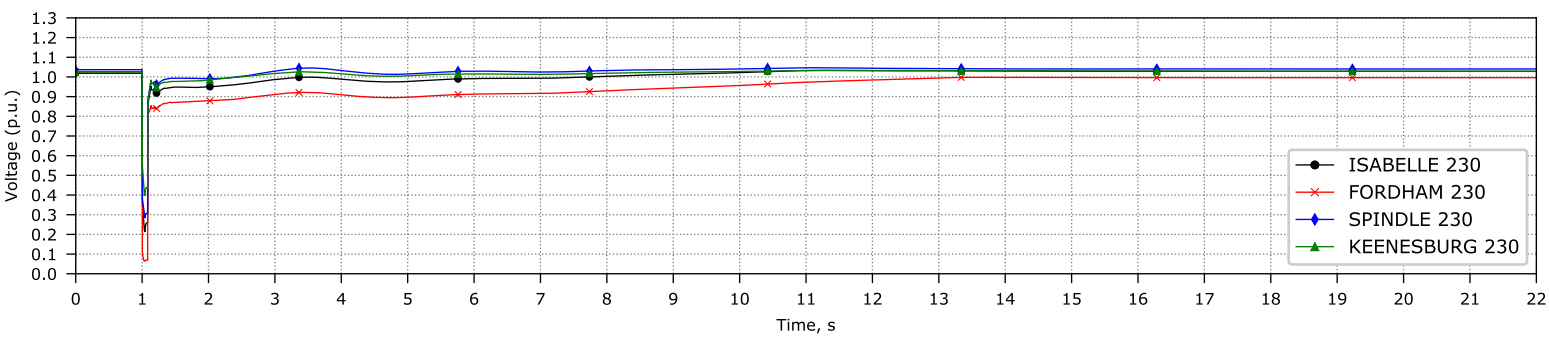


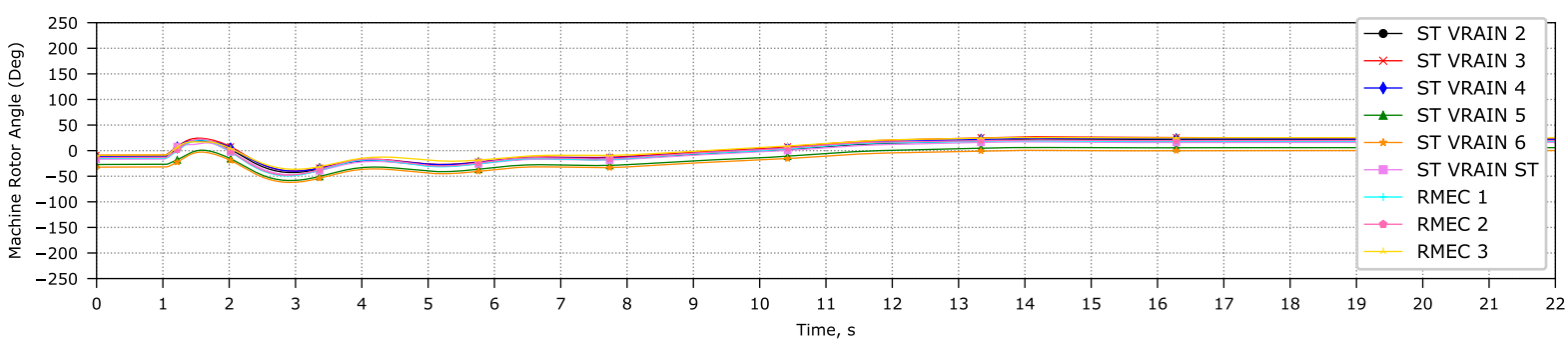


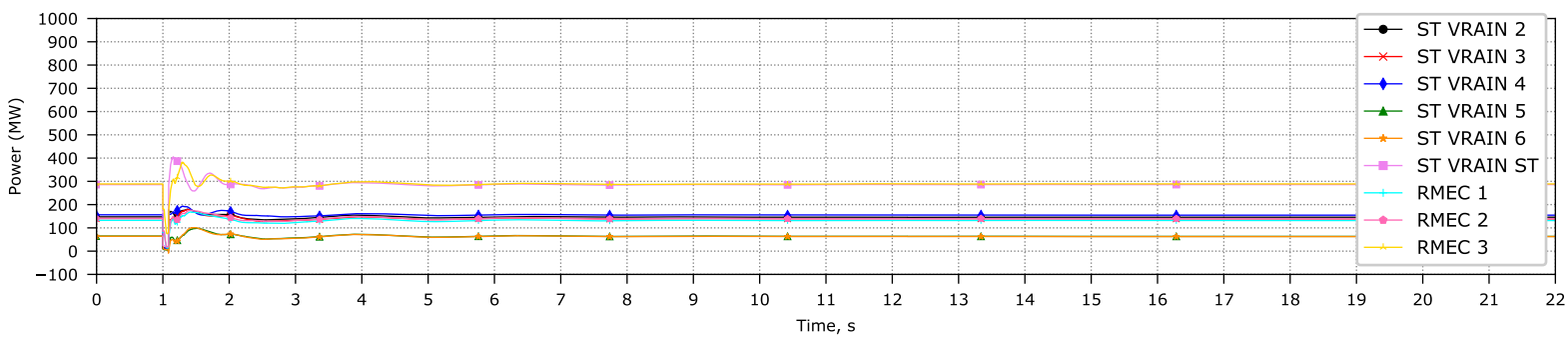












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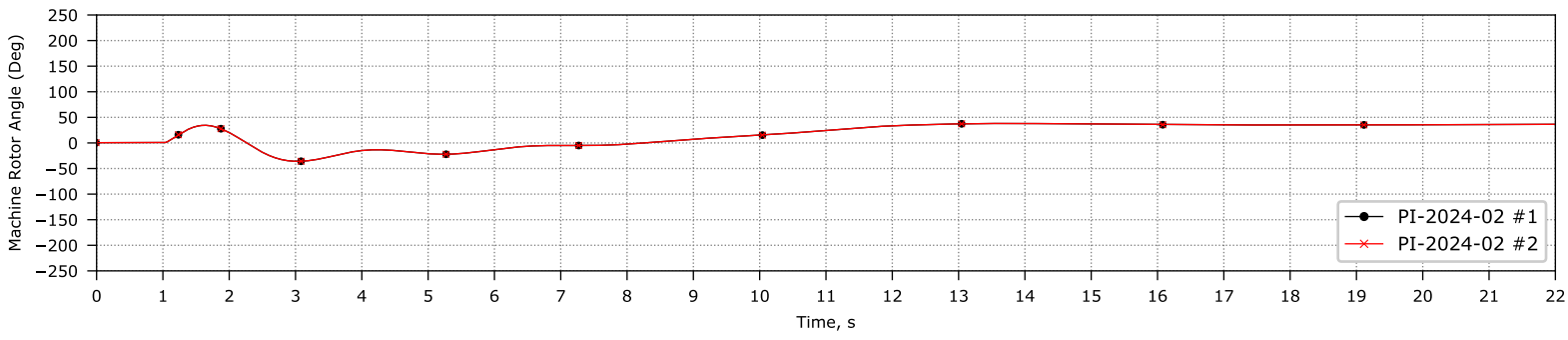

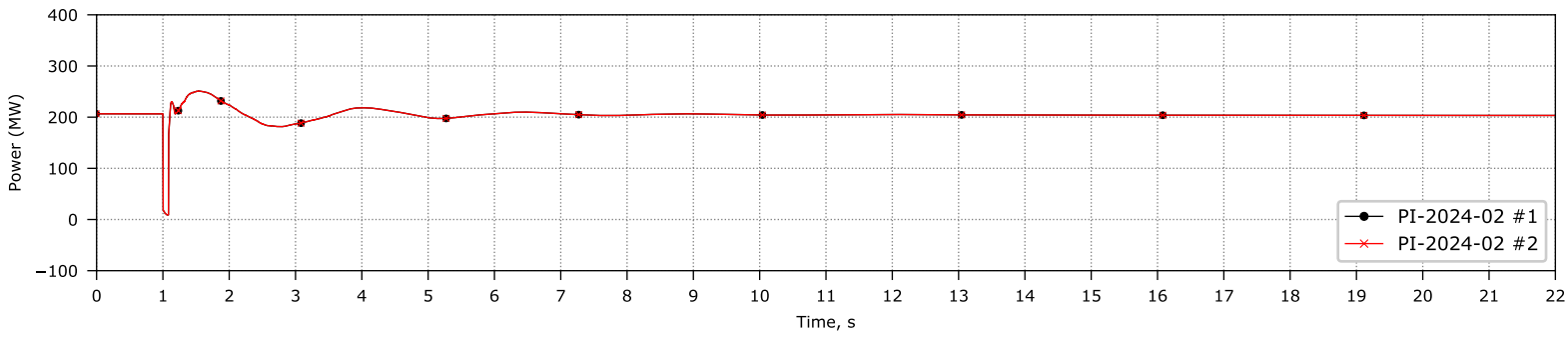

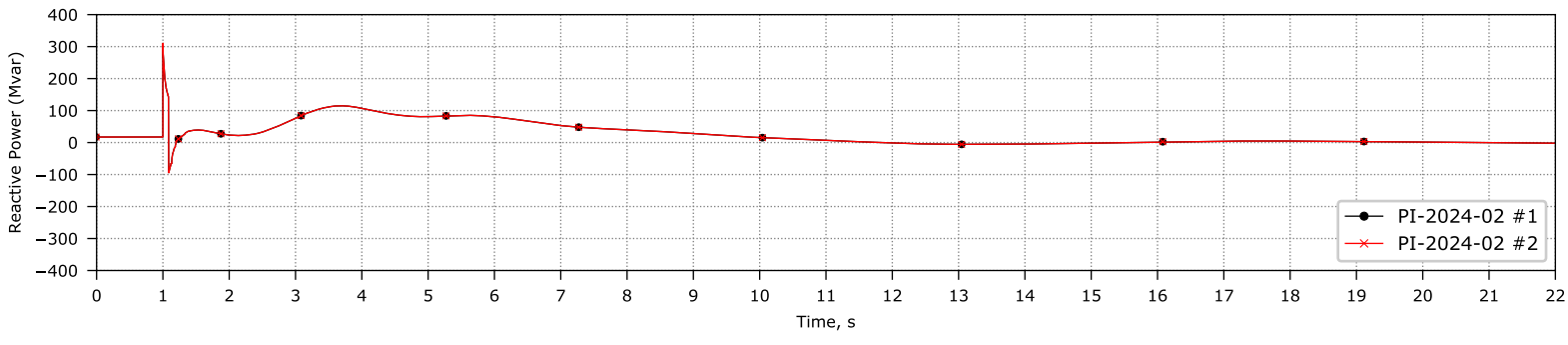

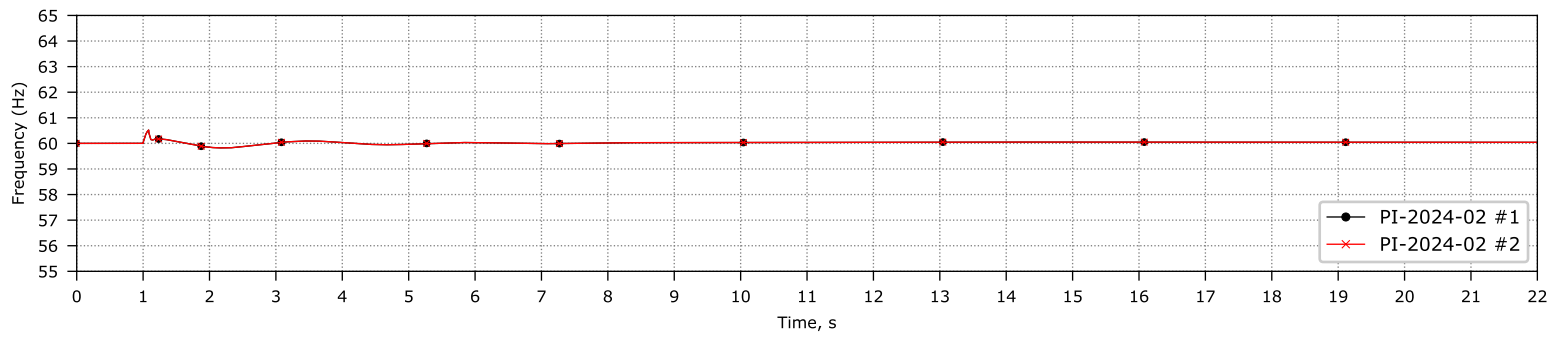

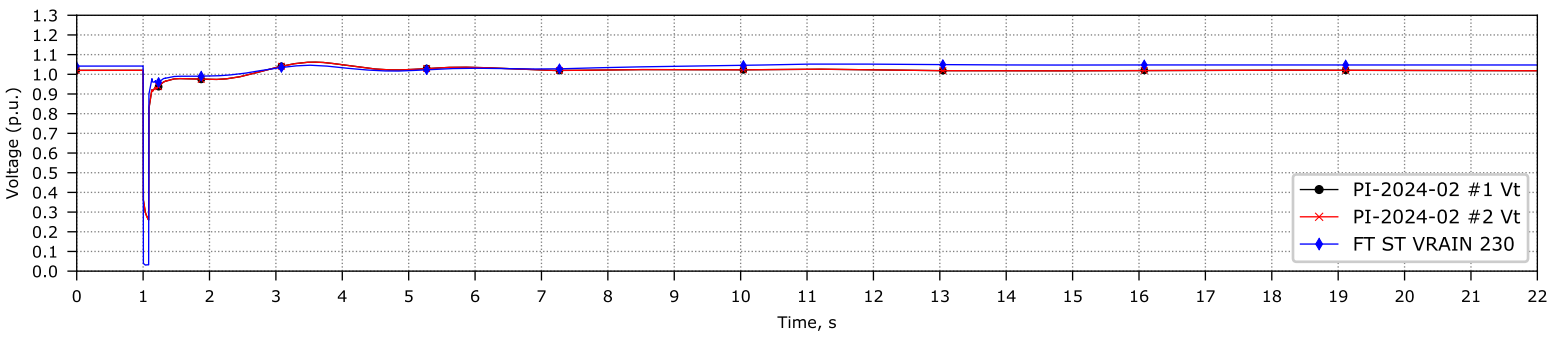

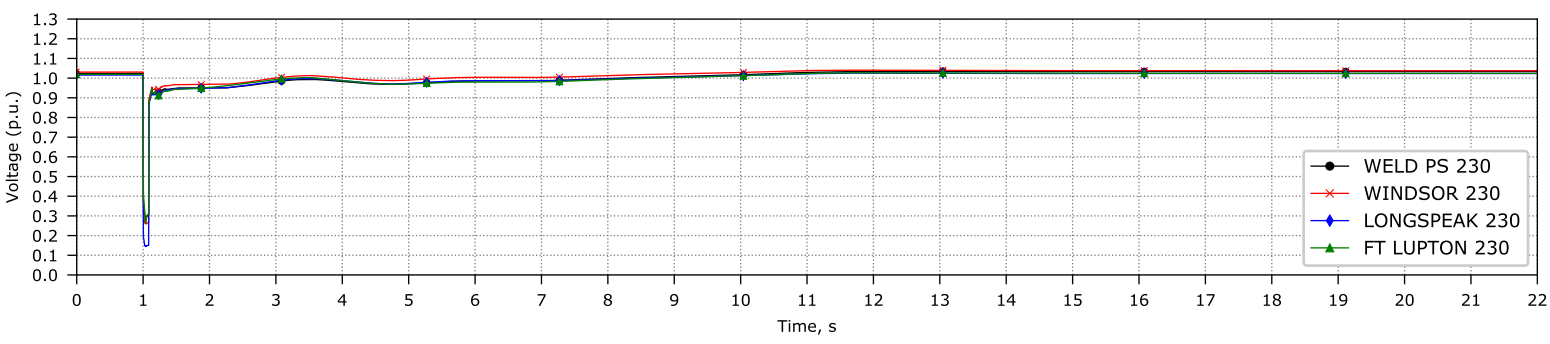

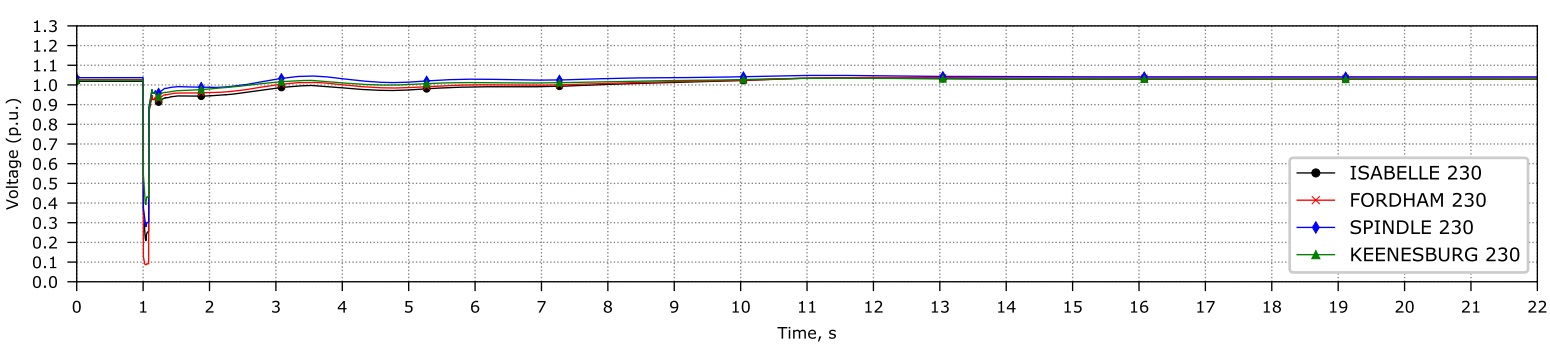

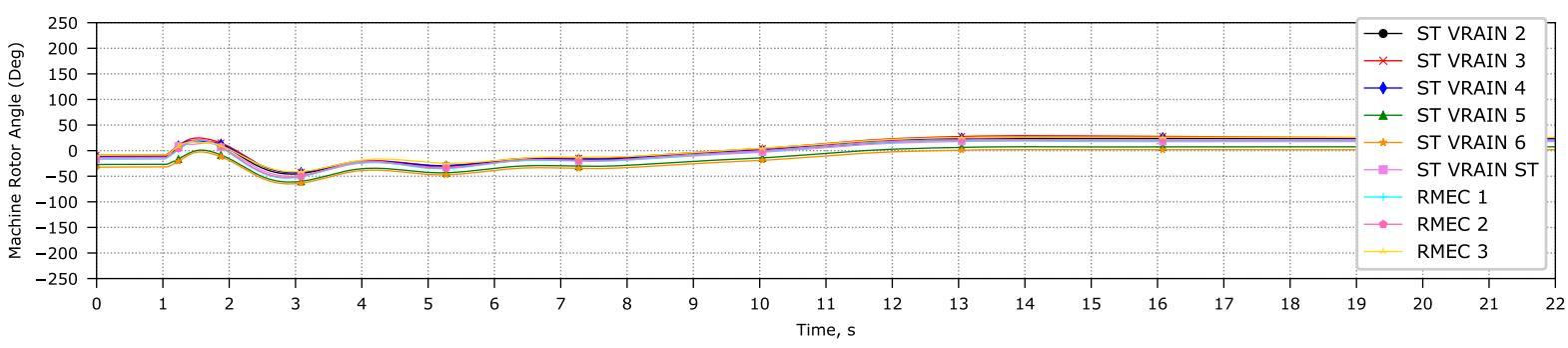

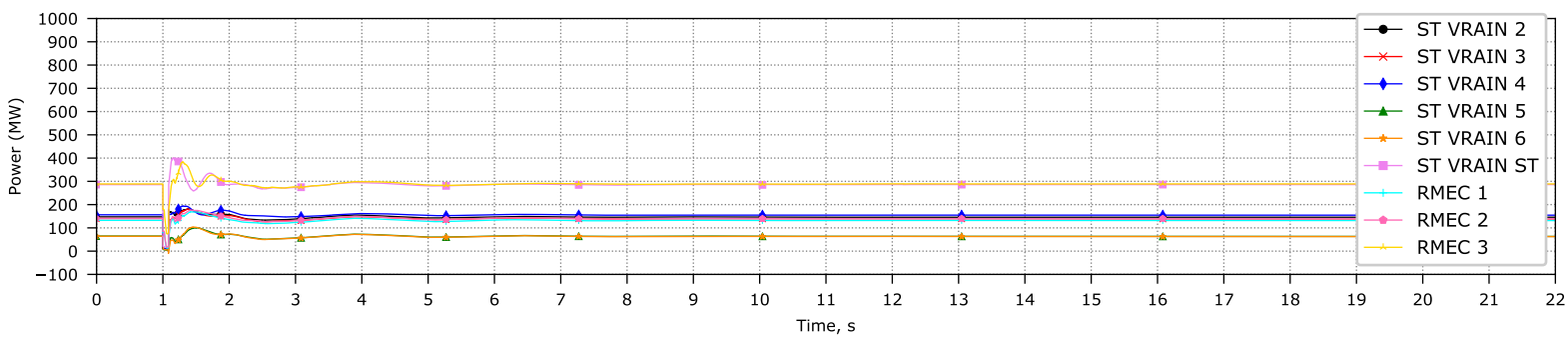

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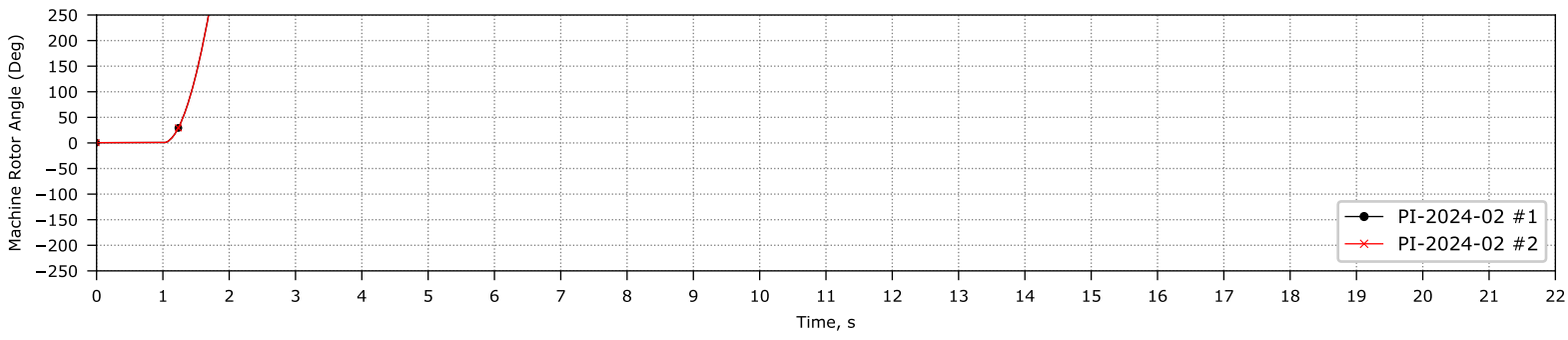

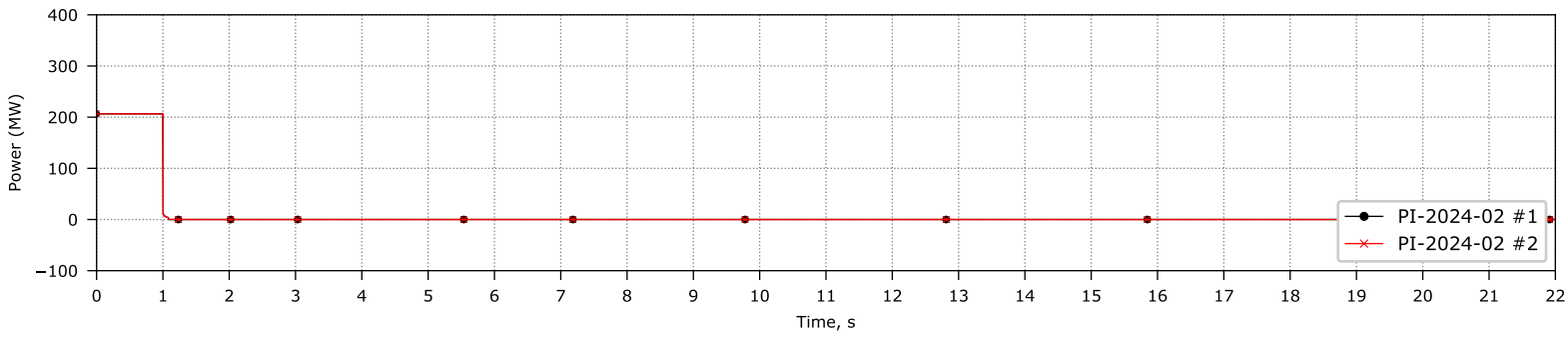

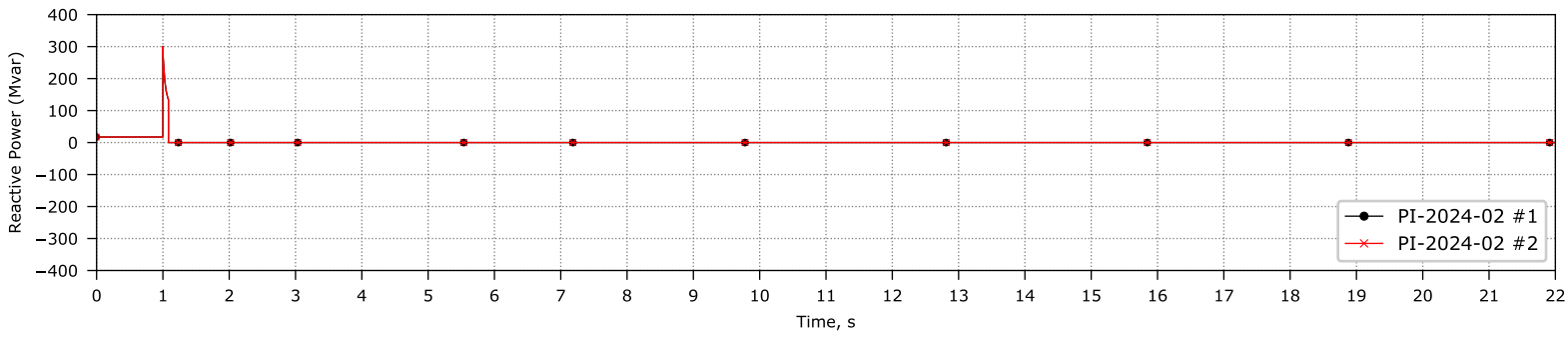

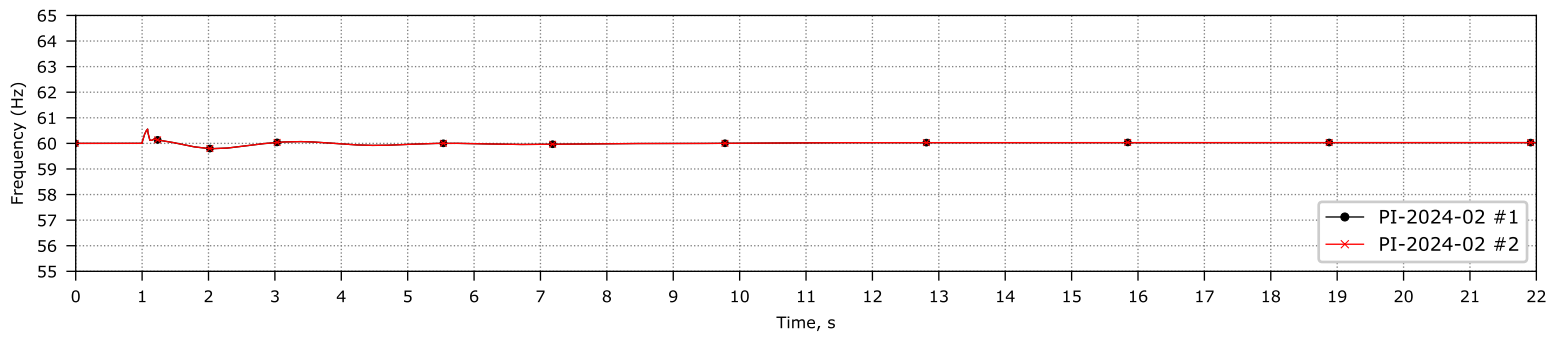

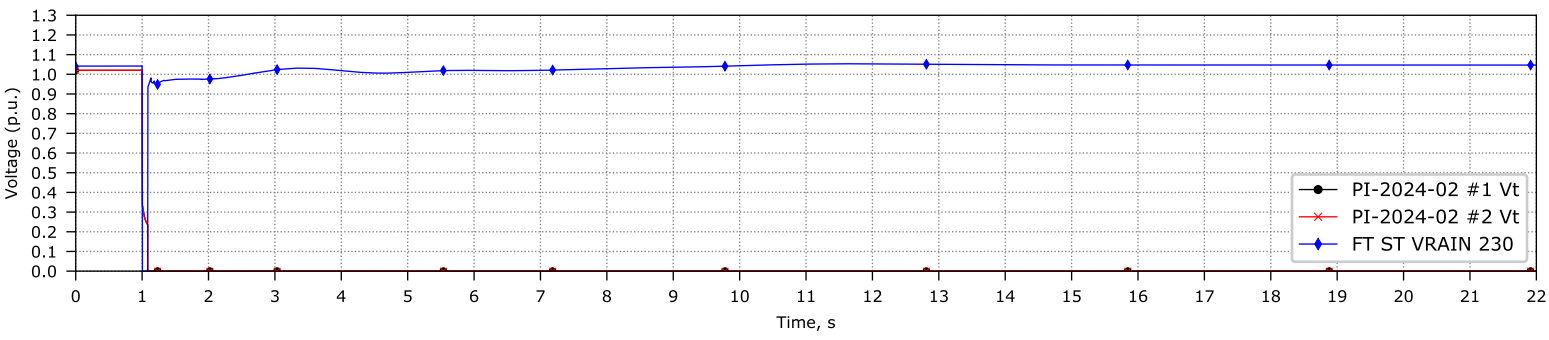

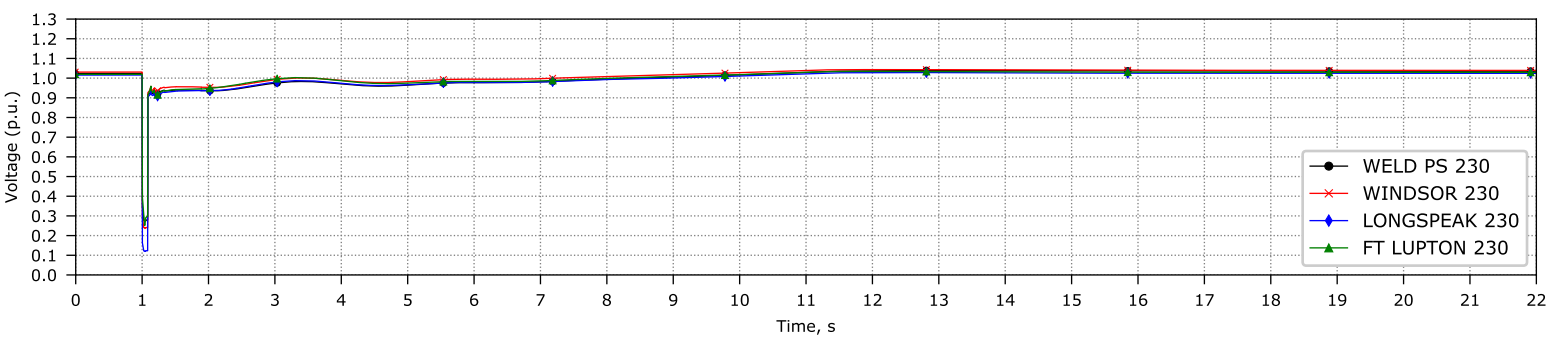

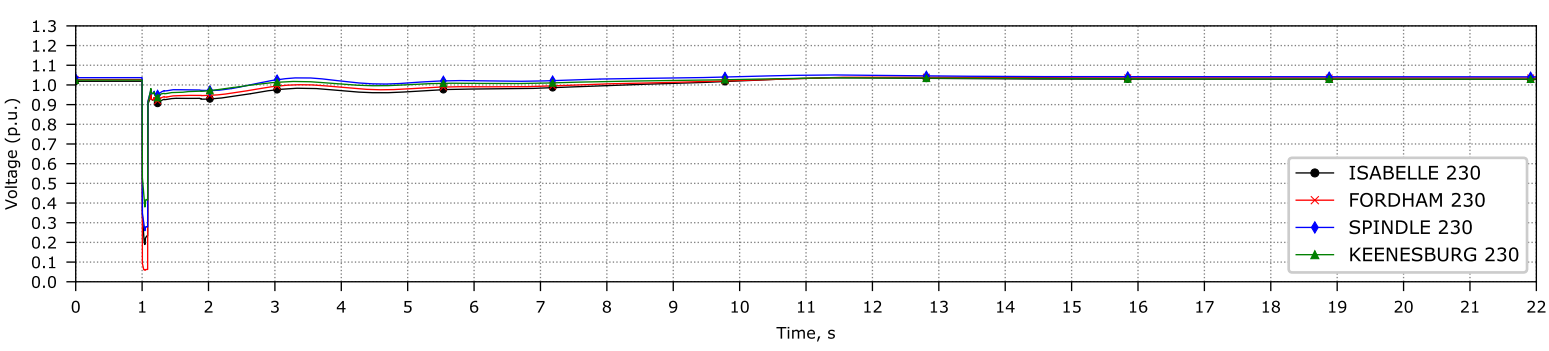

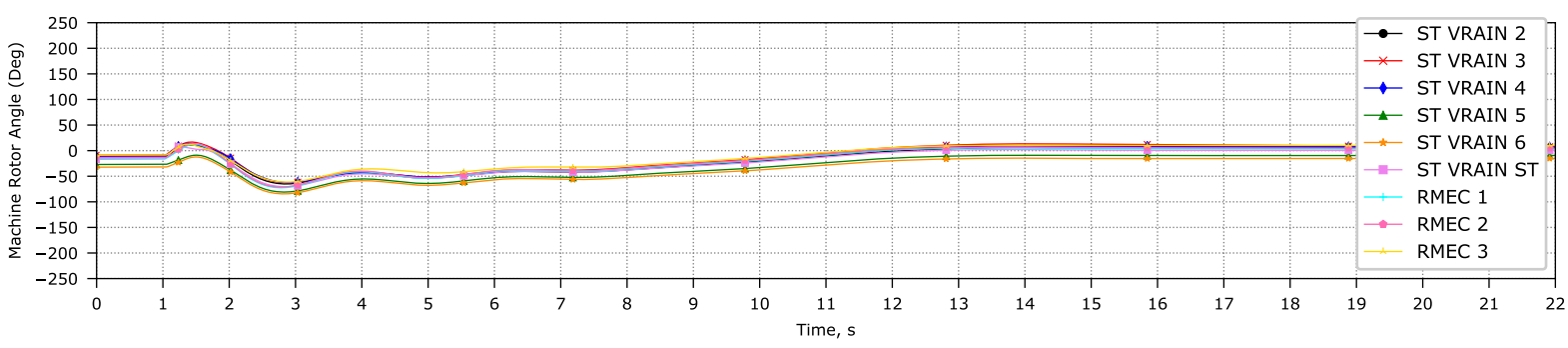

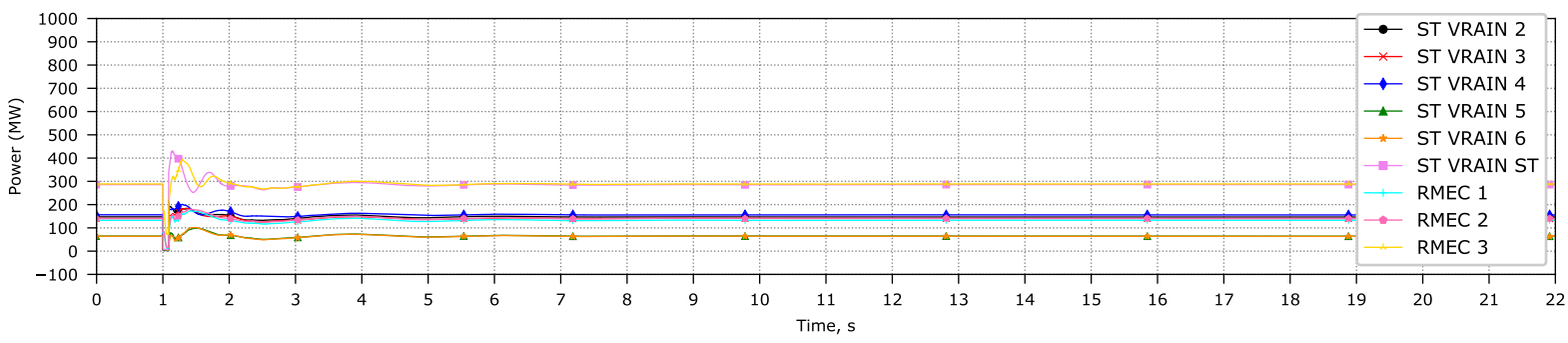

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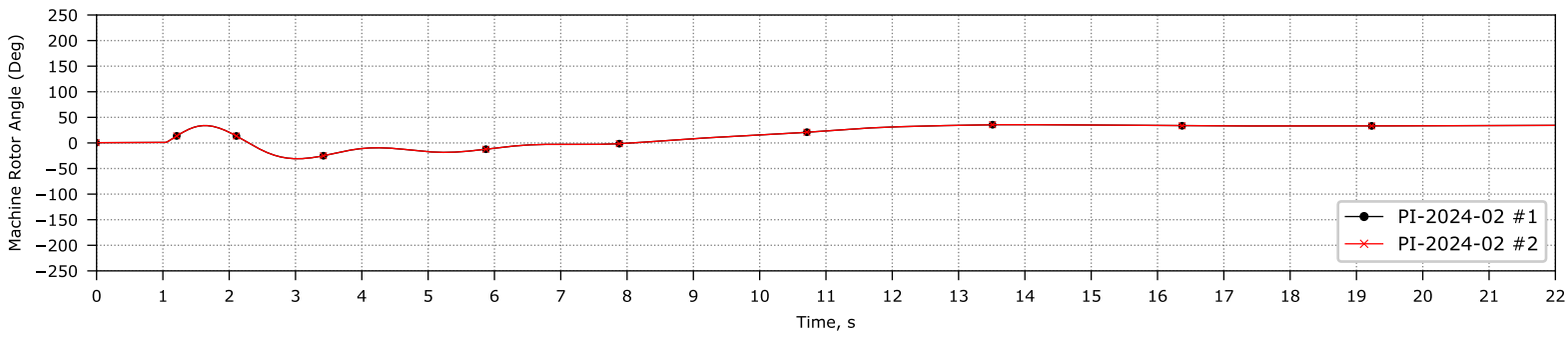
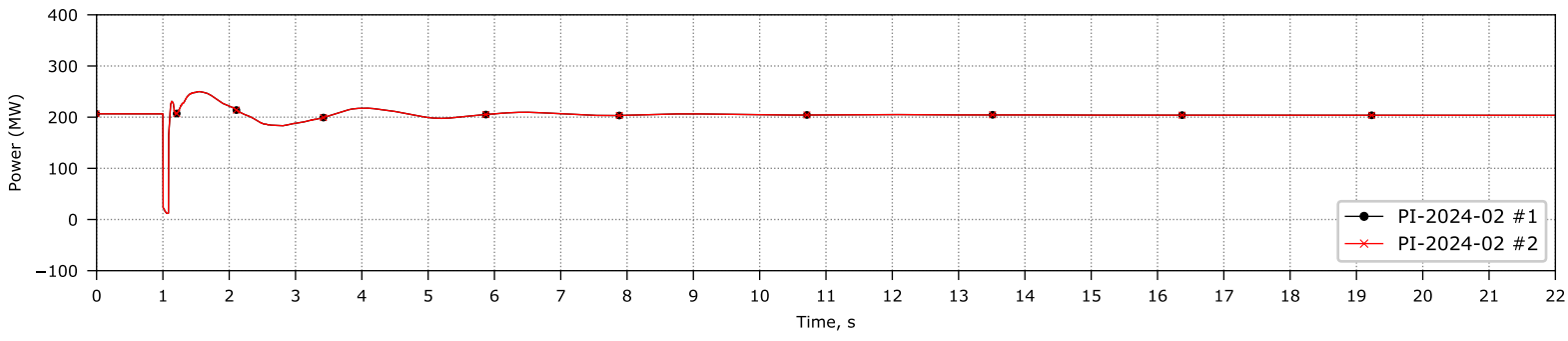
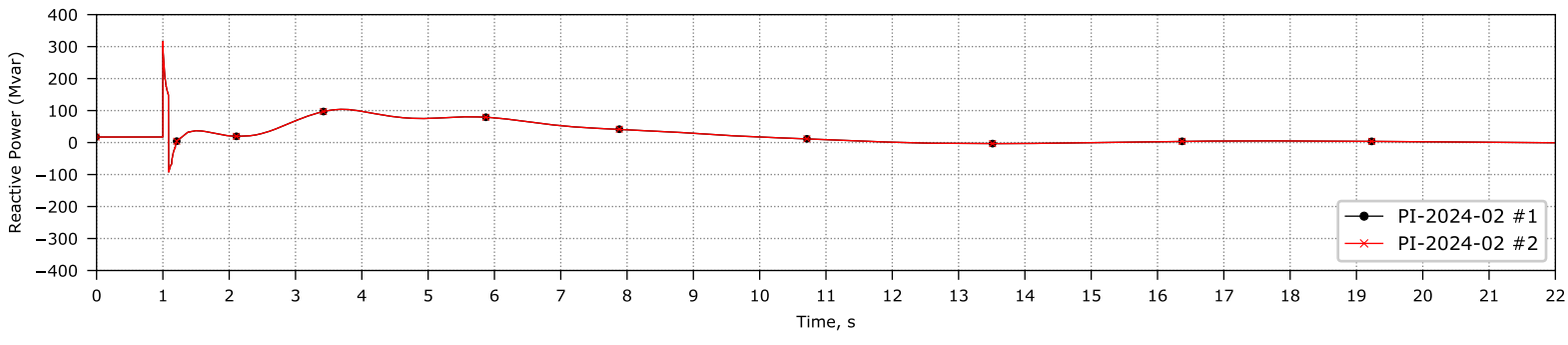
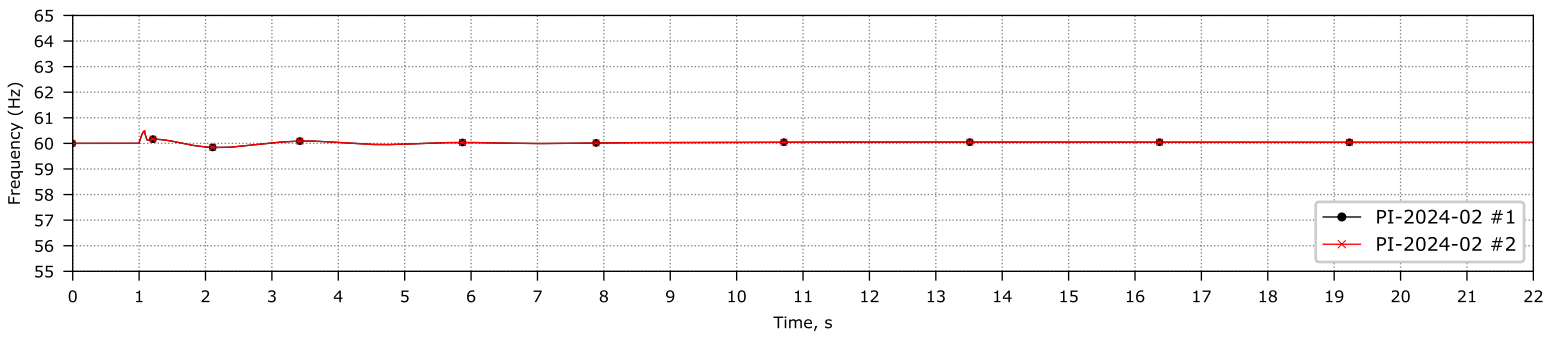
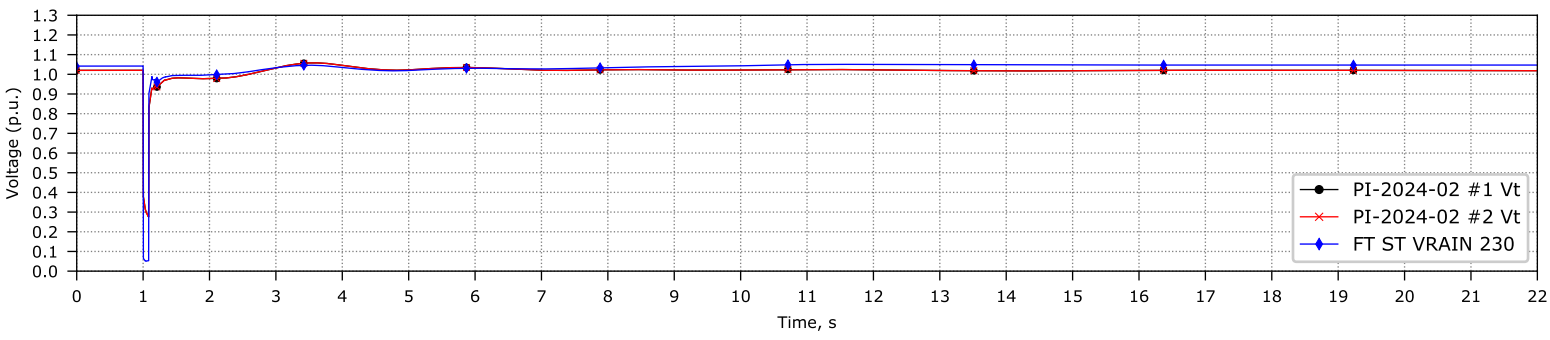
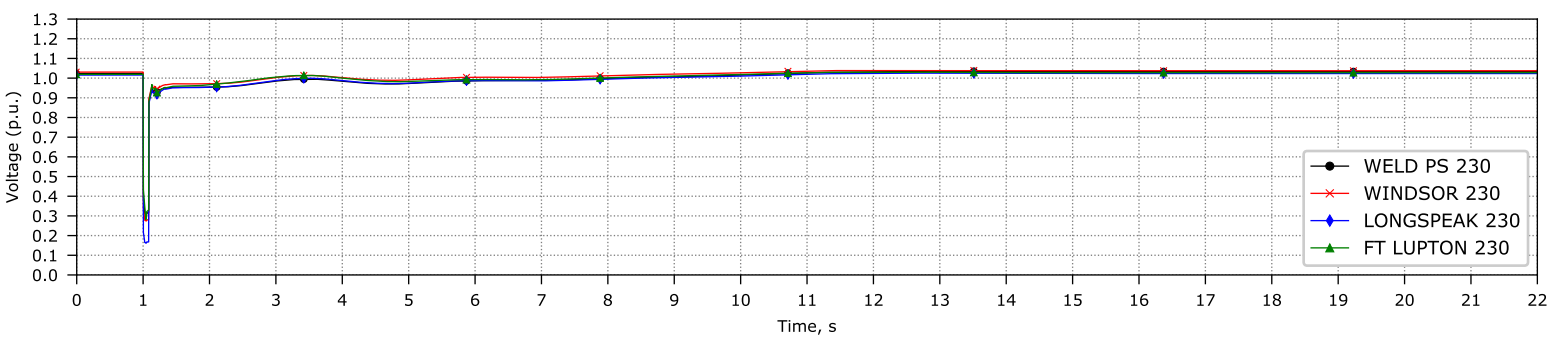


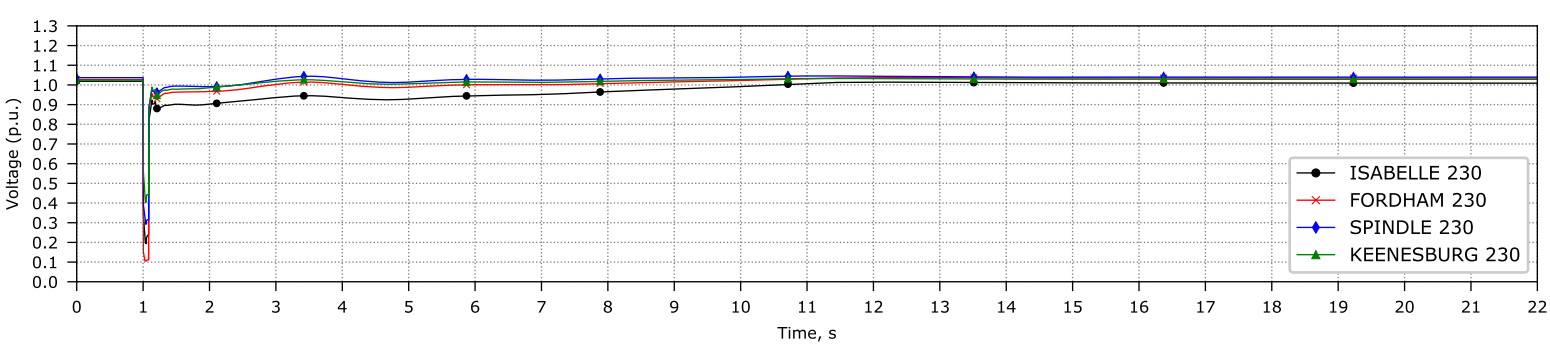


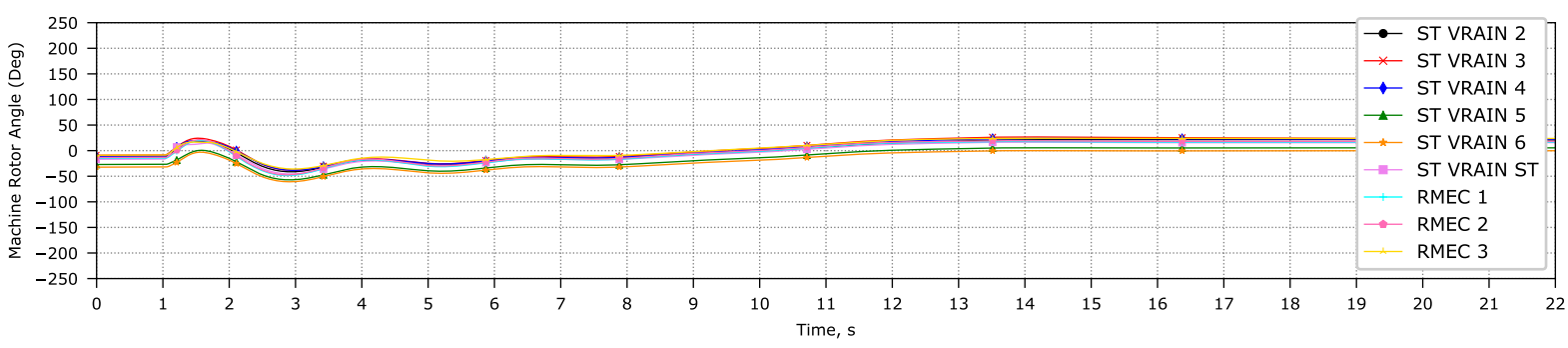


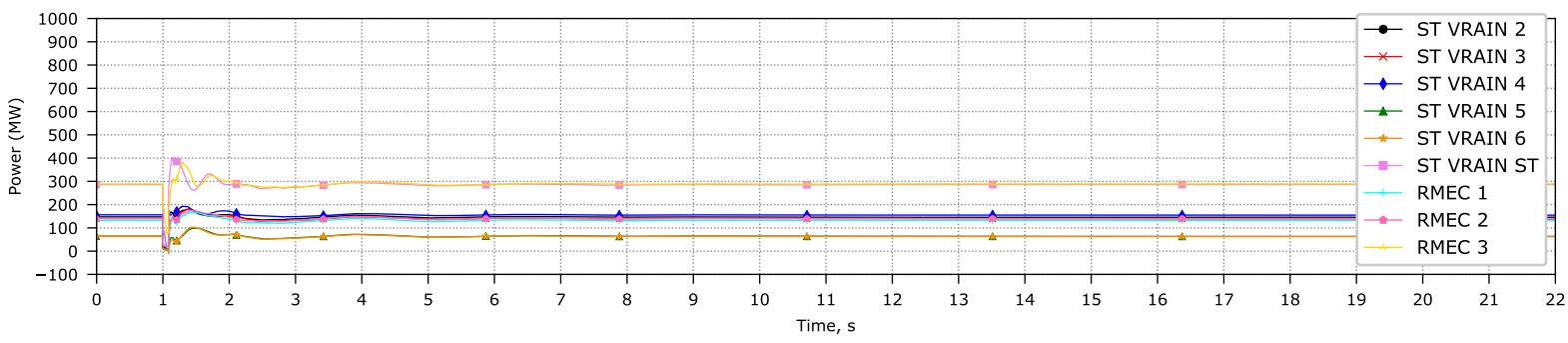




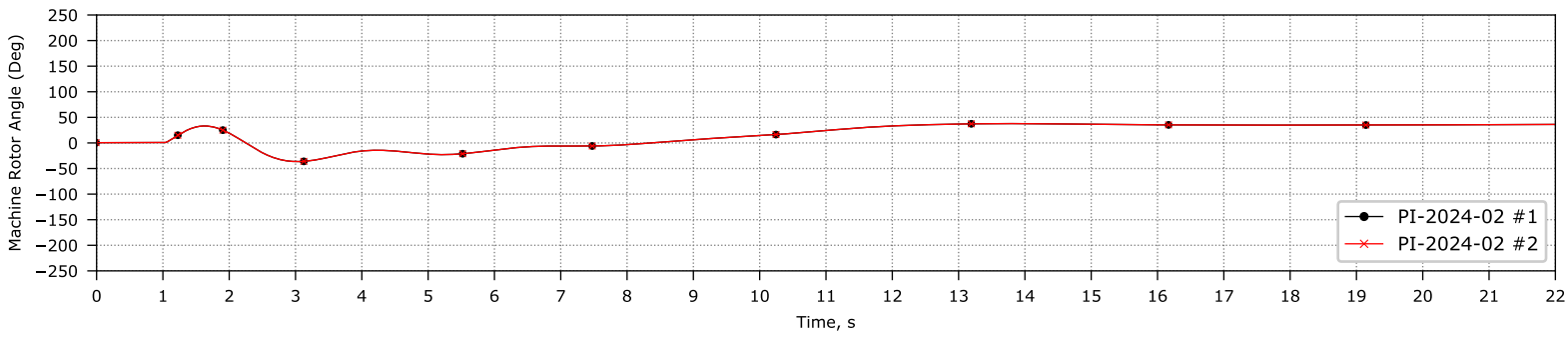


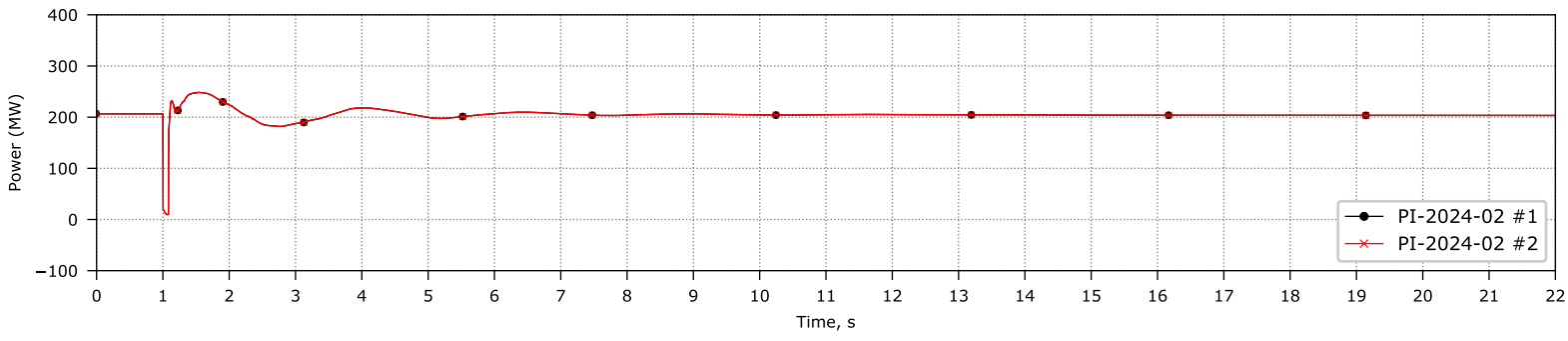


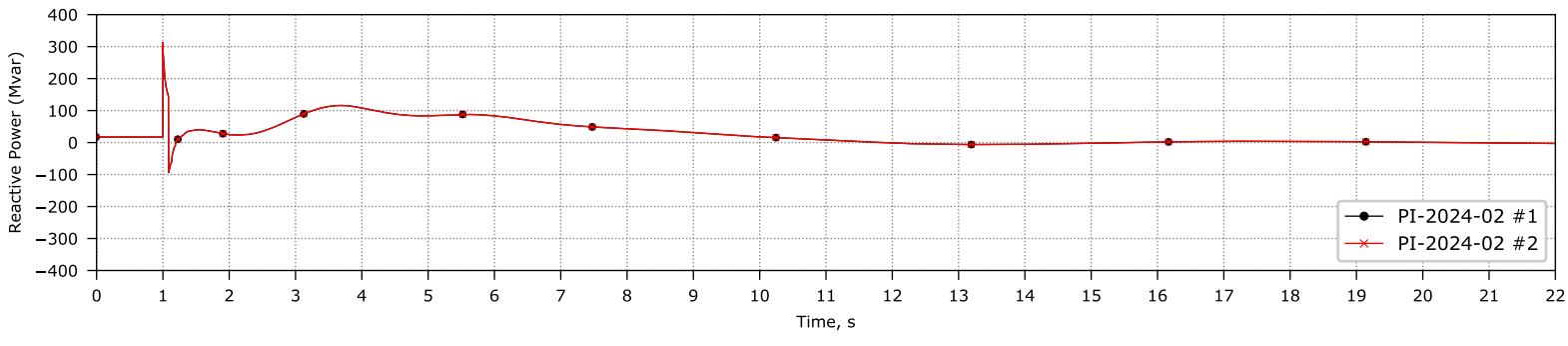


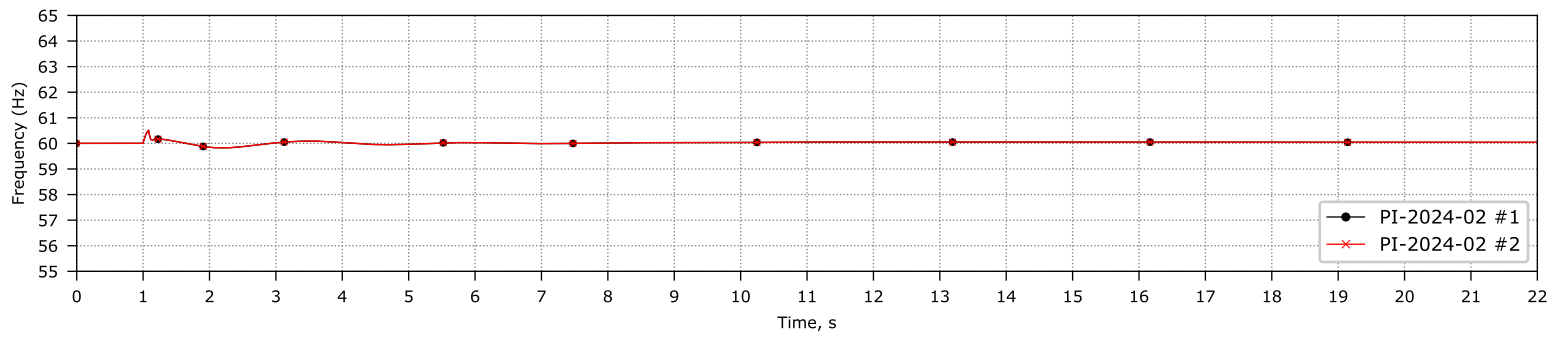


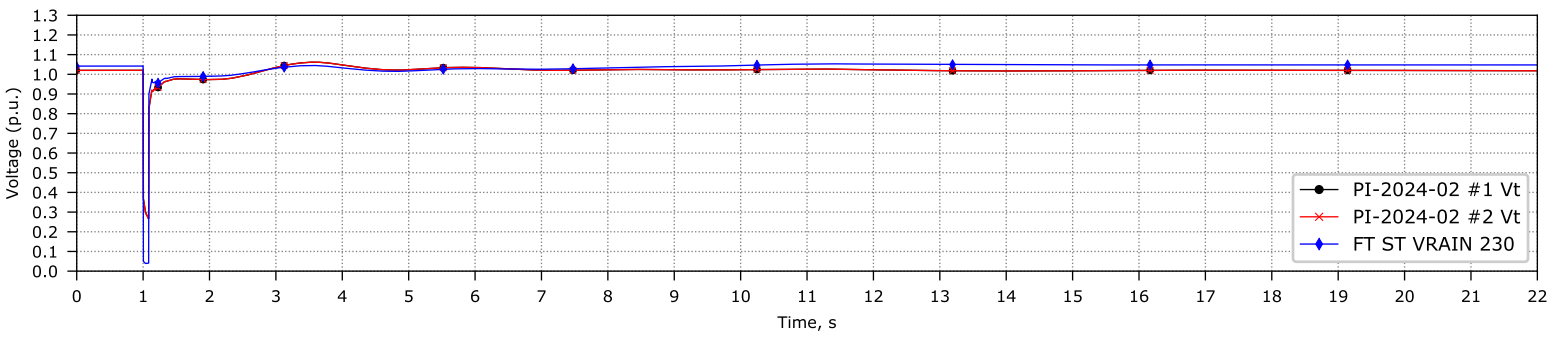
06_P1-Vrain-Keenesburg 230kV

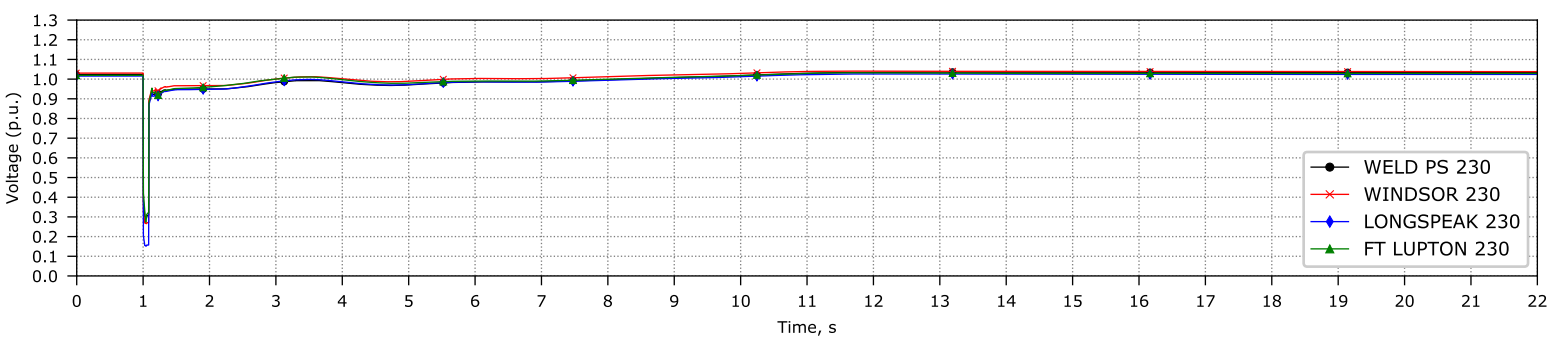


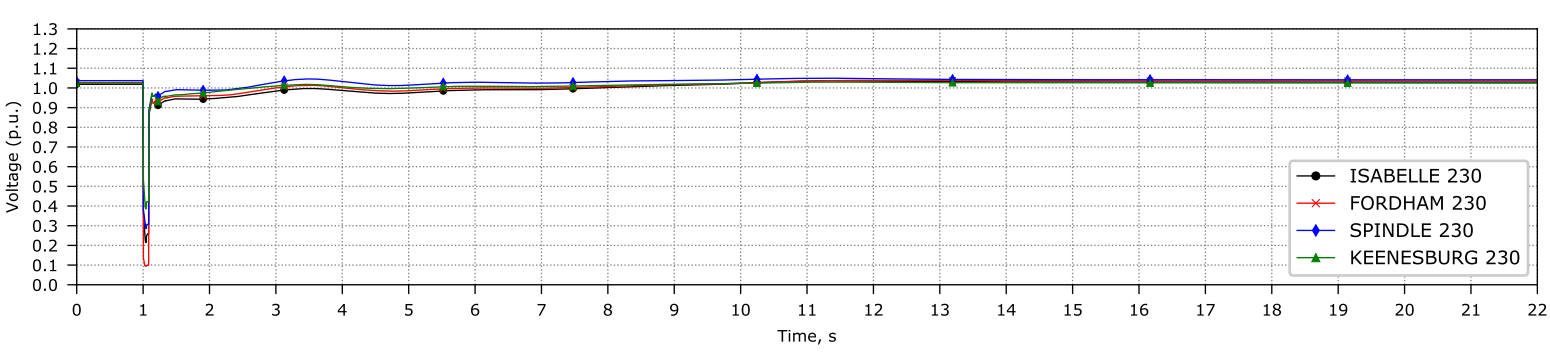


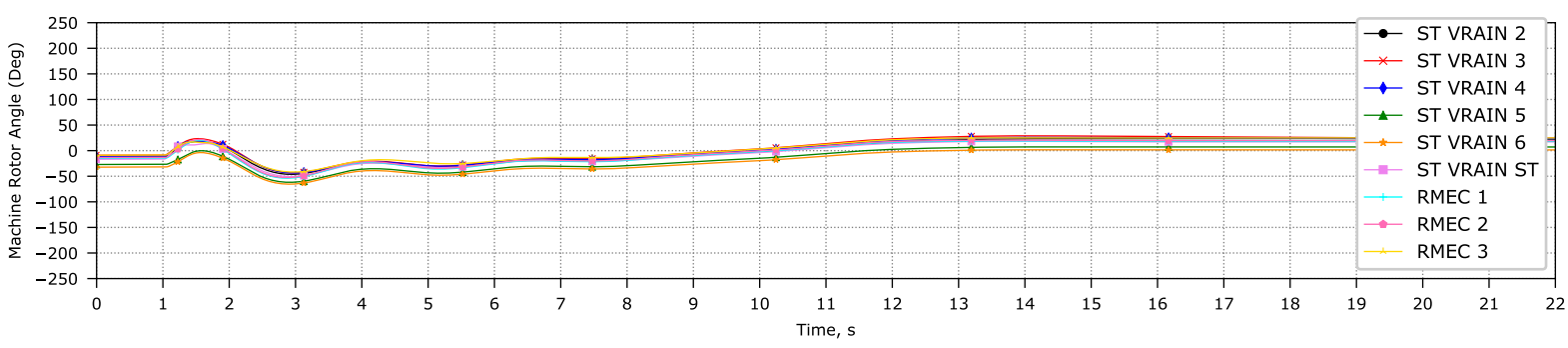


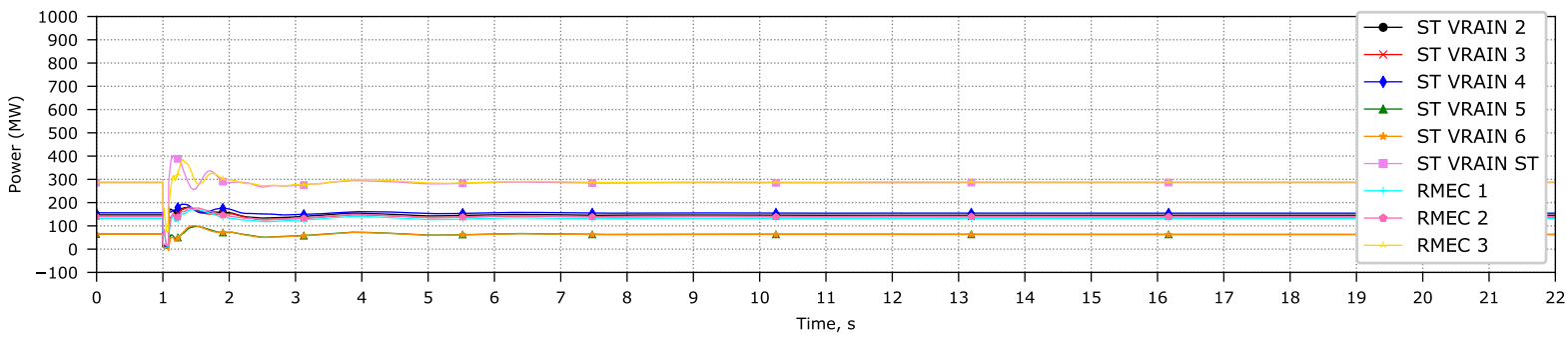




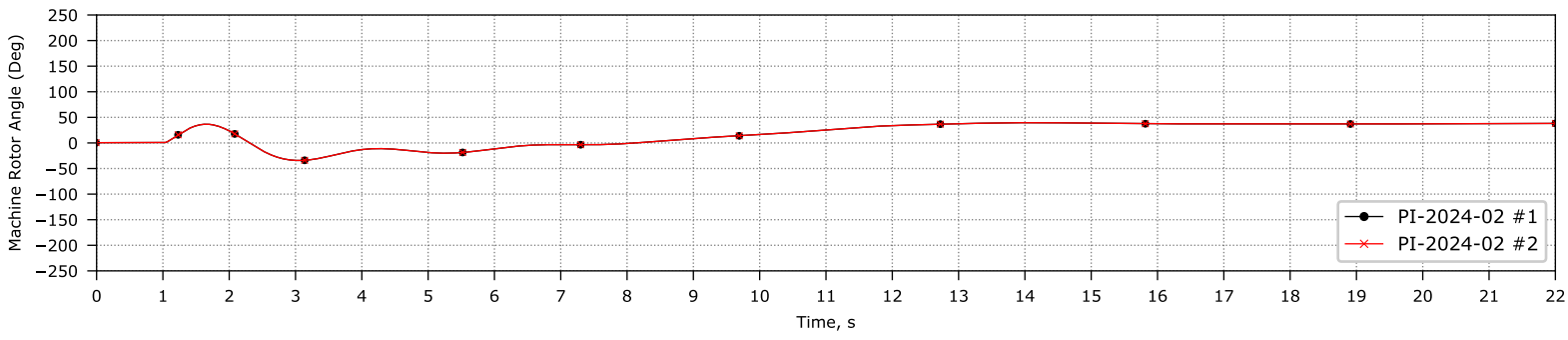


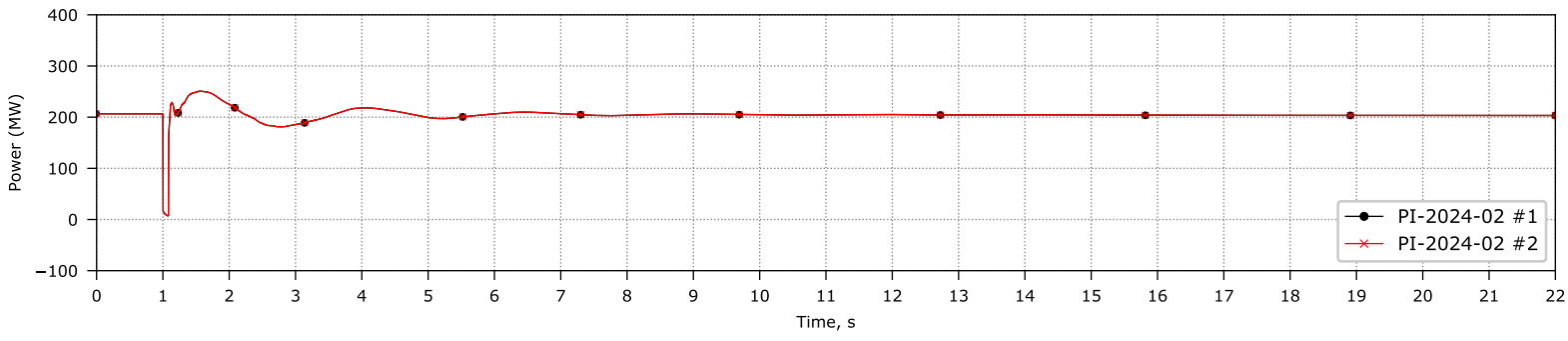


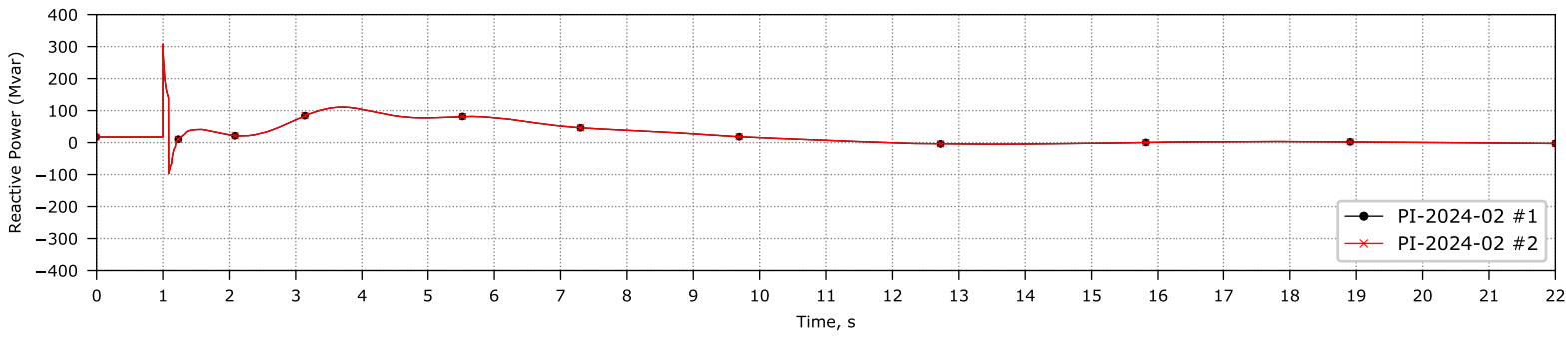


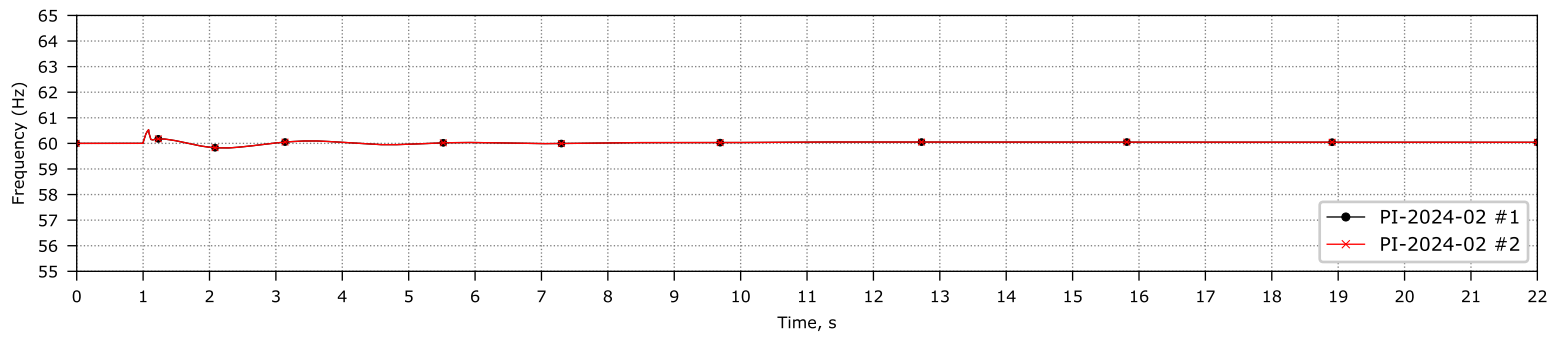


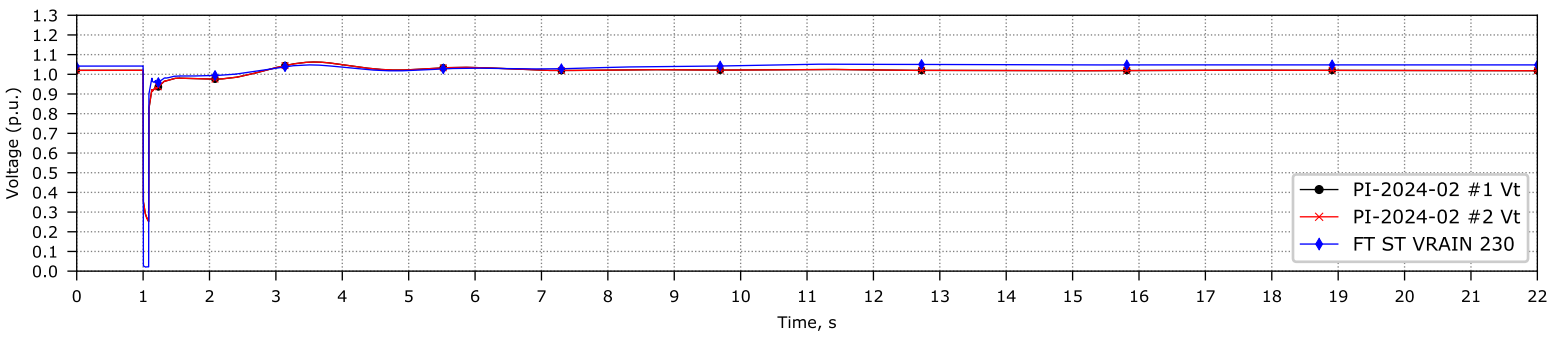
07_P1-Vrain-LONGPEAK 230kV

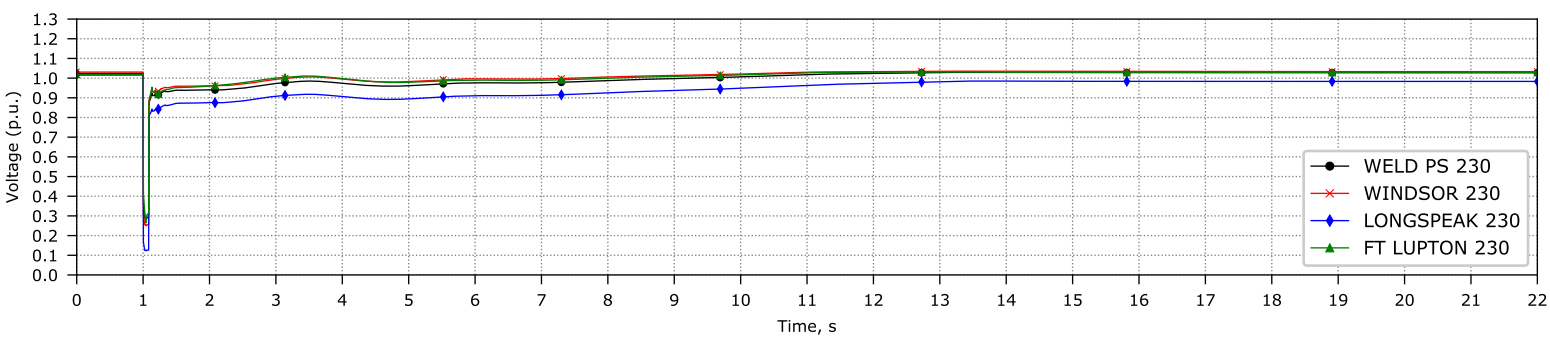


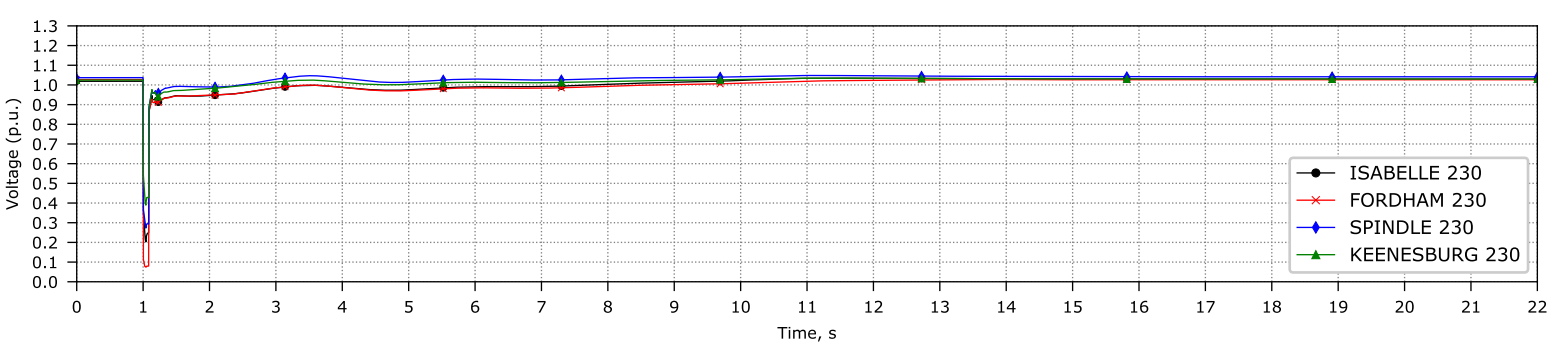


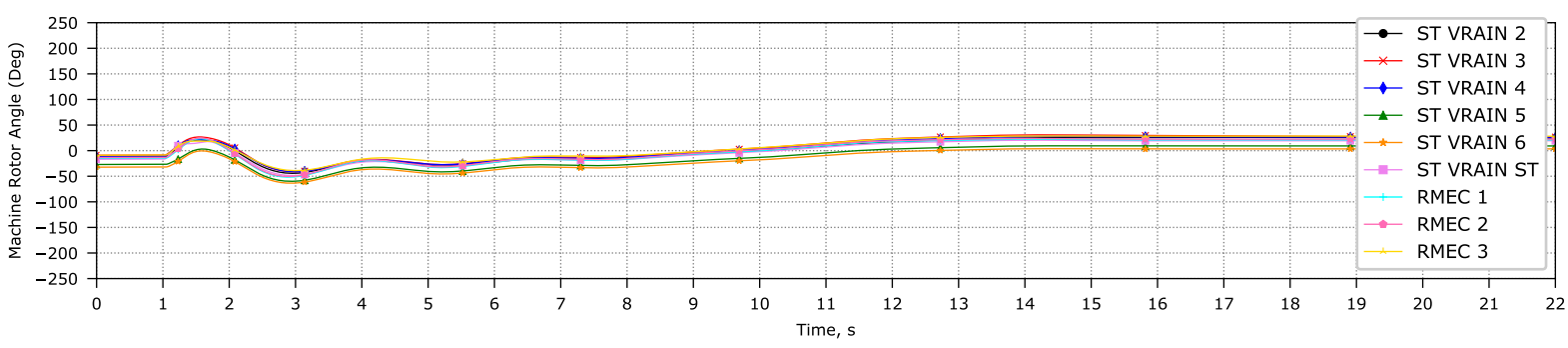


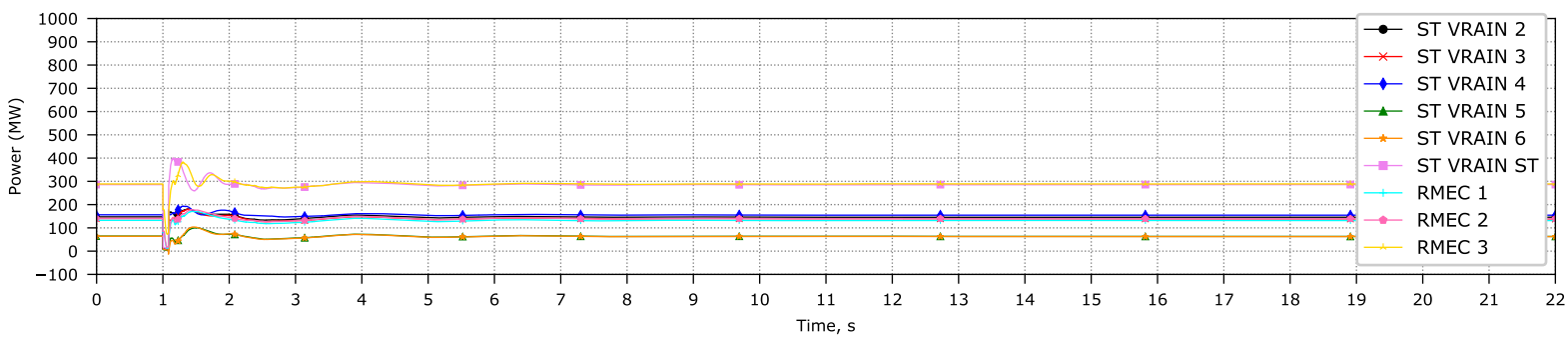




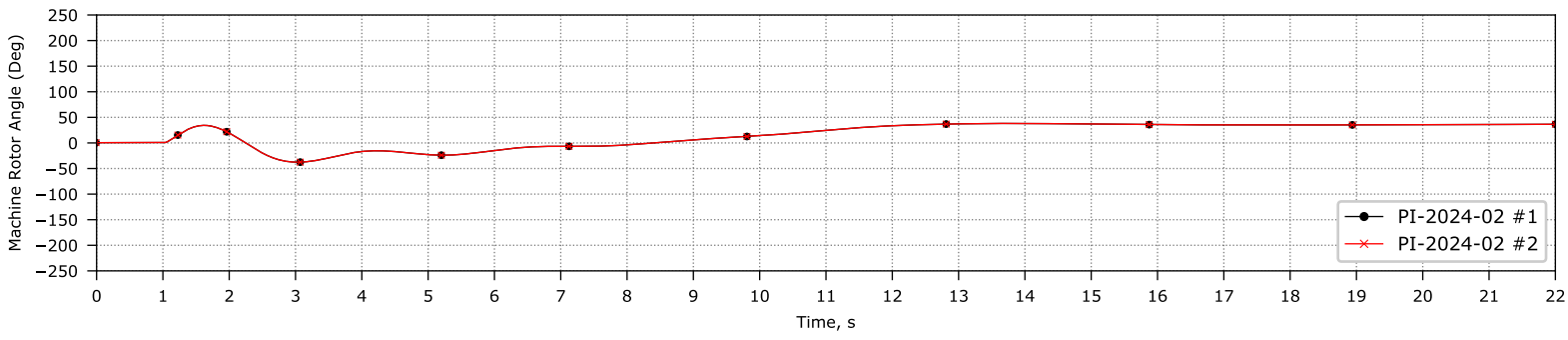


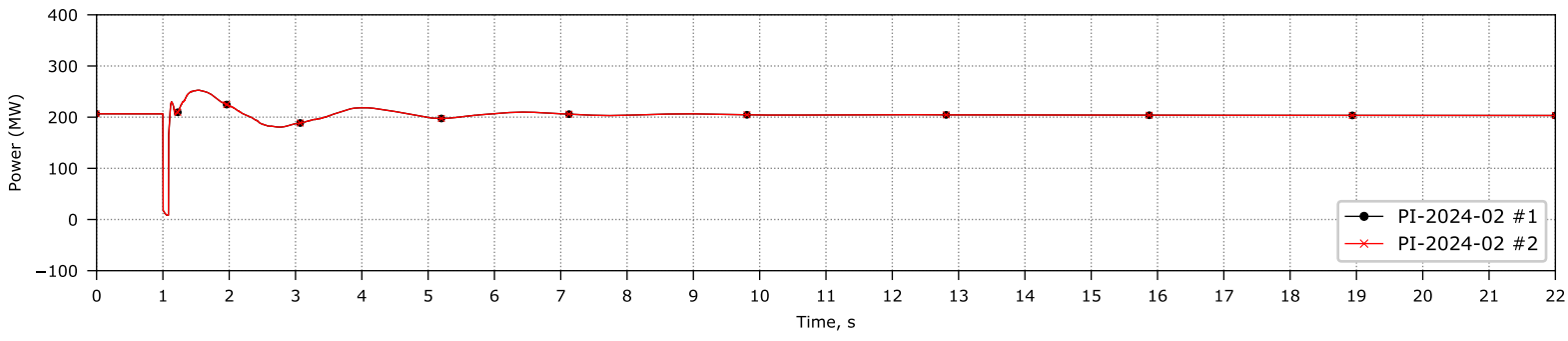


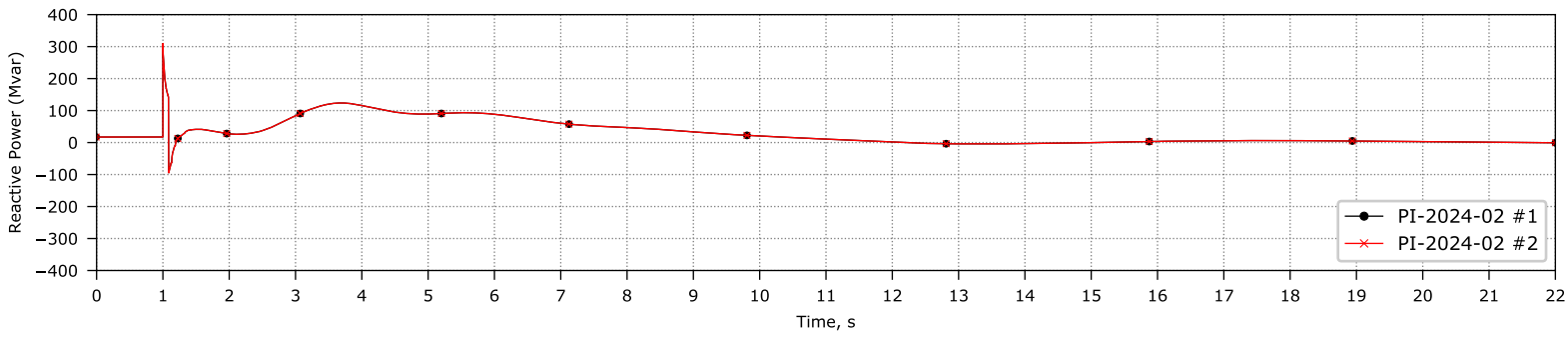


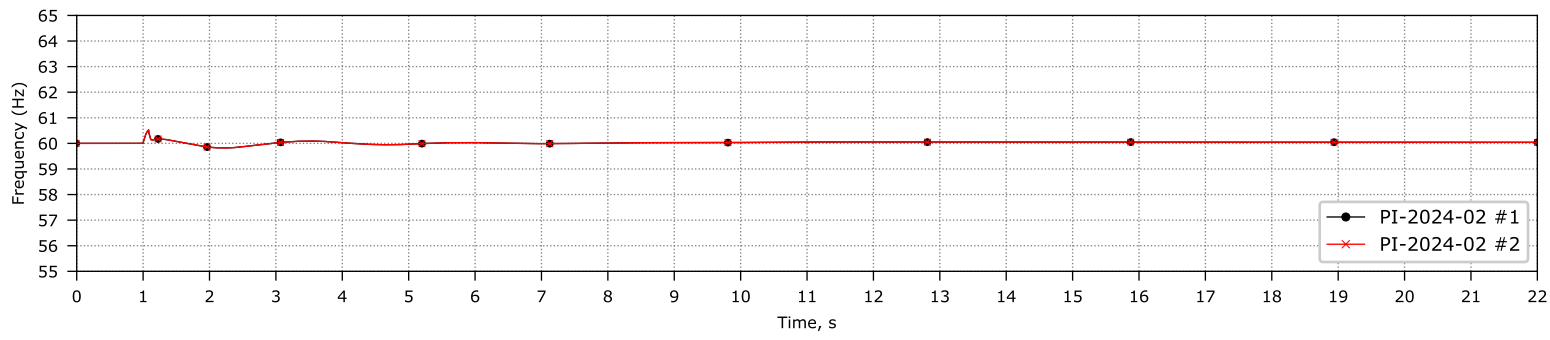


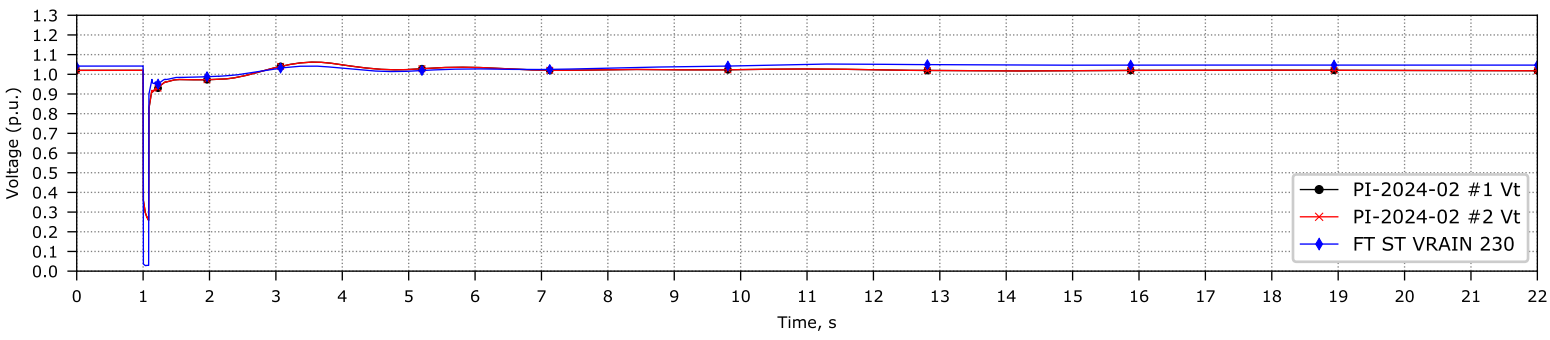
08_P1-Vrain-Spindle 230kV

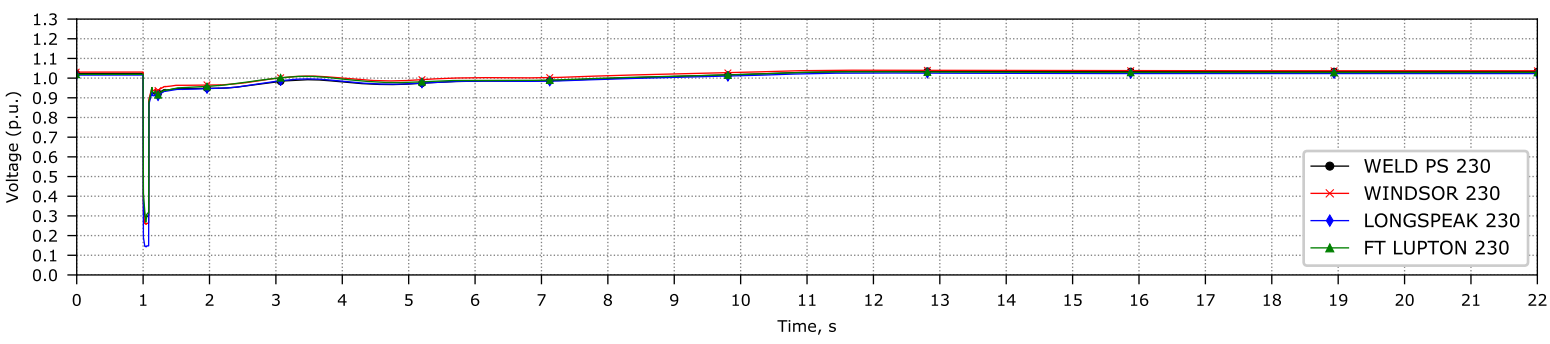


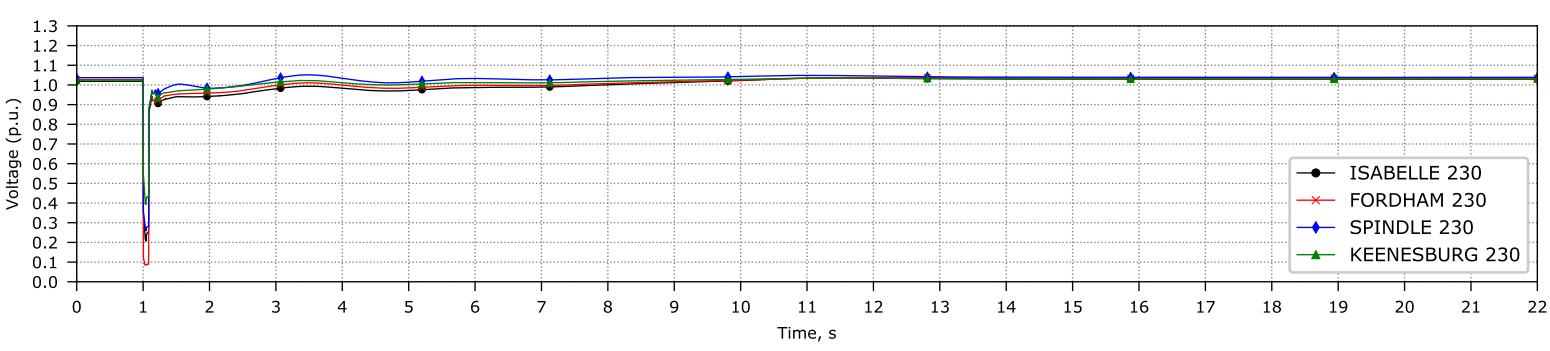


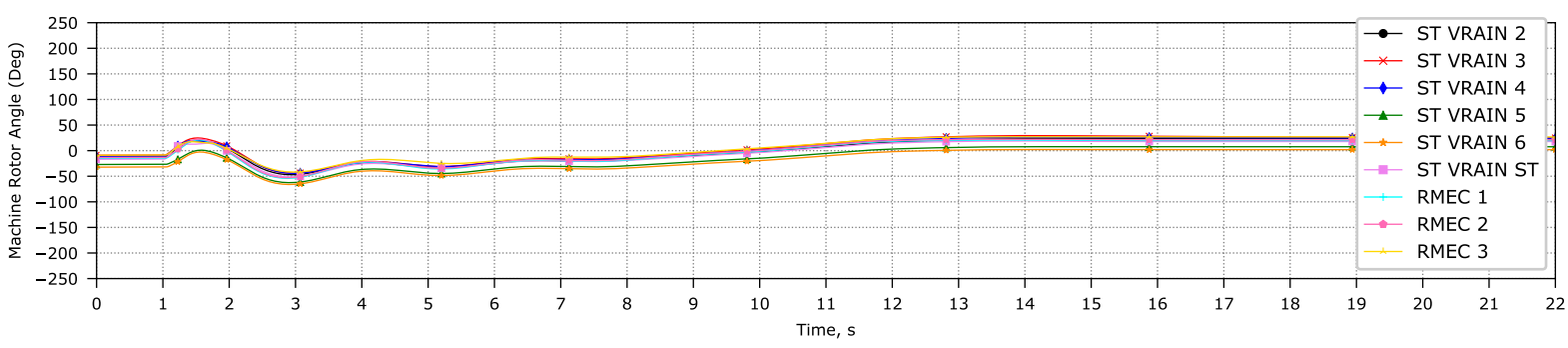


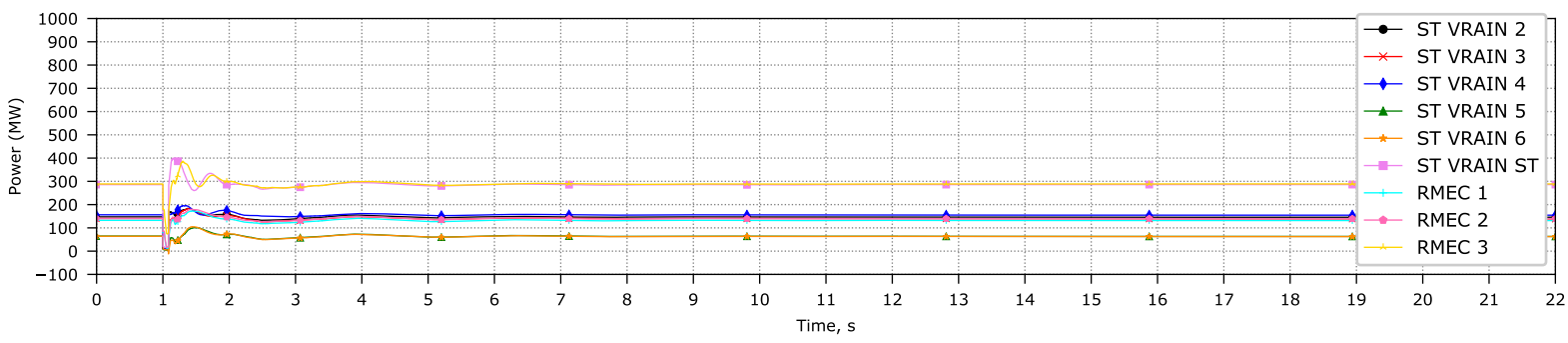




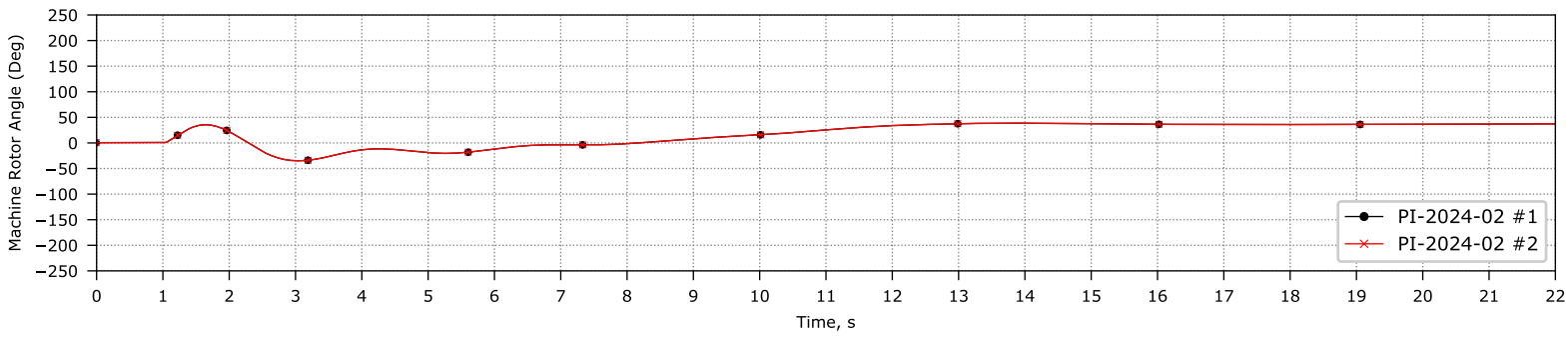


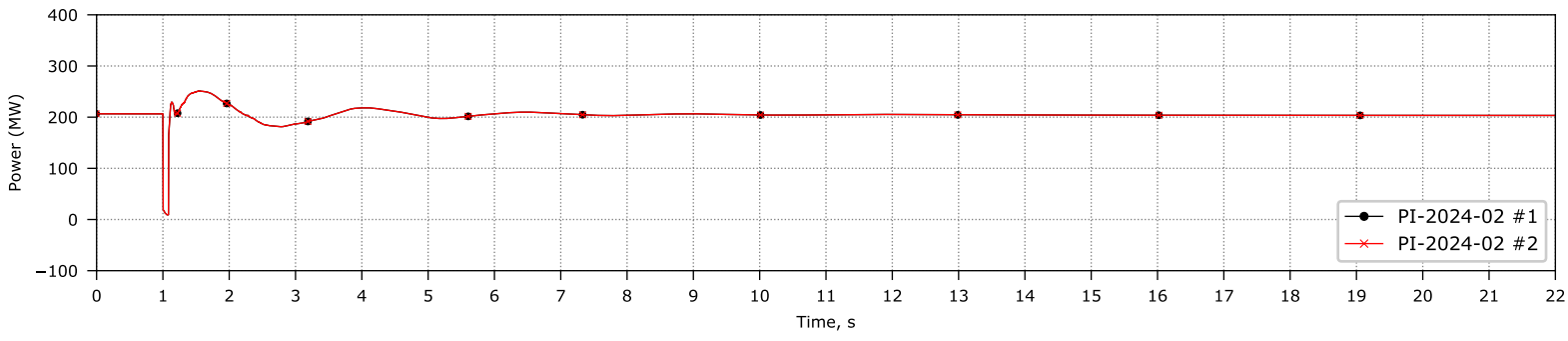


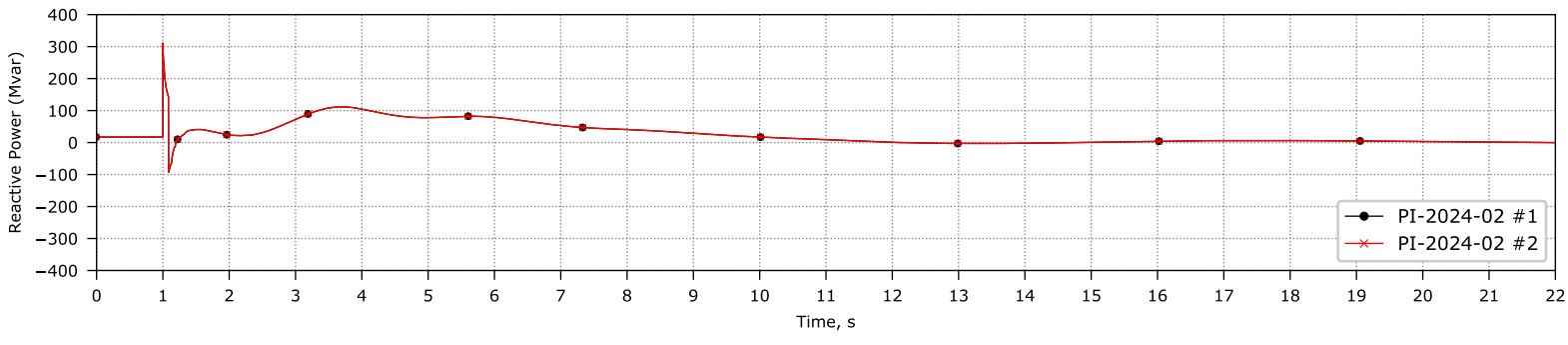


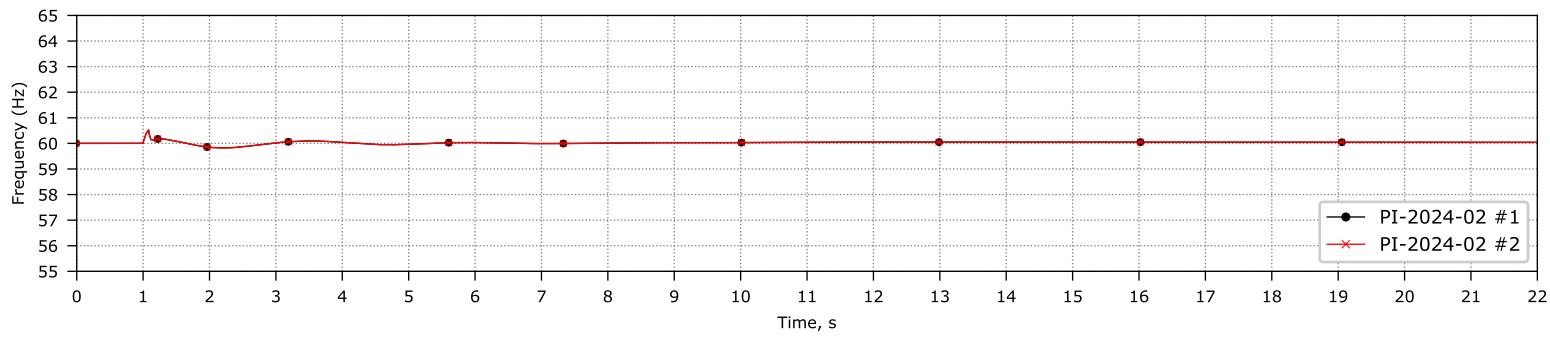


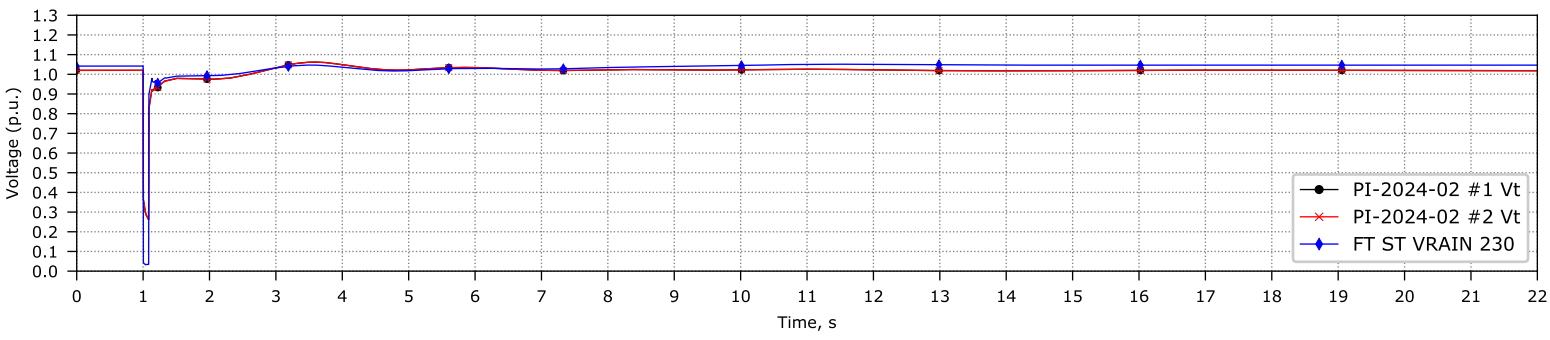
09_P1-Vrain-WELDPS 230kV

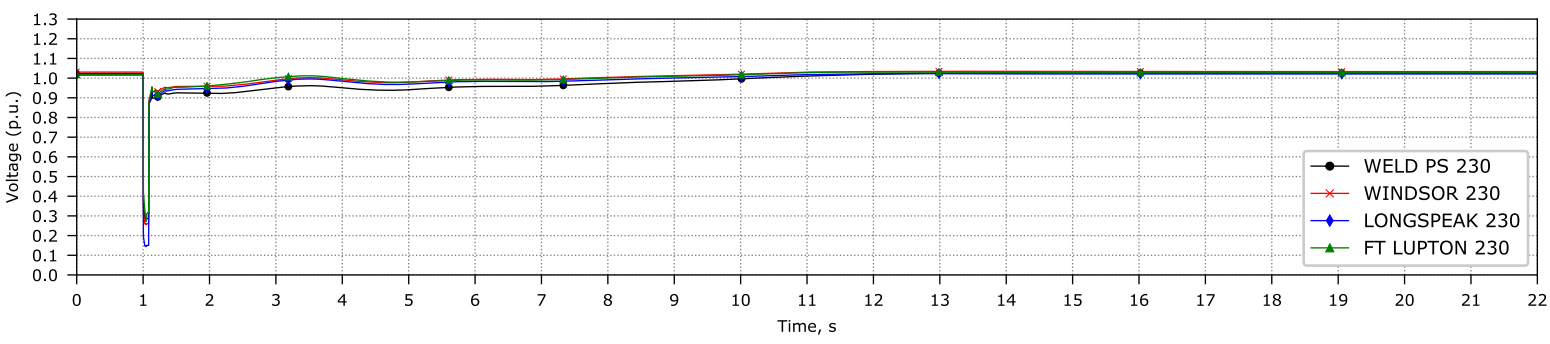


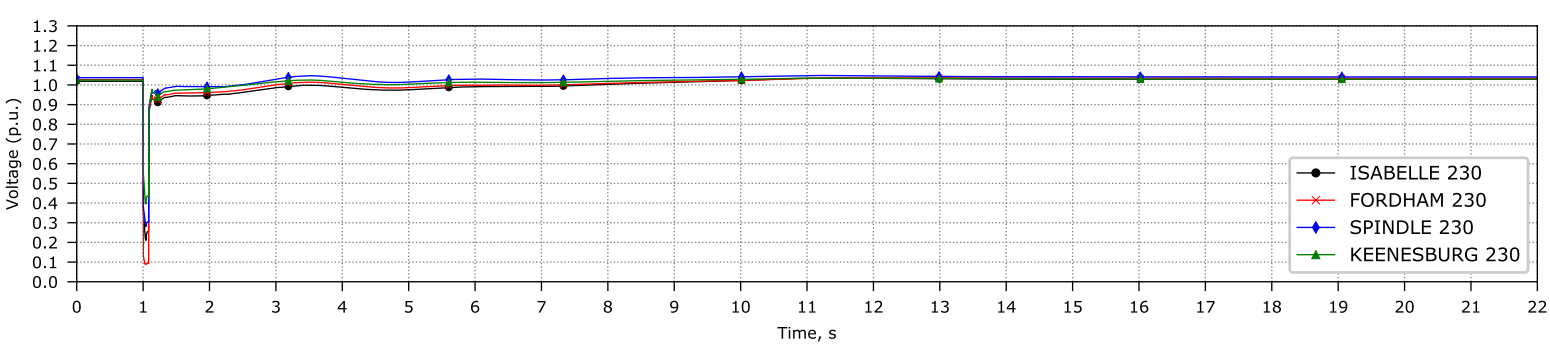


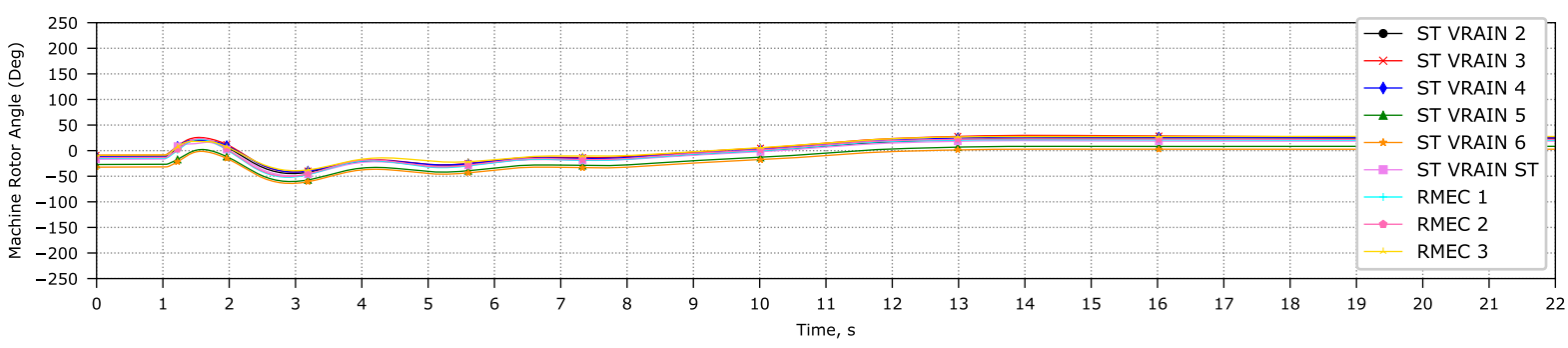


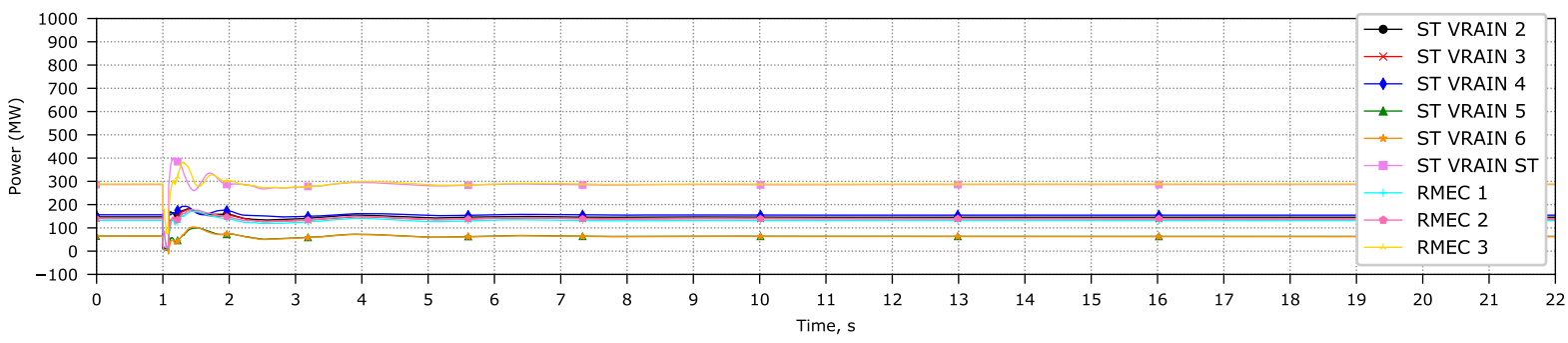




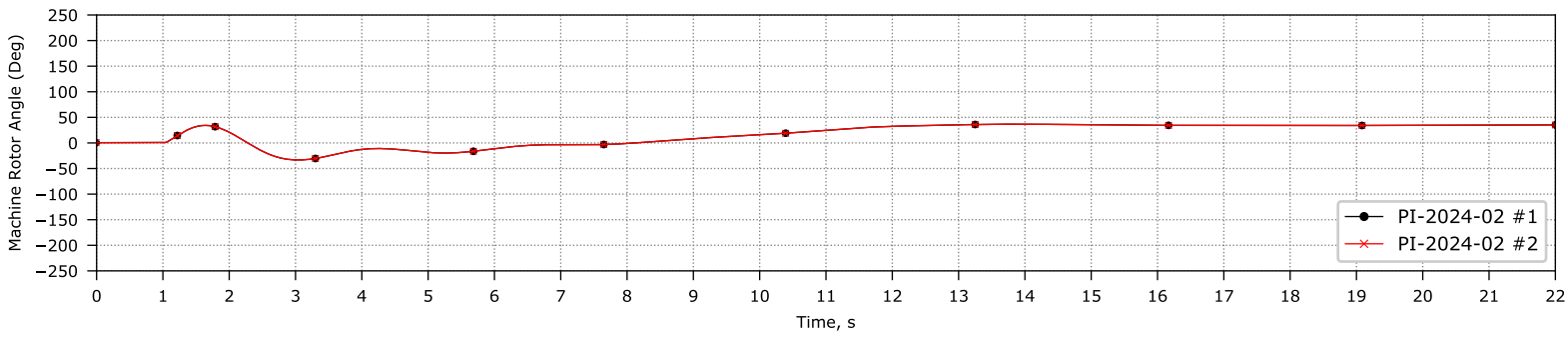


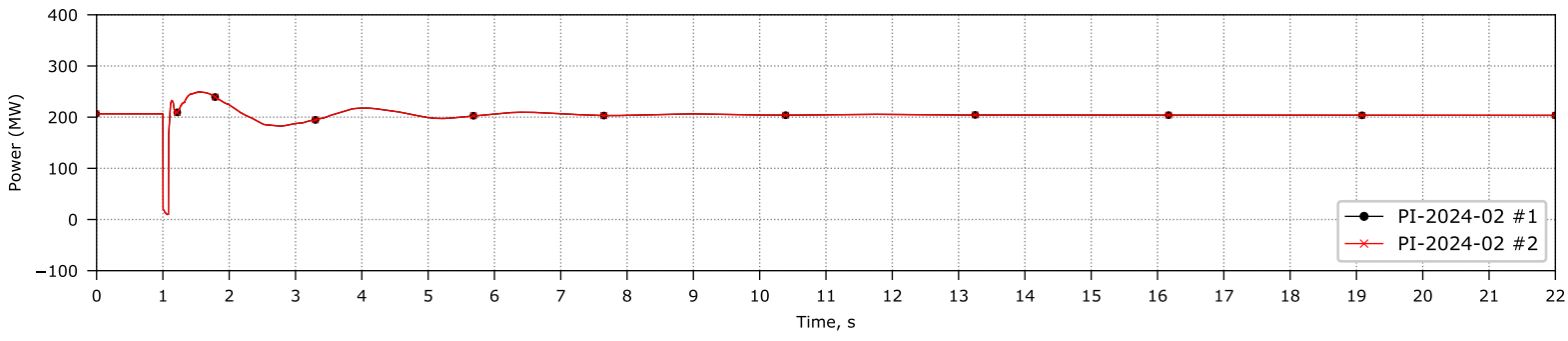


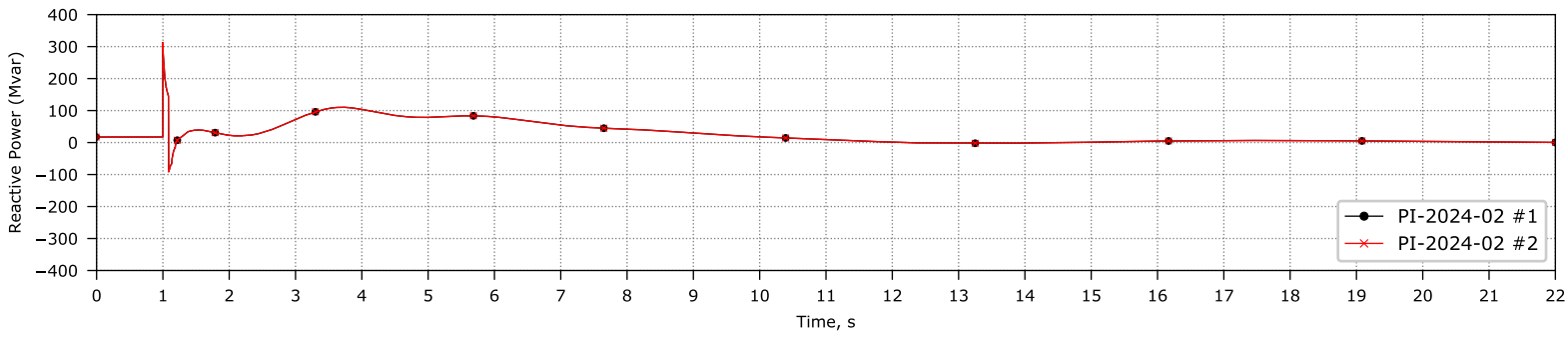


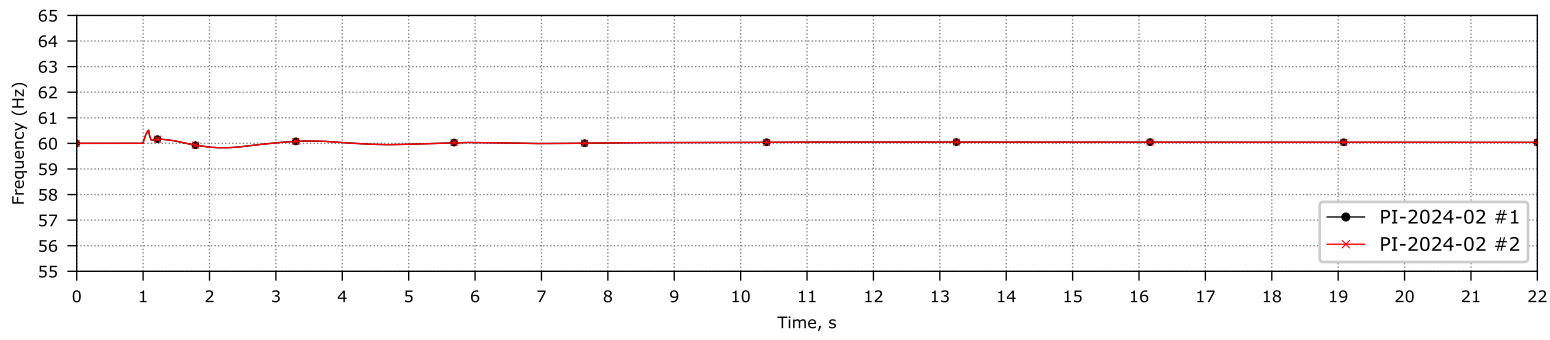


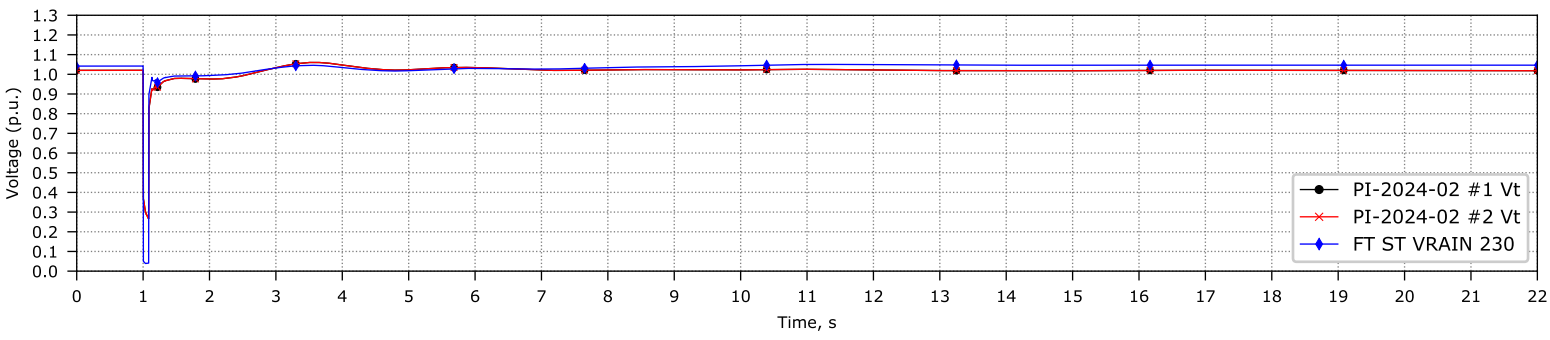
10_P1-Vrain-WINDSOR 230kV

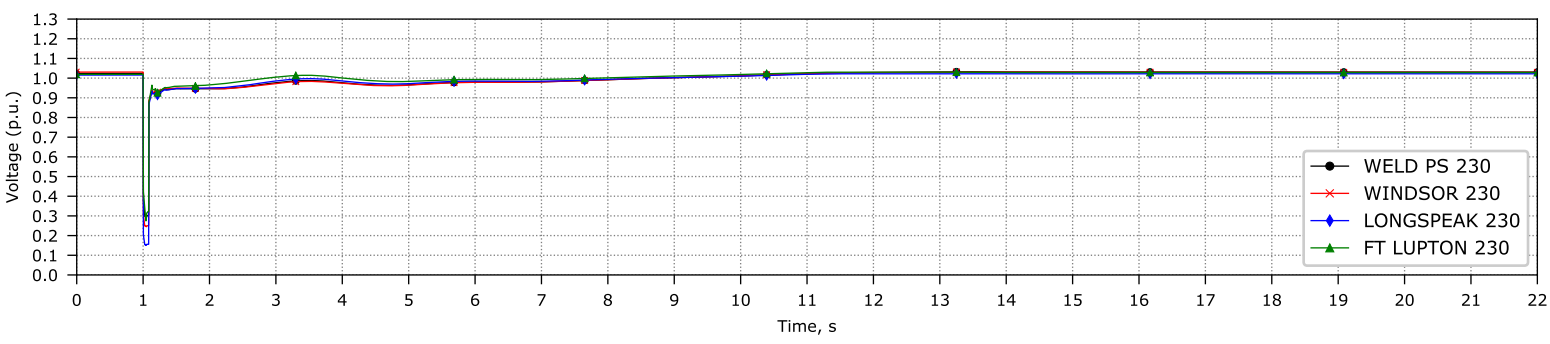


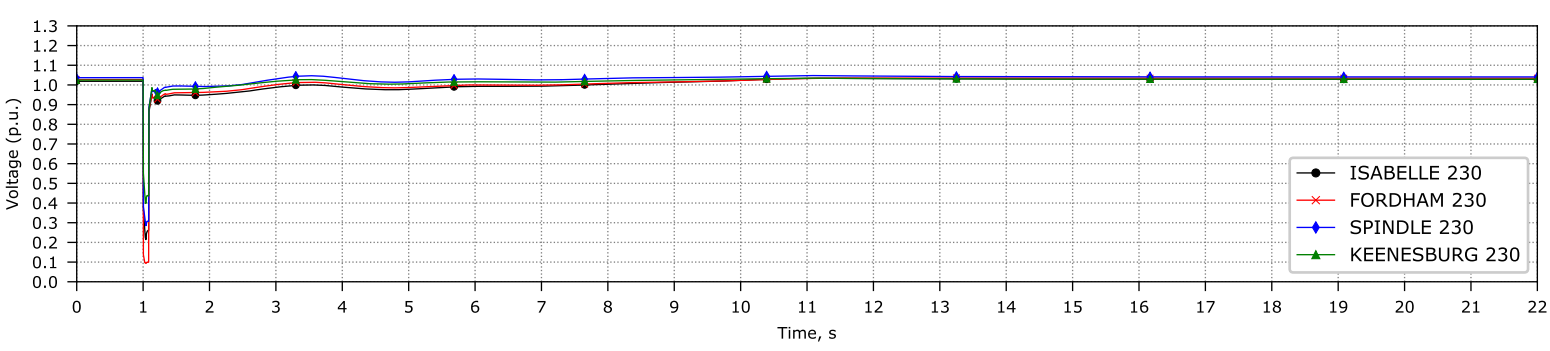


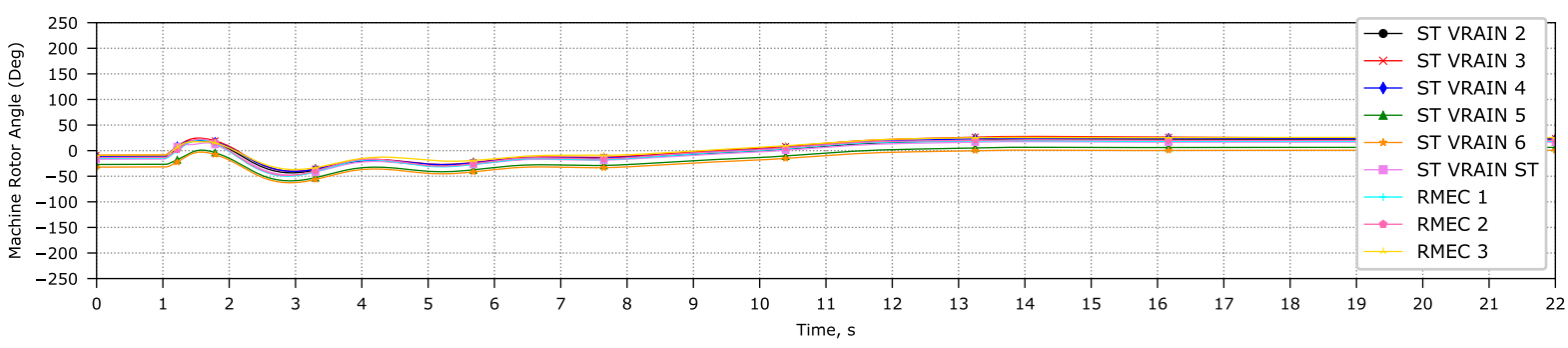


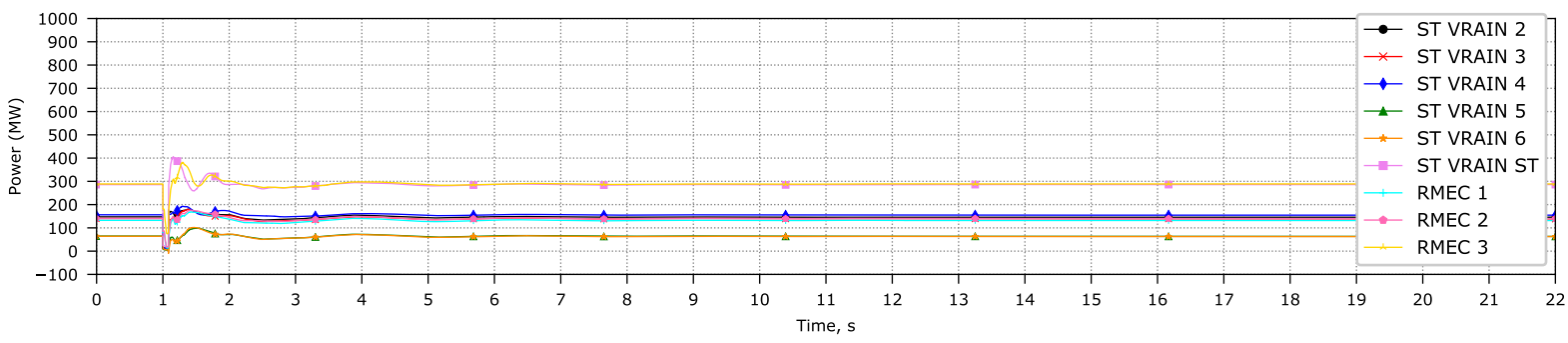




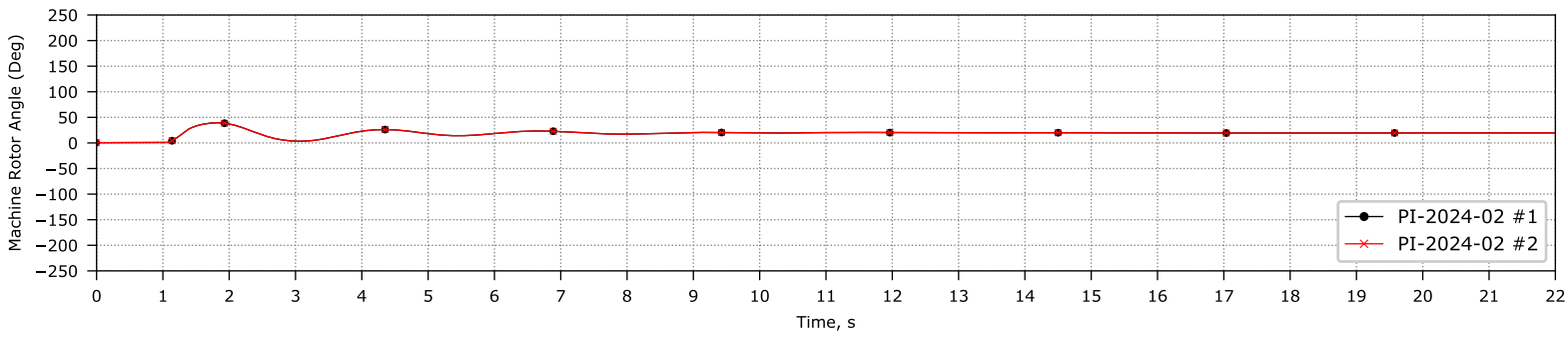


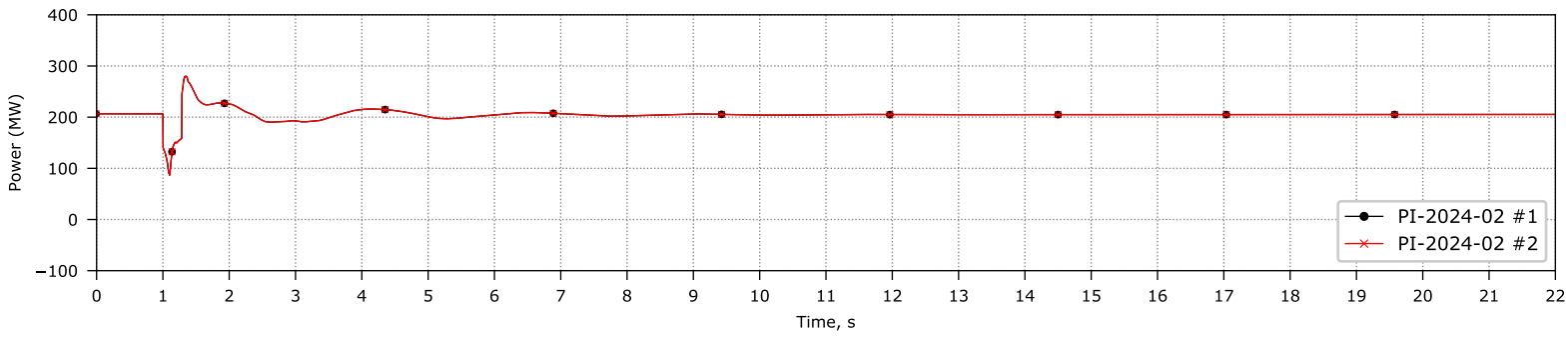


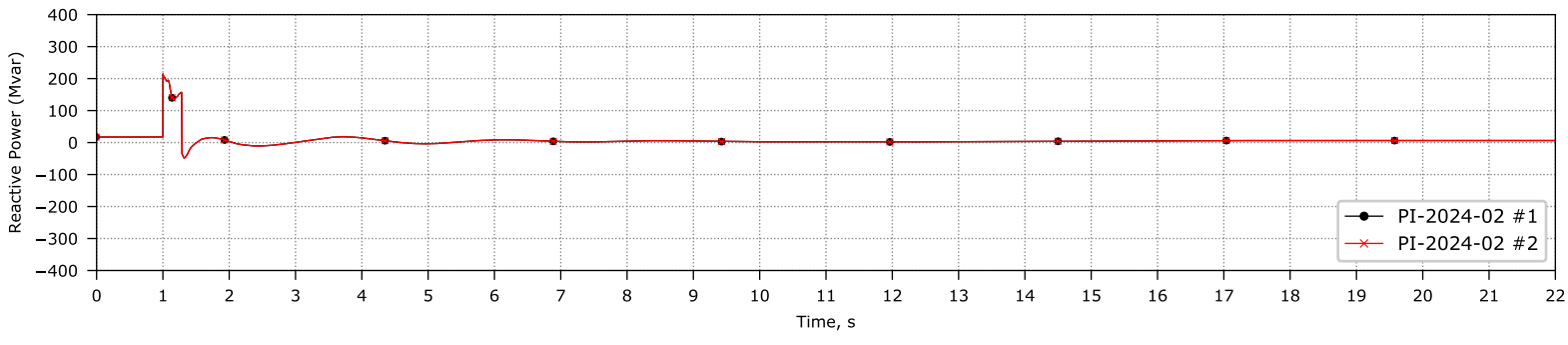


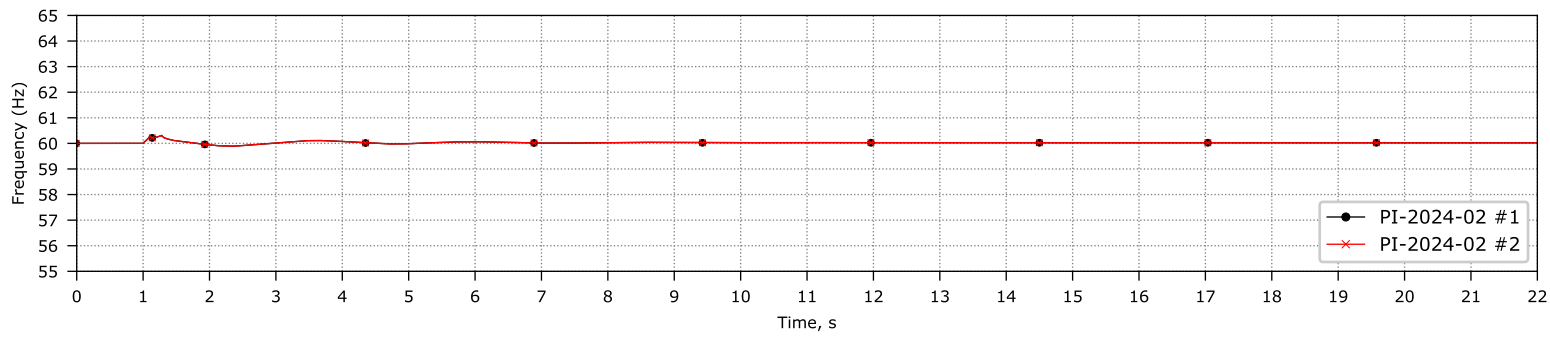


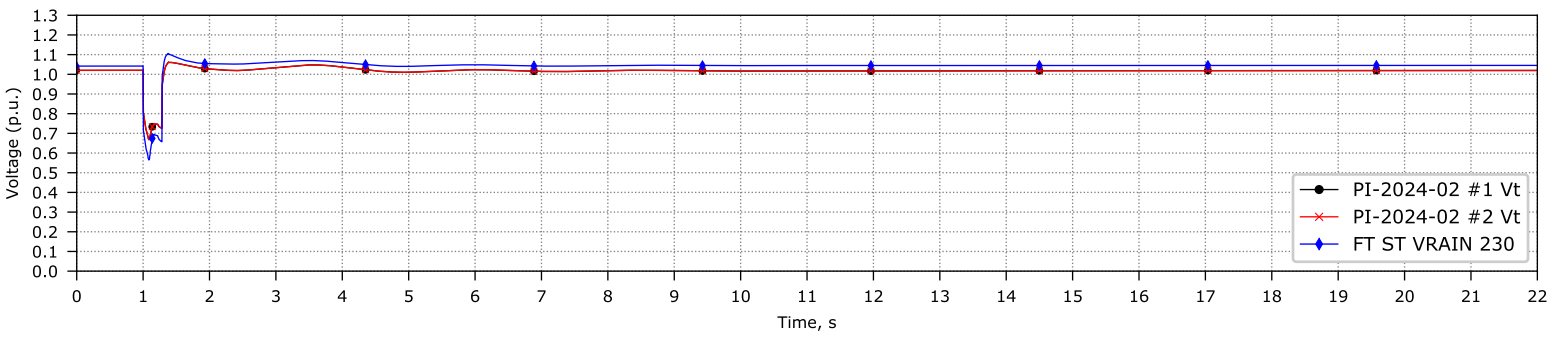
11_P4-line_213

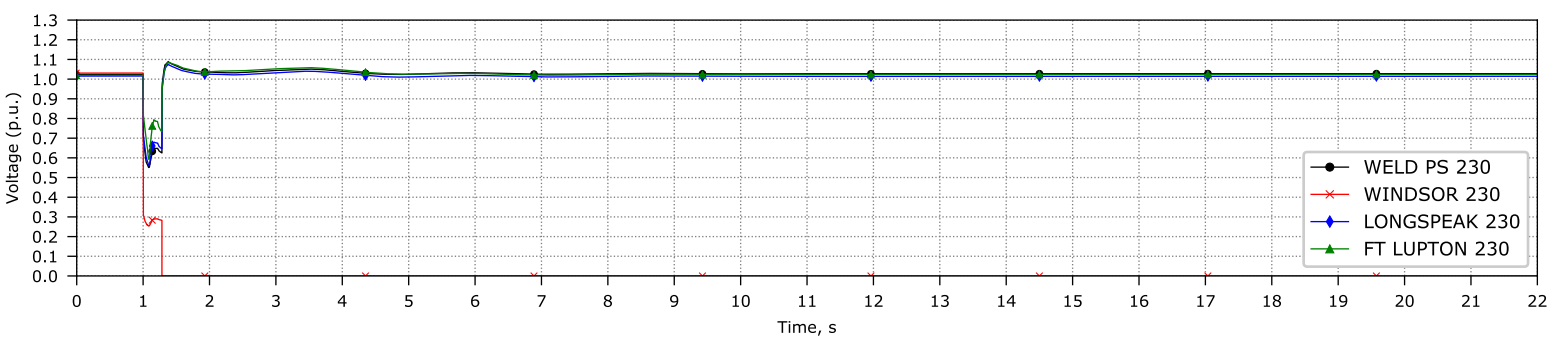


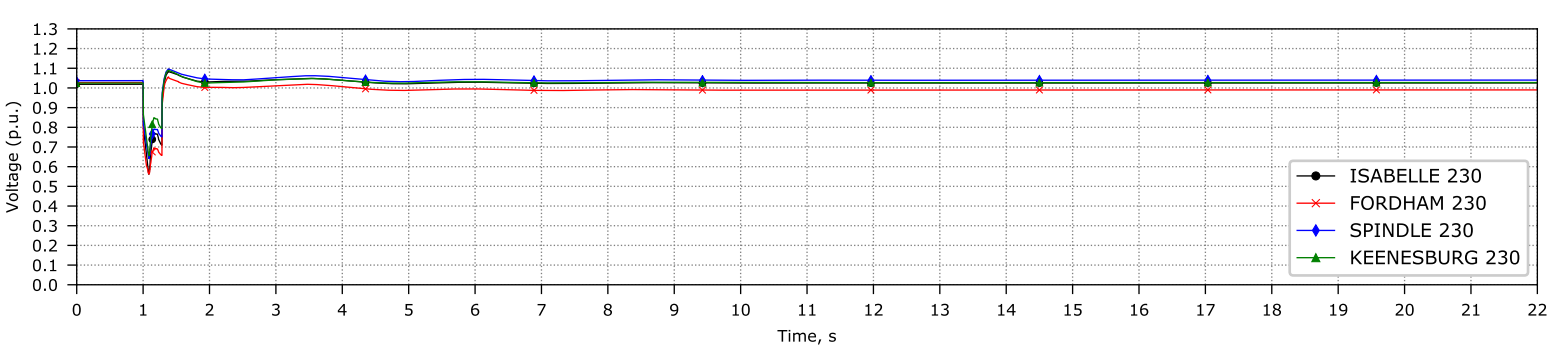


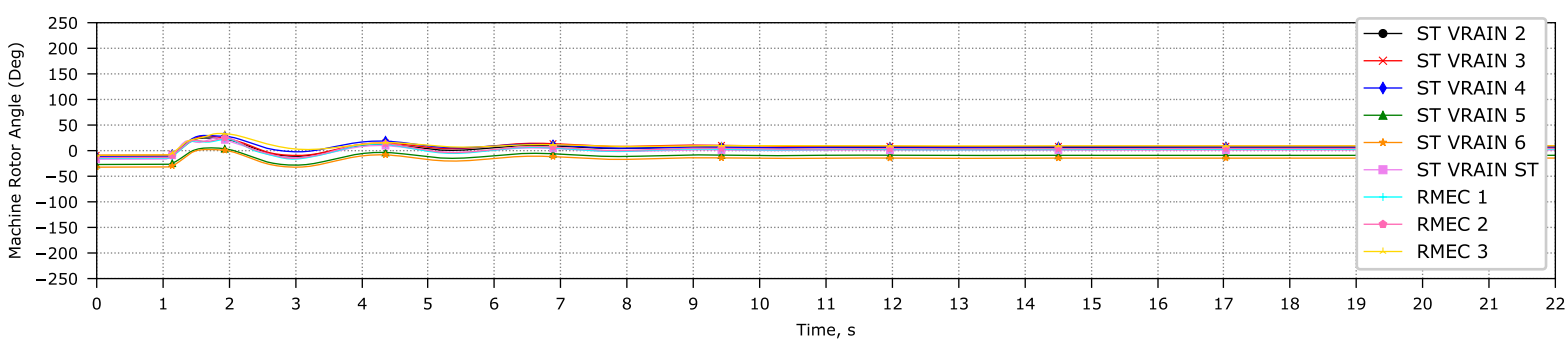


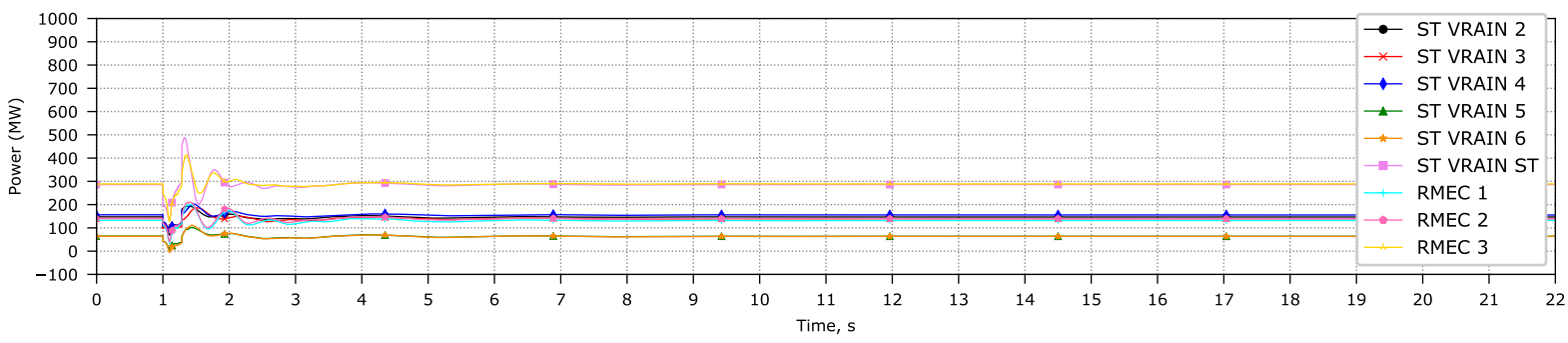




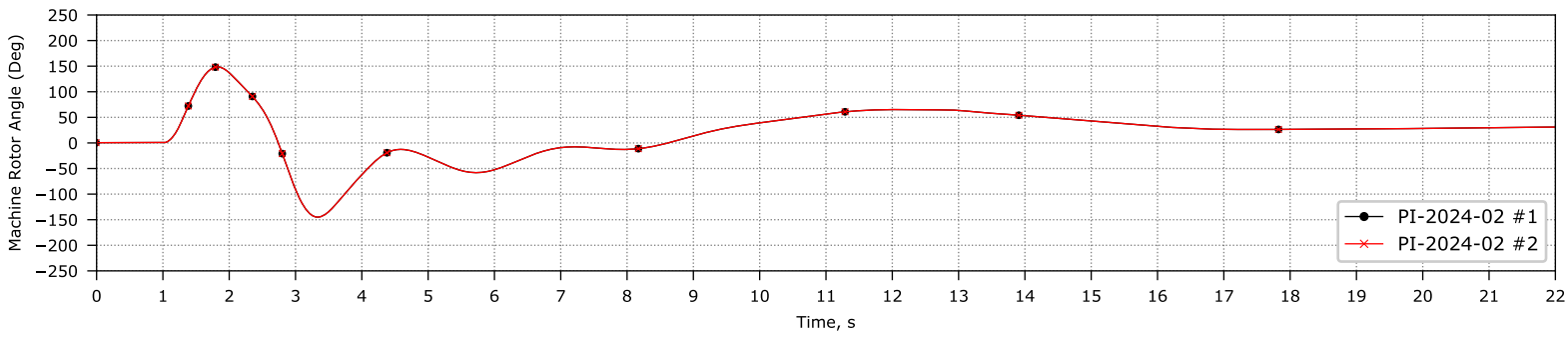


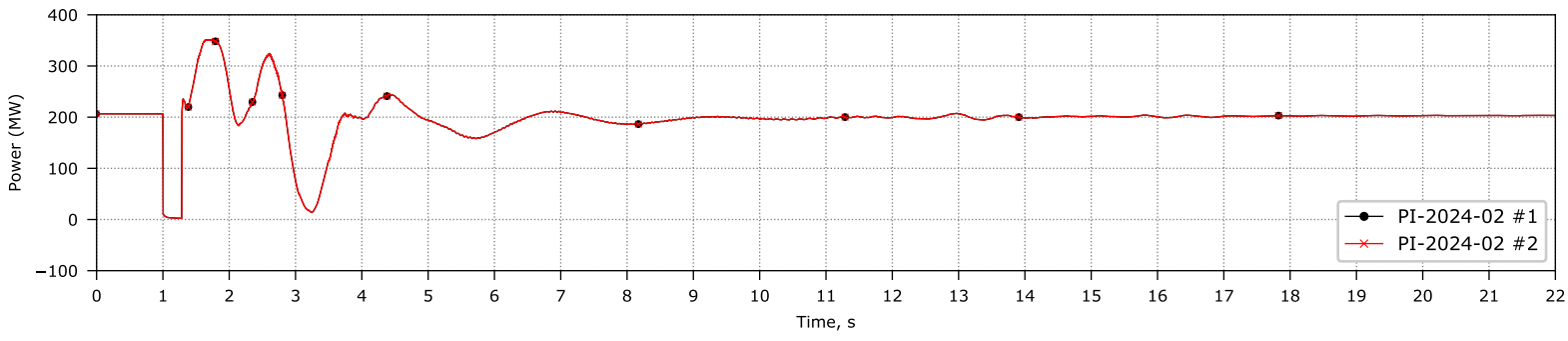


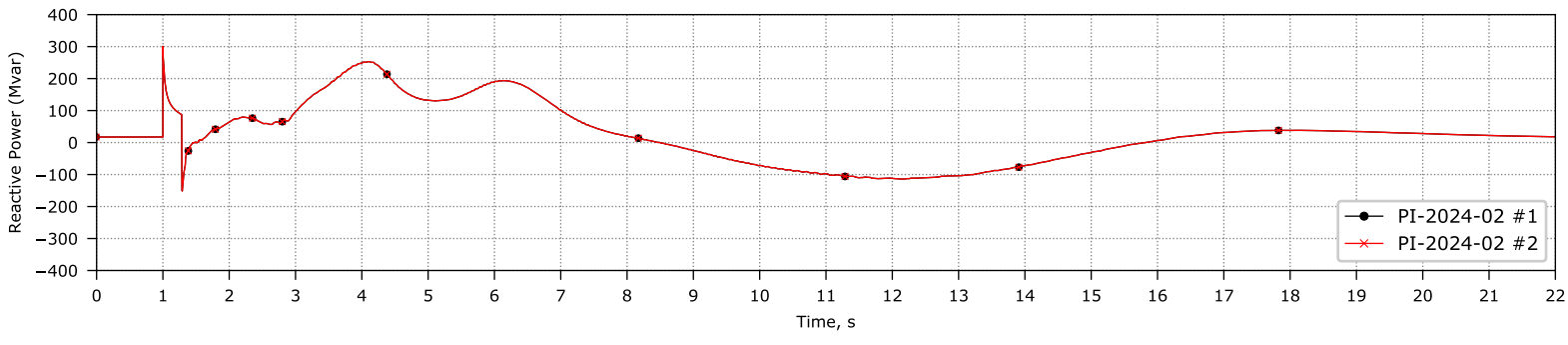


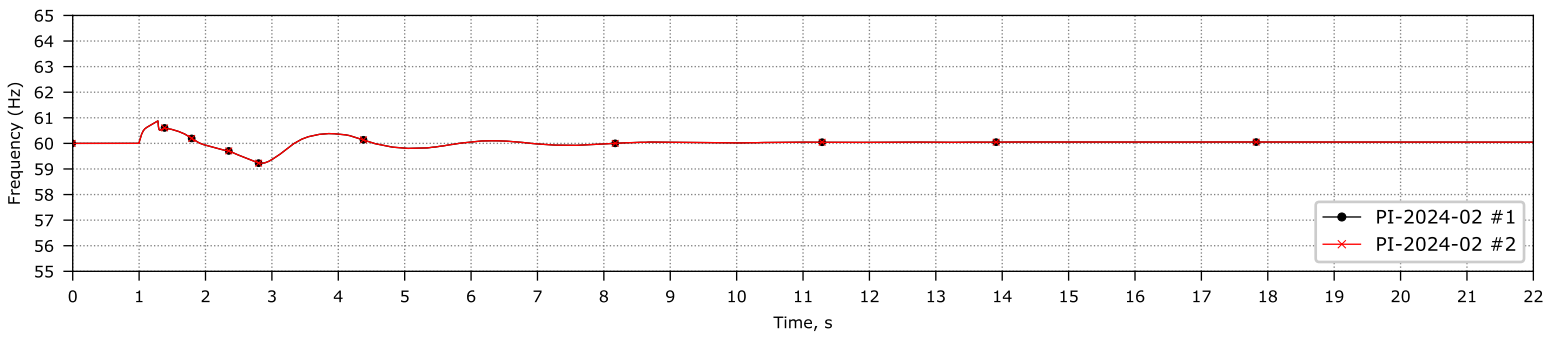


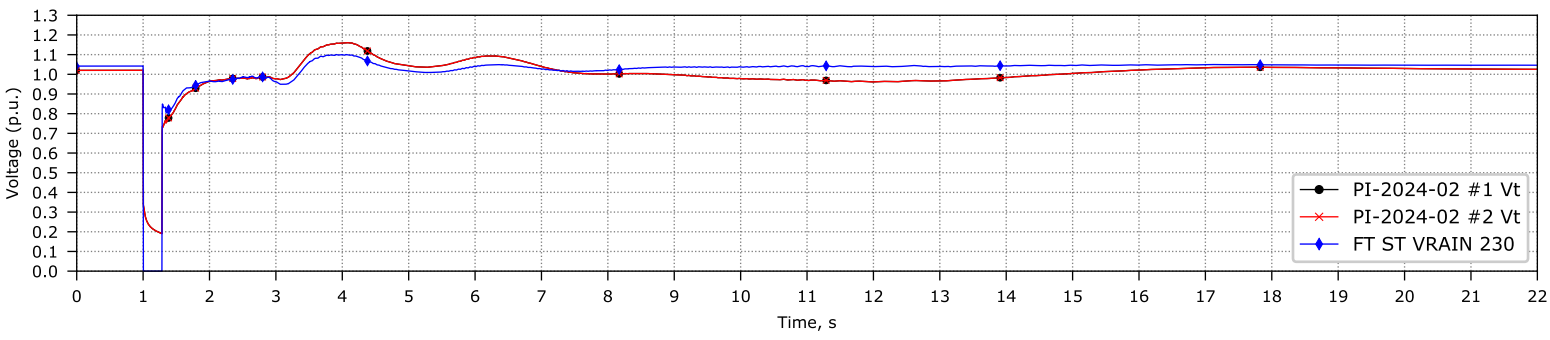
12_P4-line_214

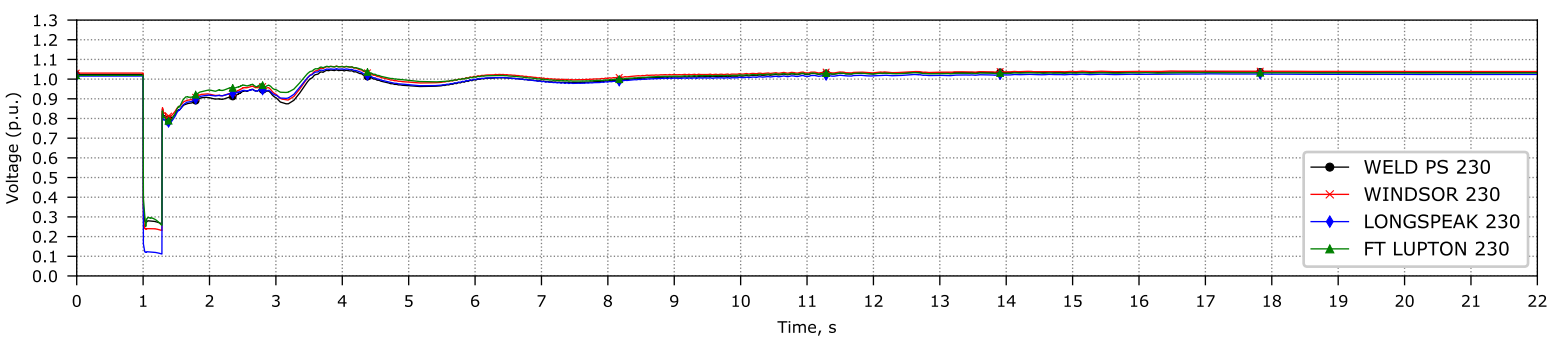


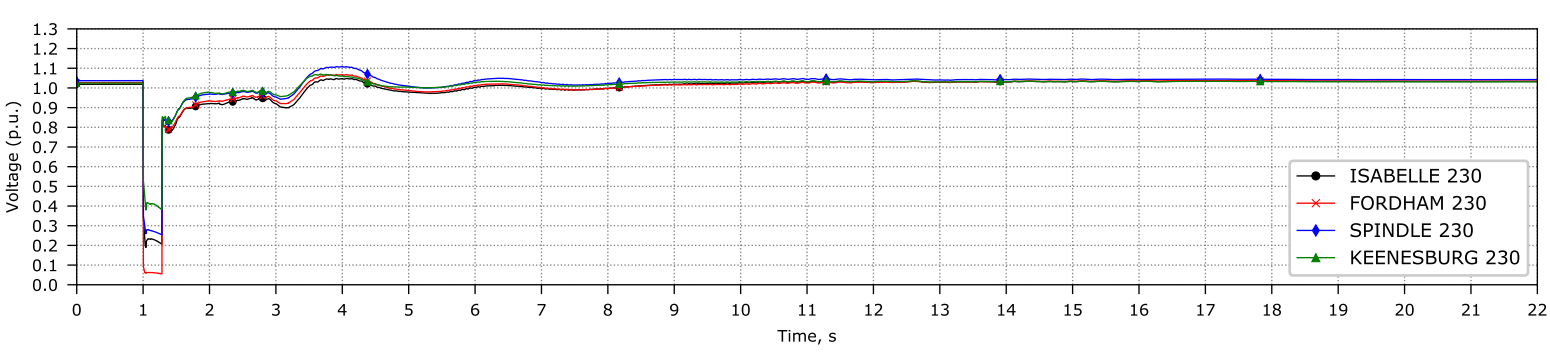


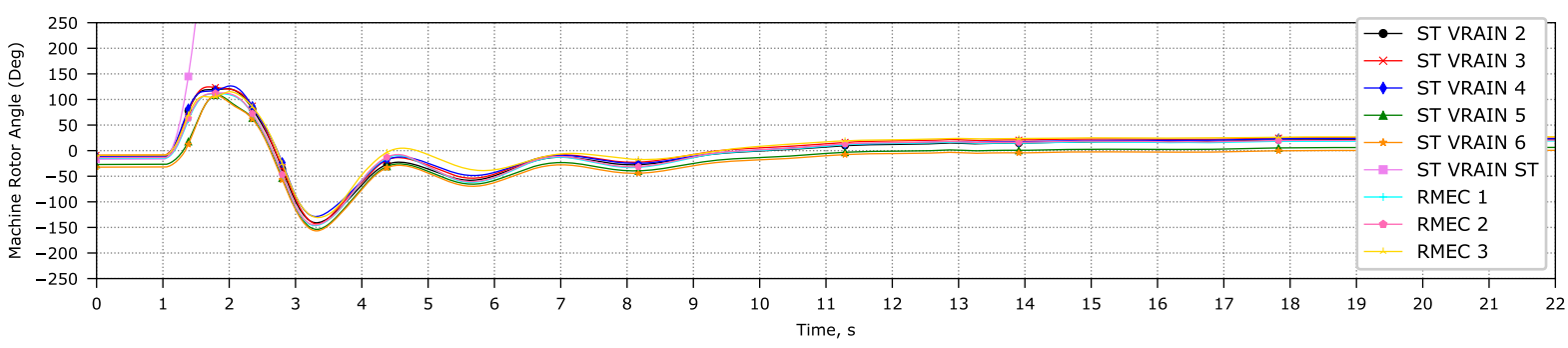


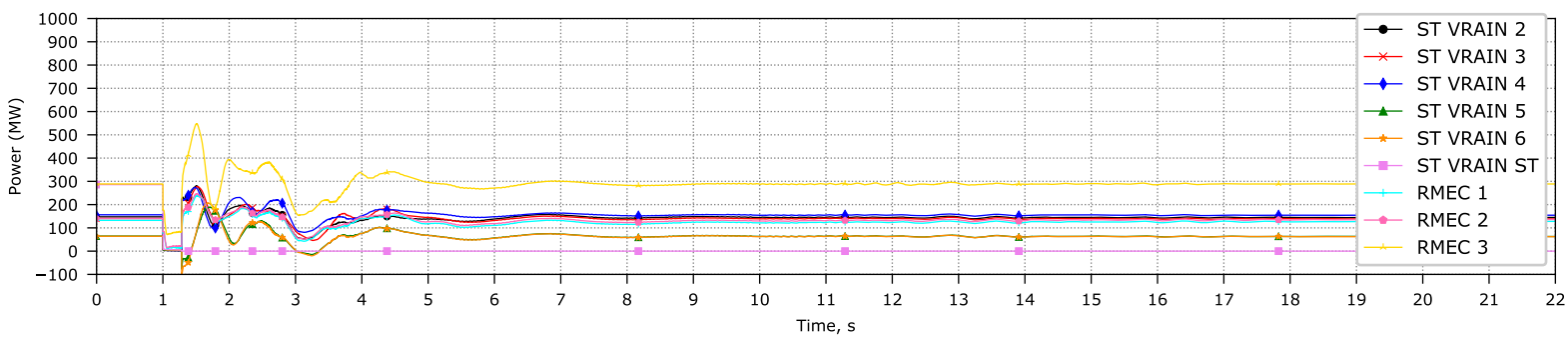




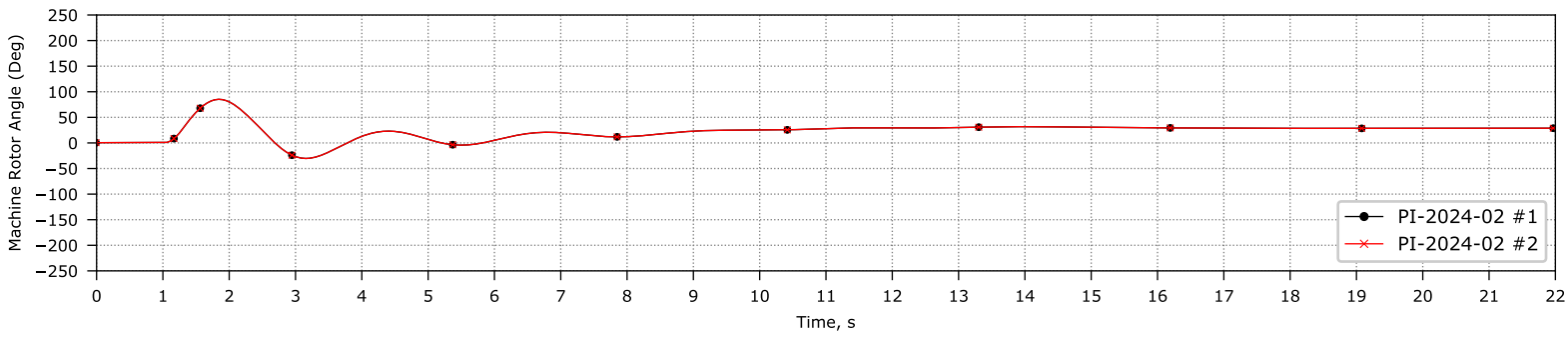


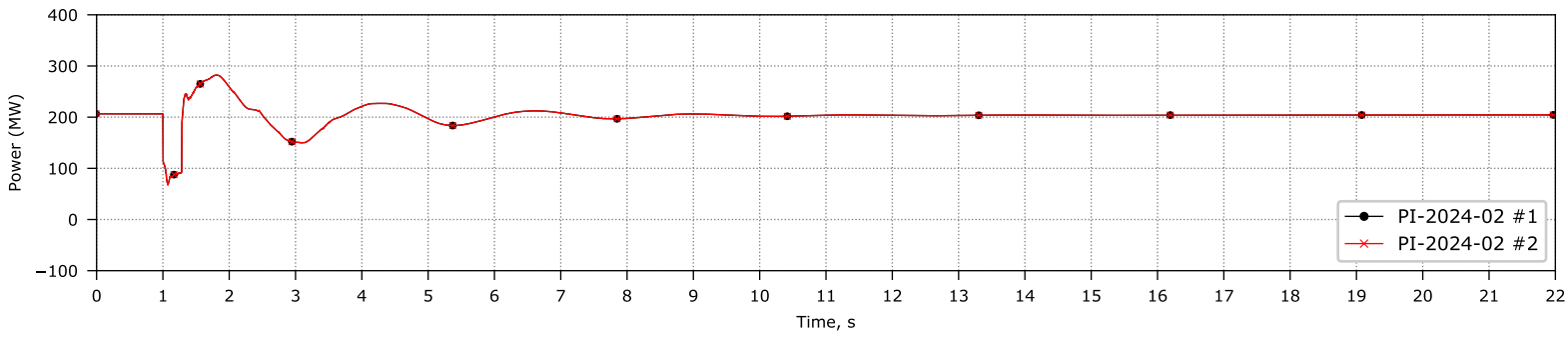


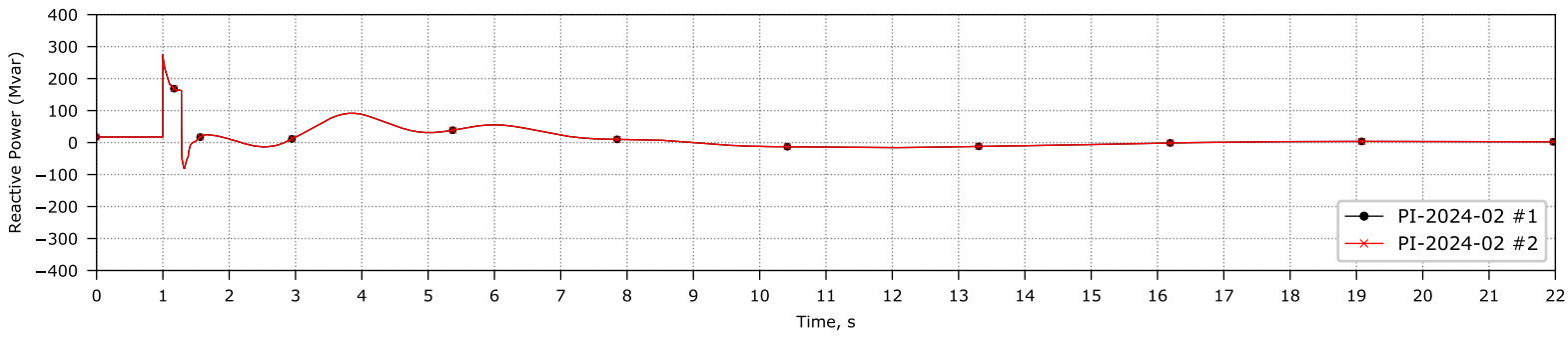


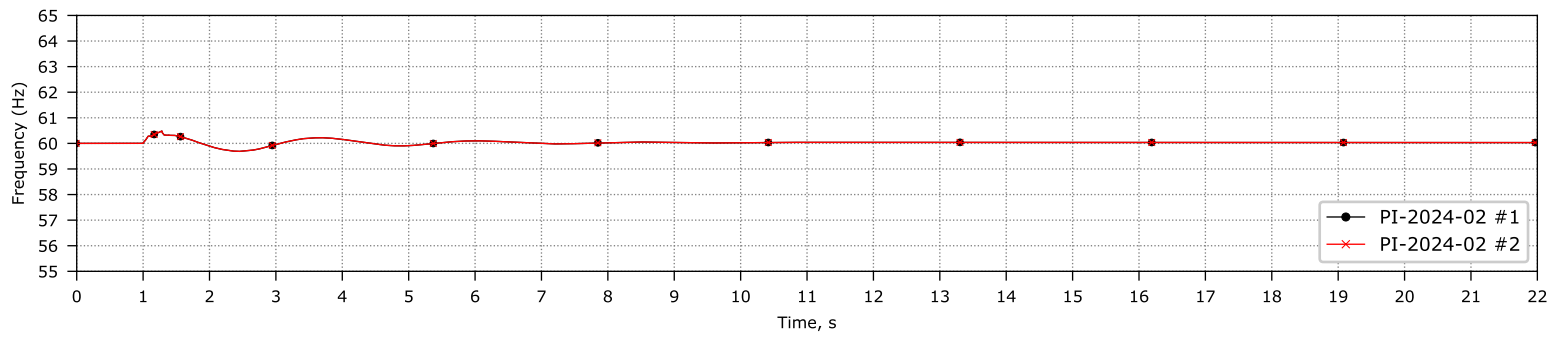


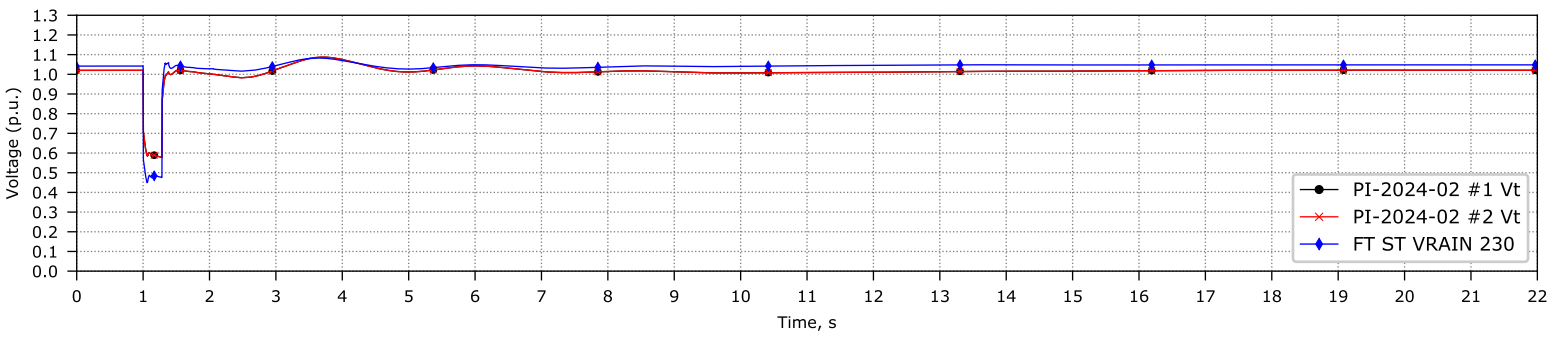
13_P4-line_215

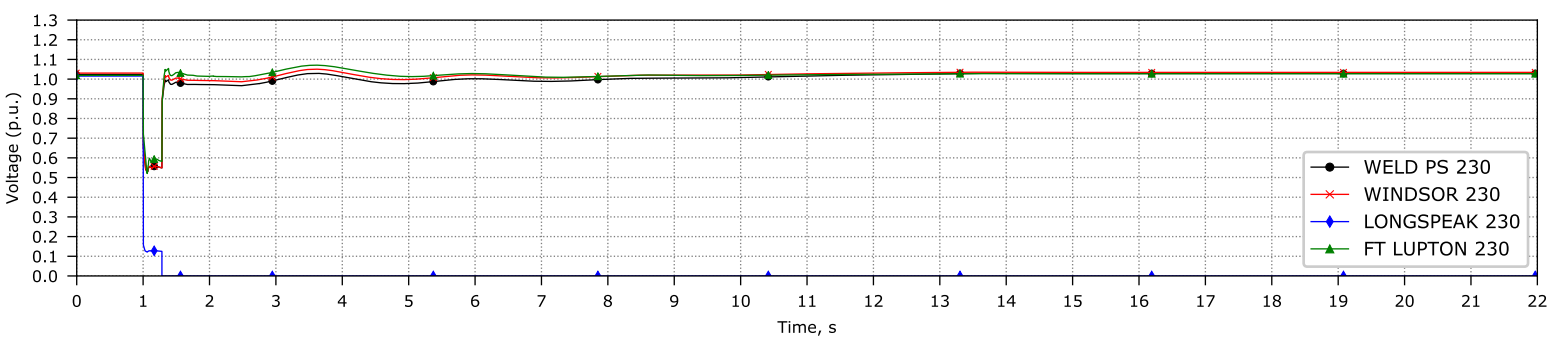


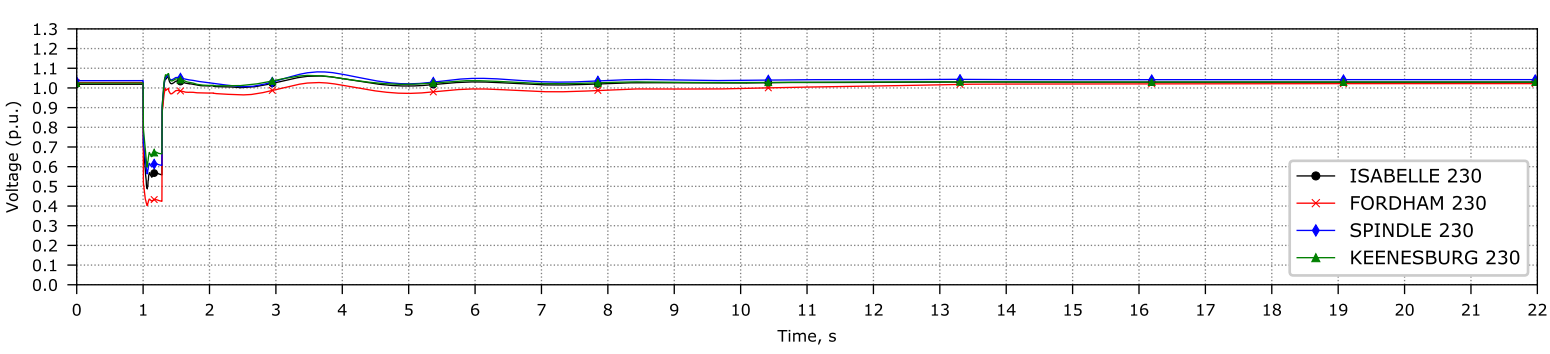


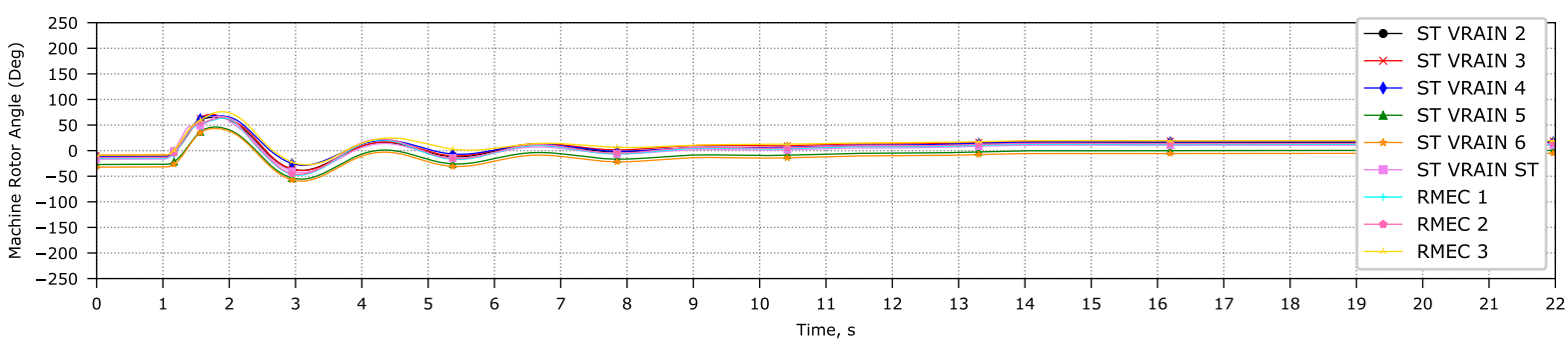


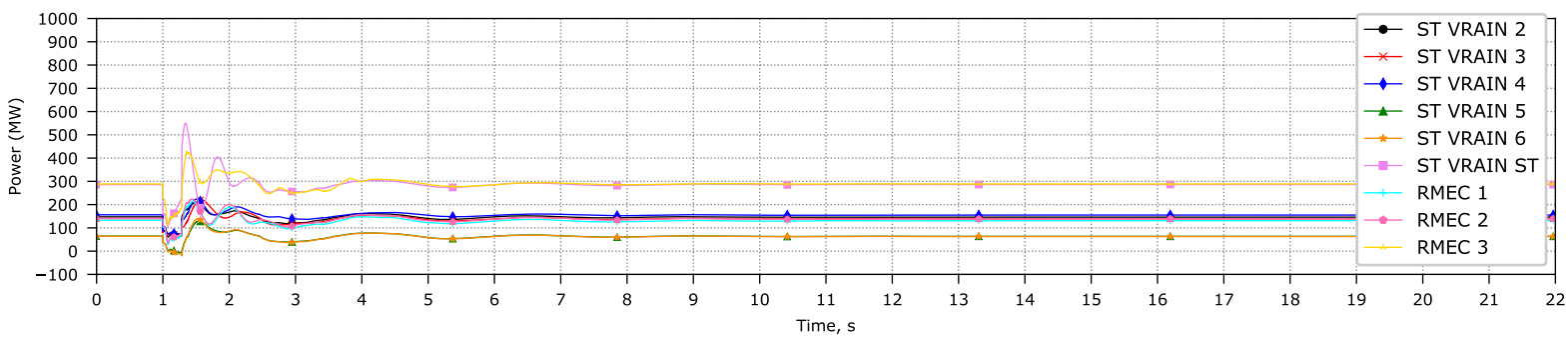




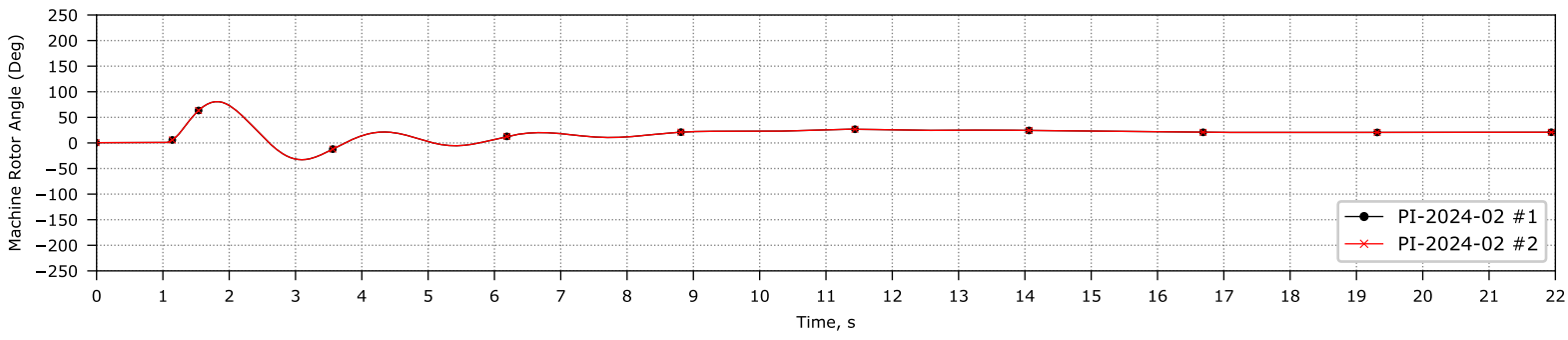


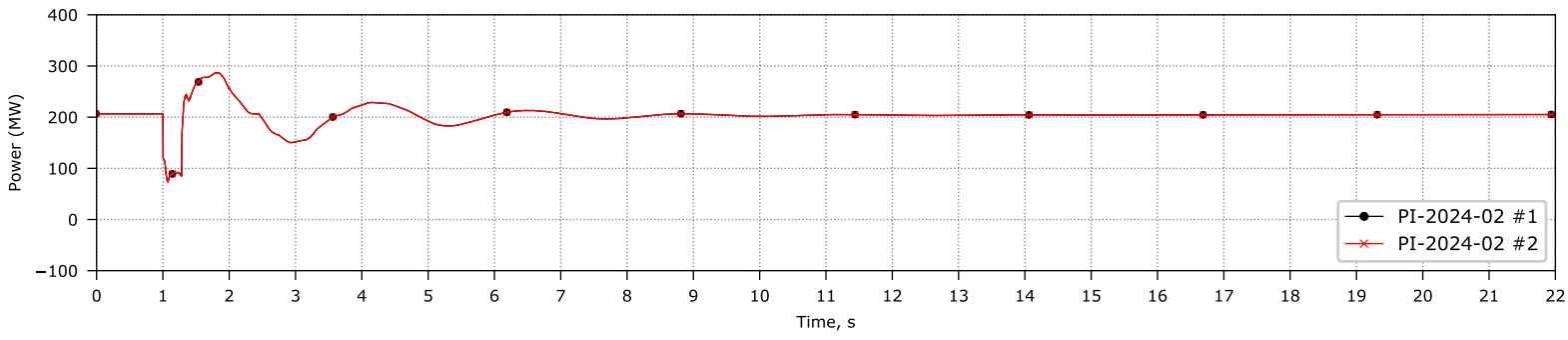


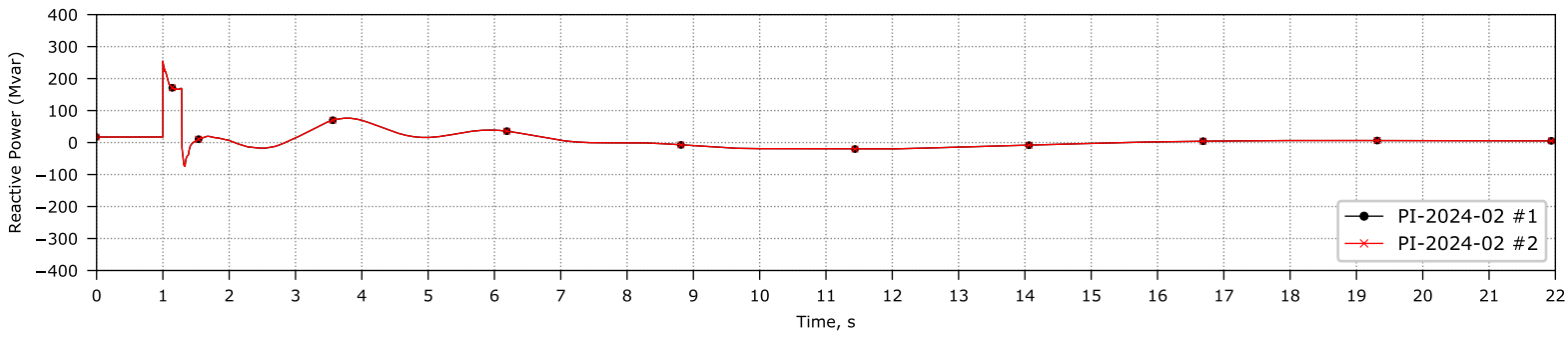


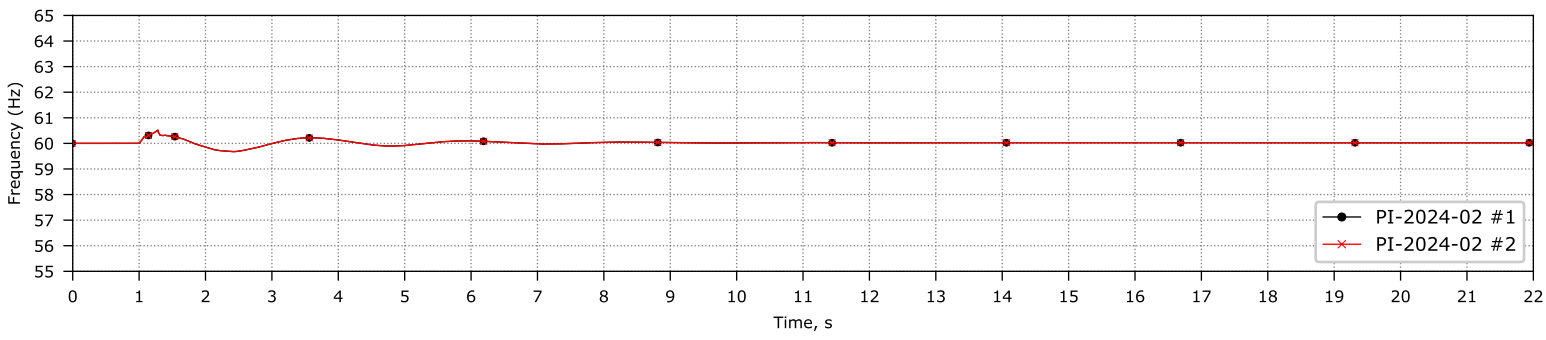


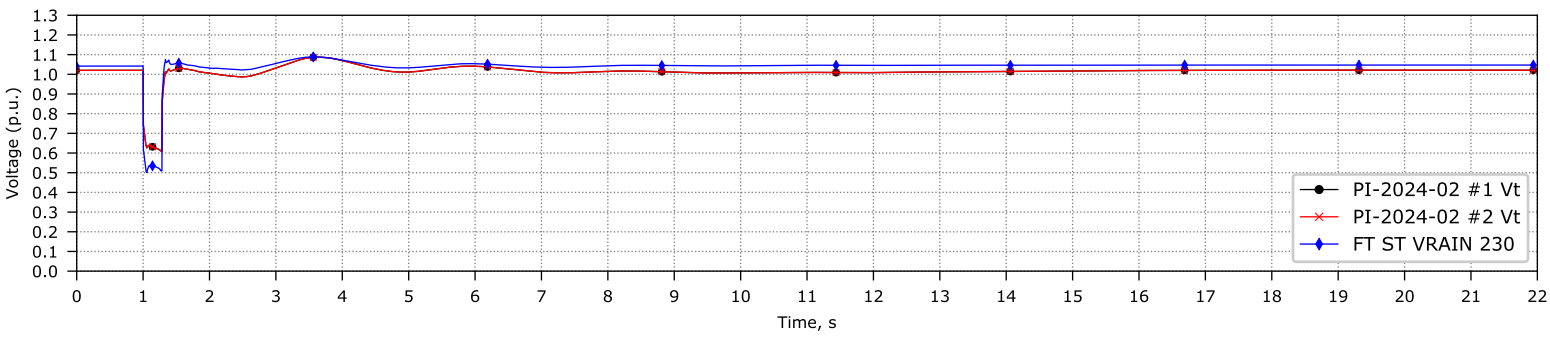
14_P4-line_216

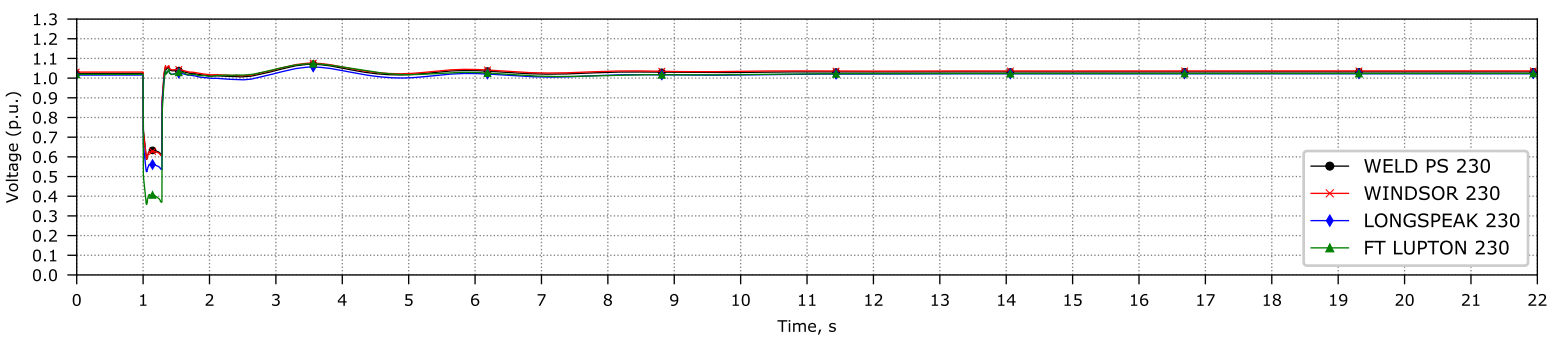


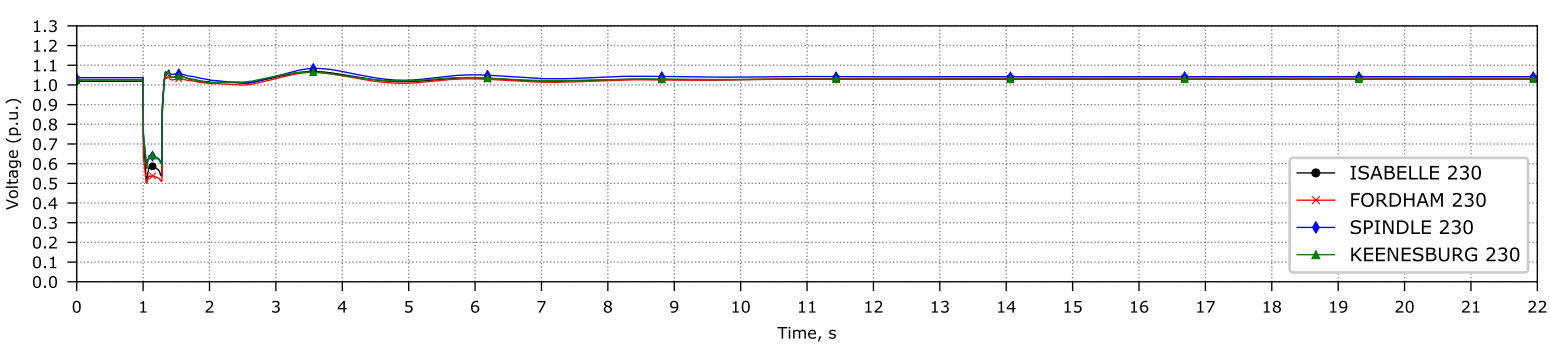


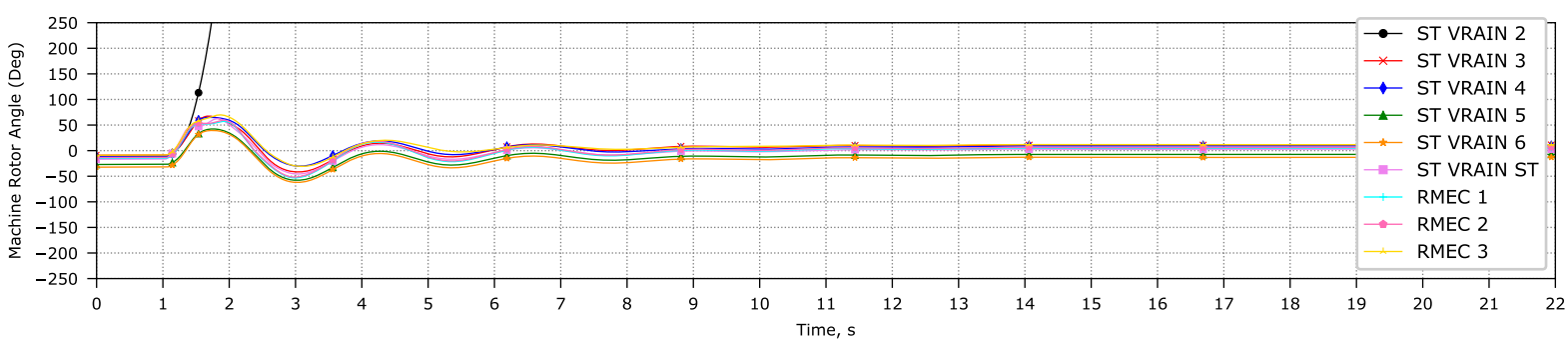


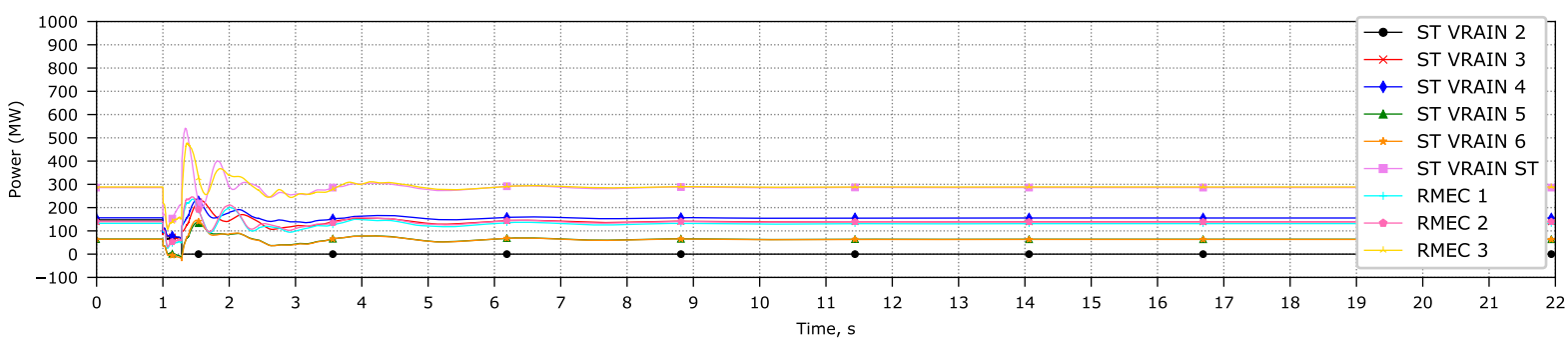




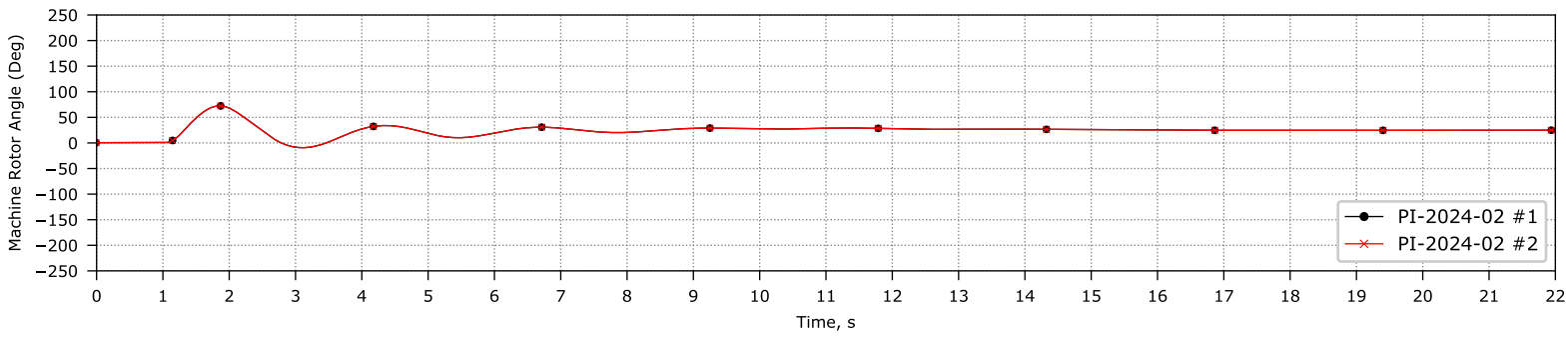


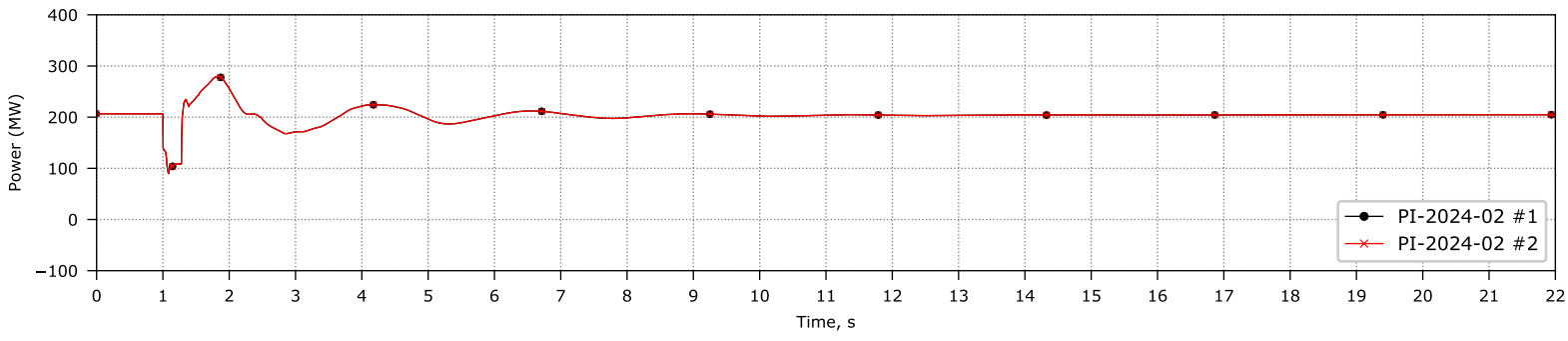


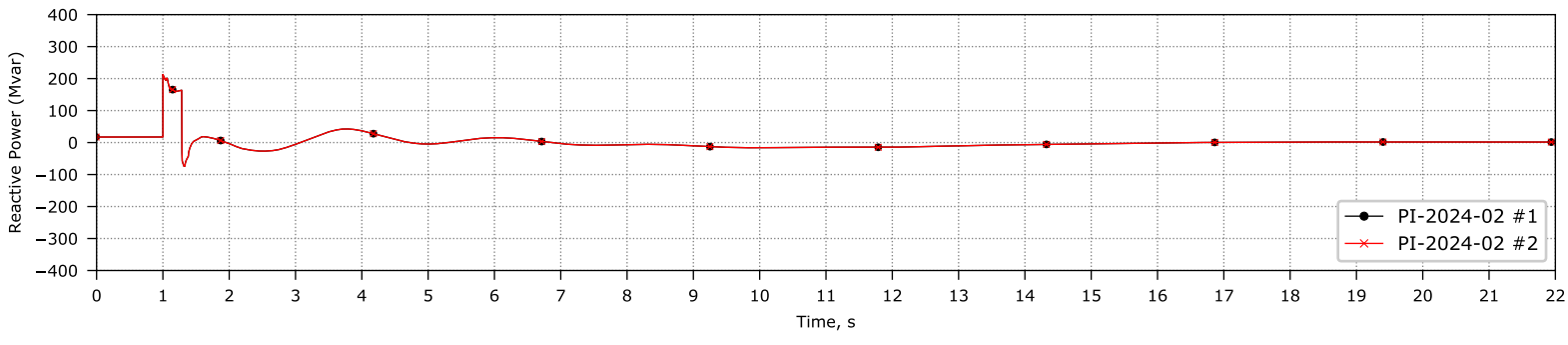


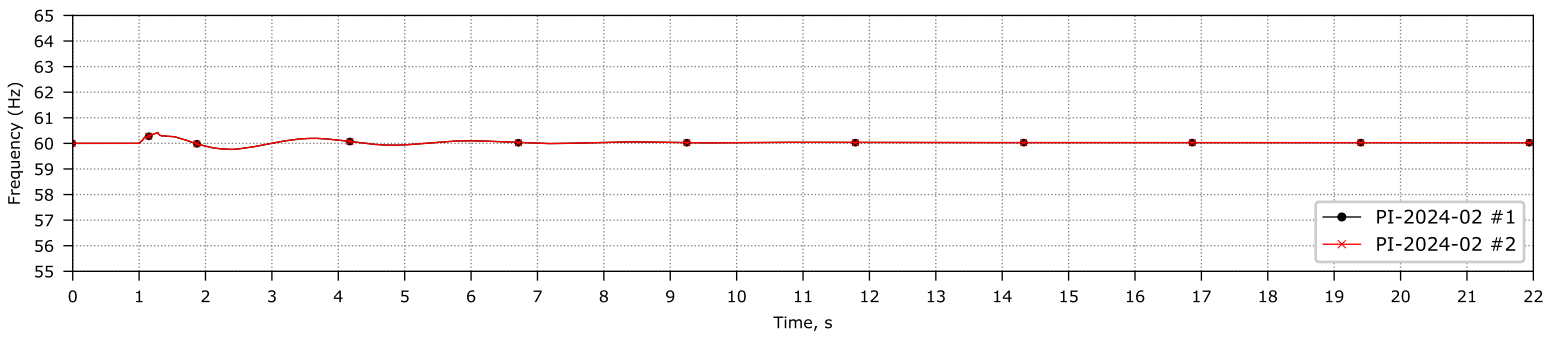


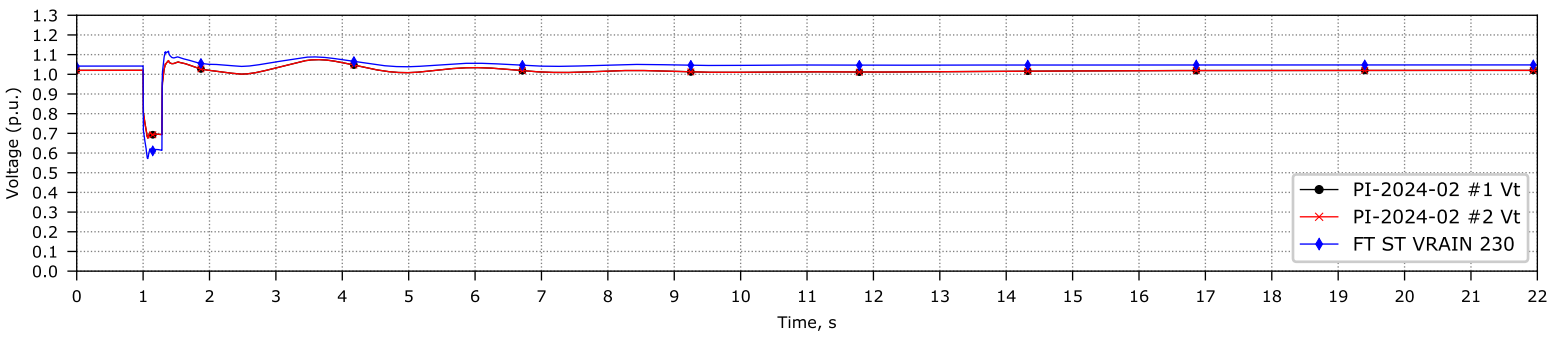
15_P4-line_217

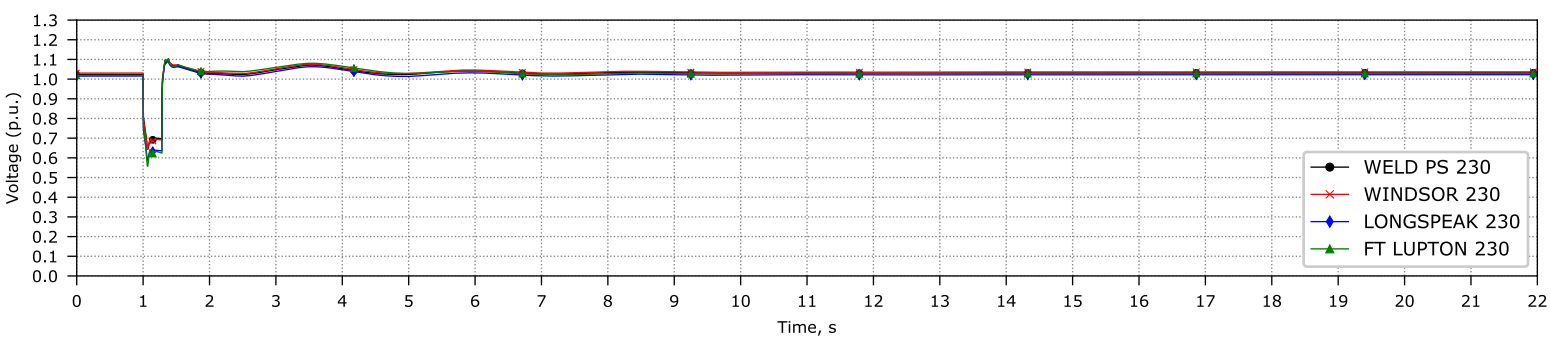


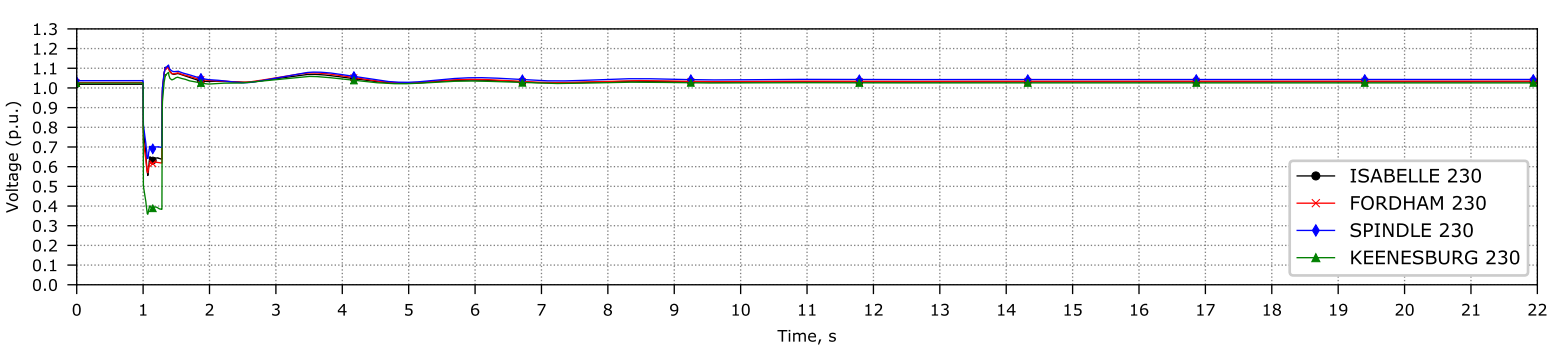


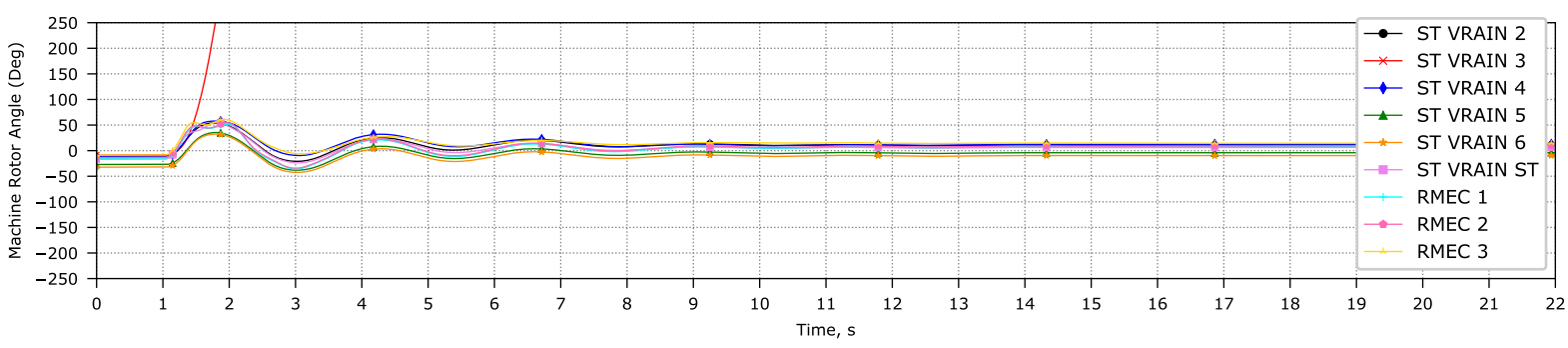


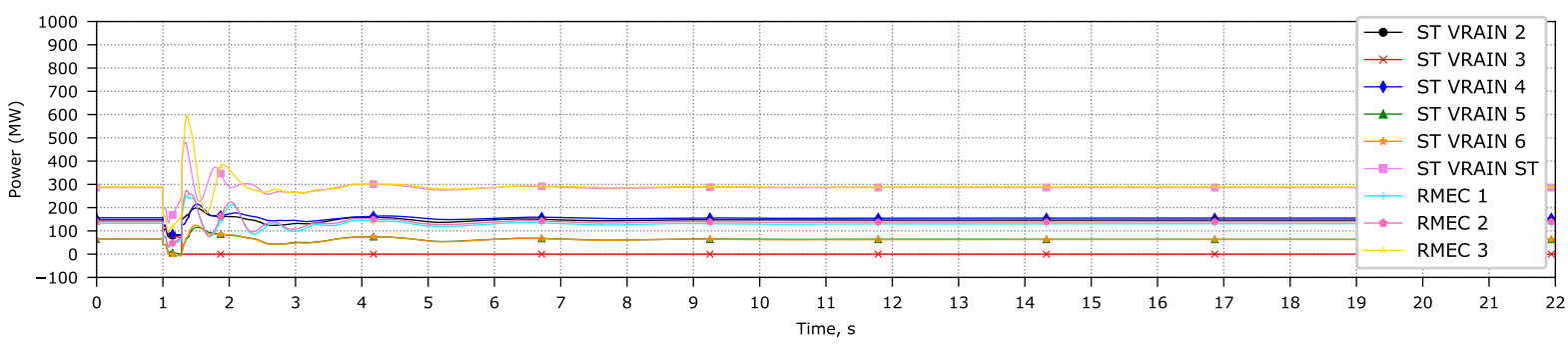




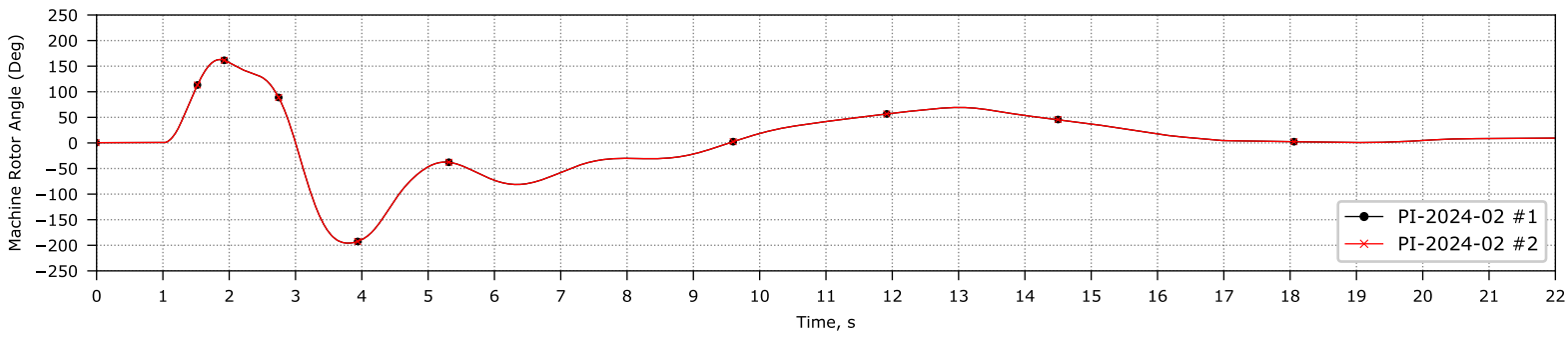


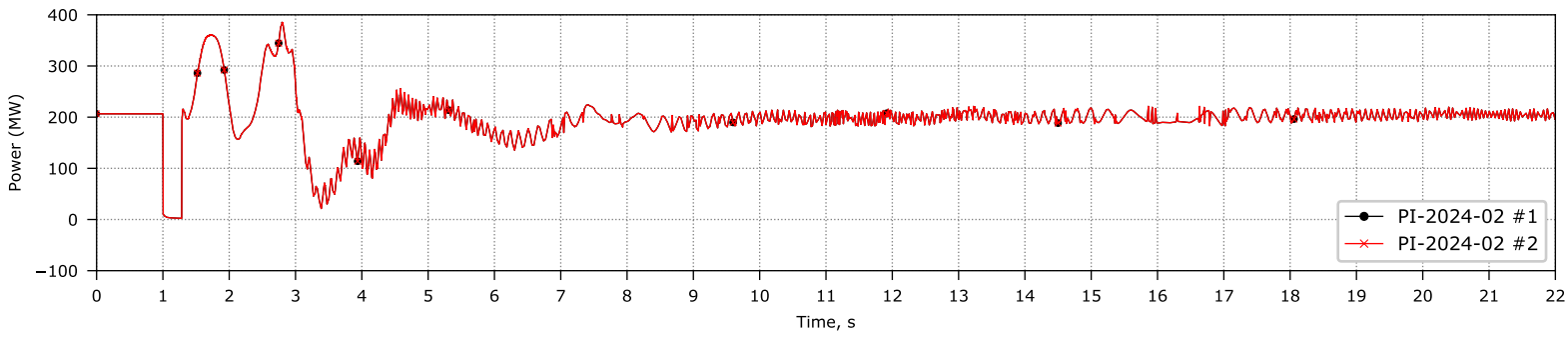


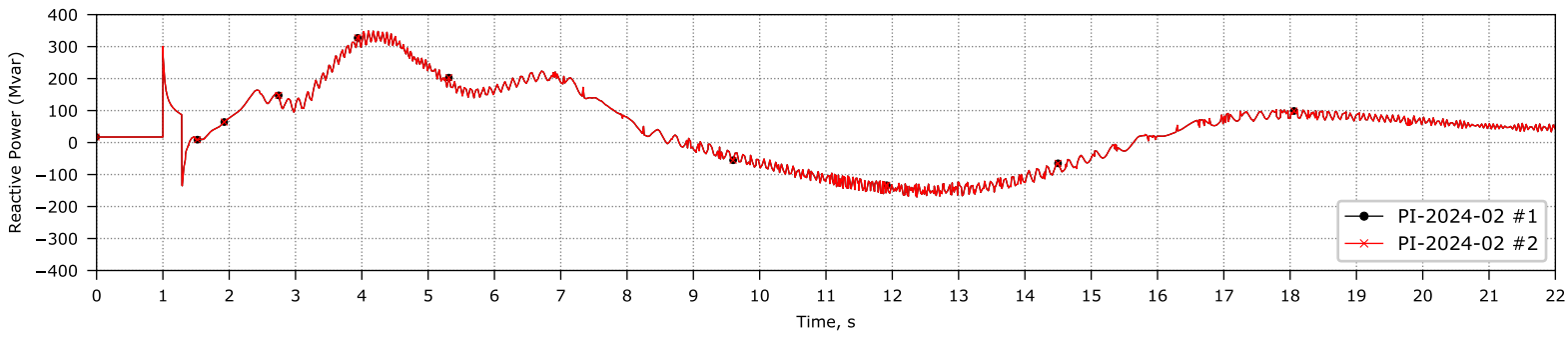


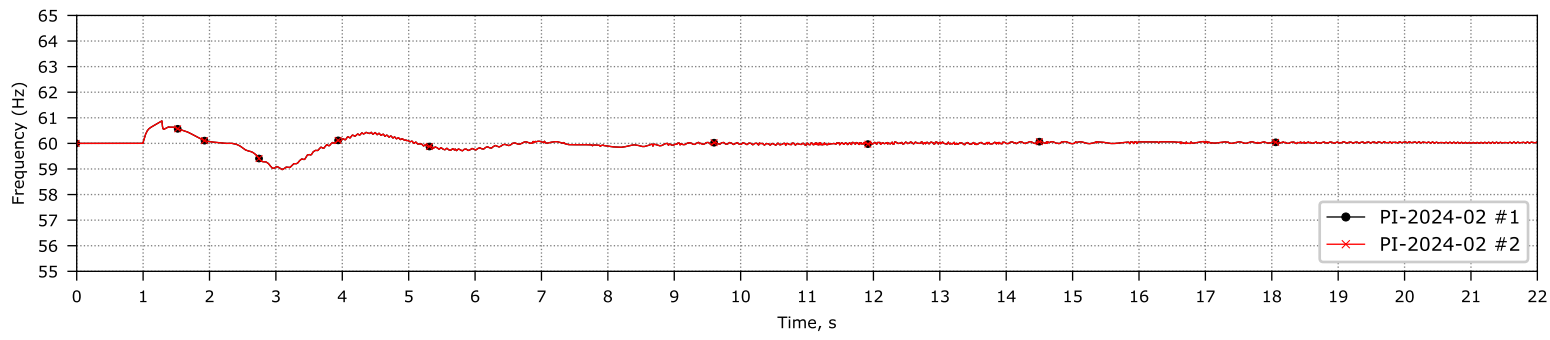


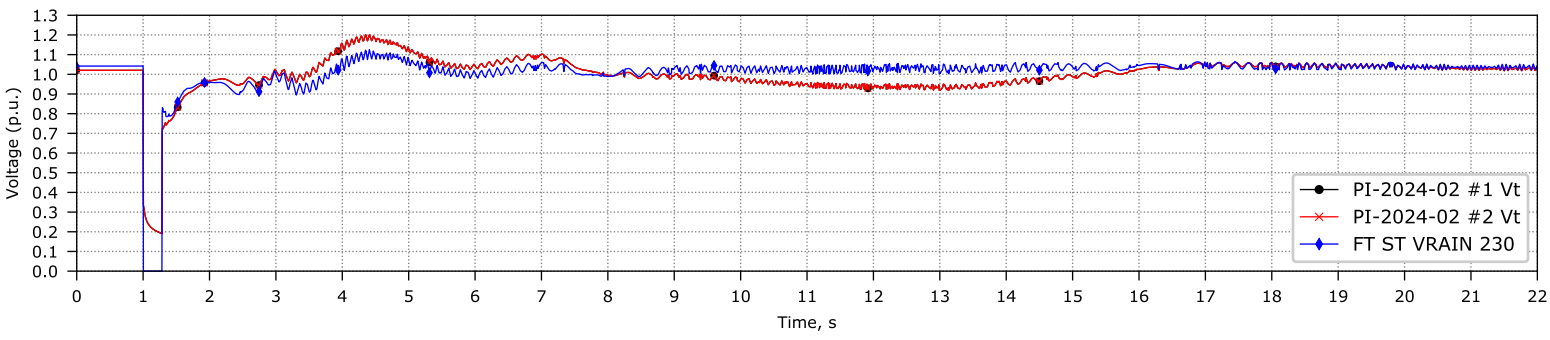
16_P4-line_218

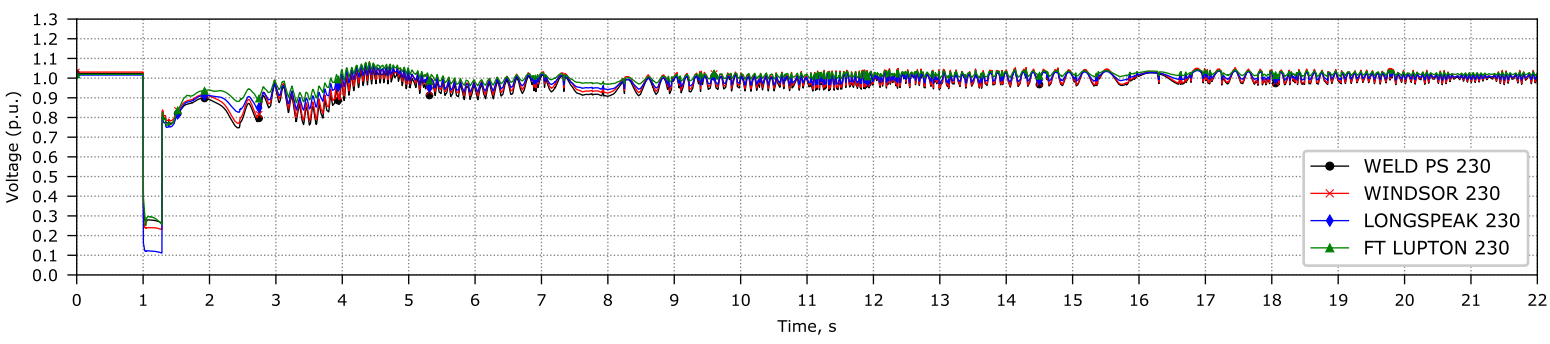


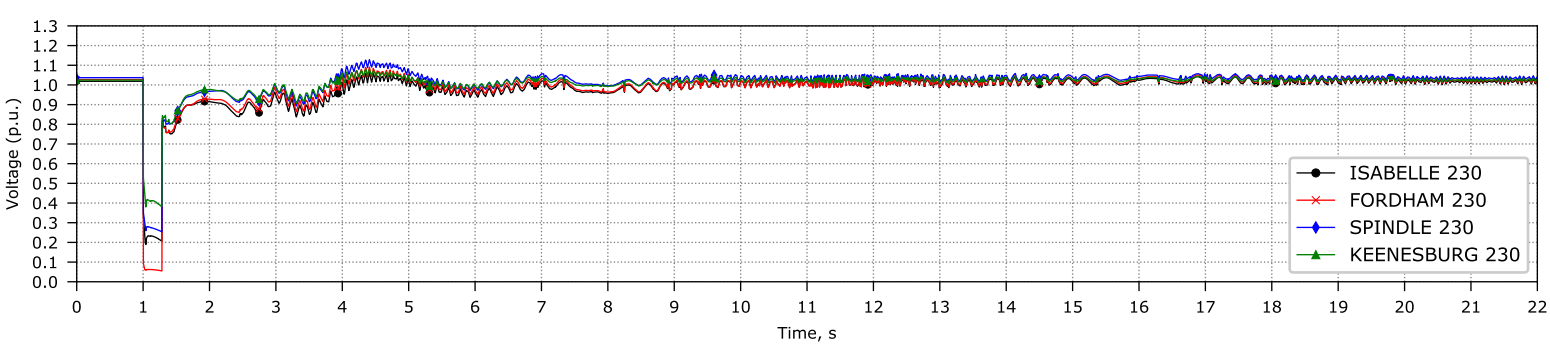


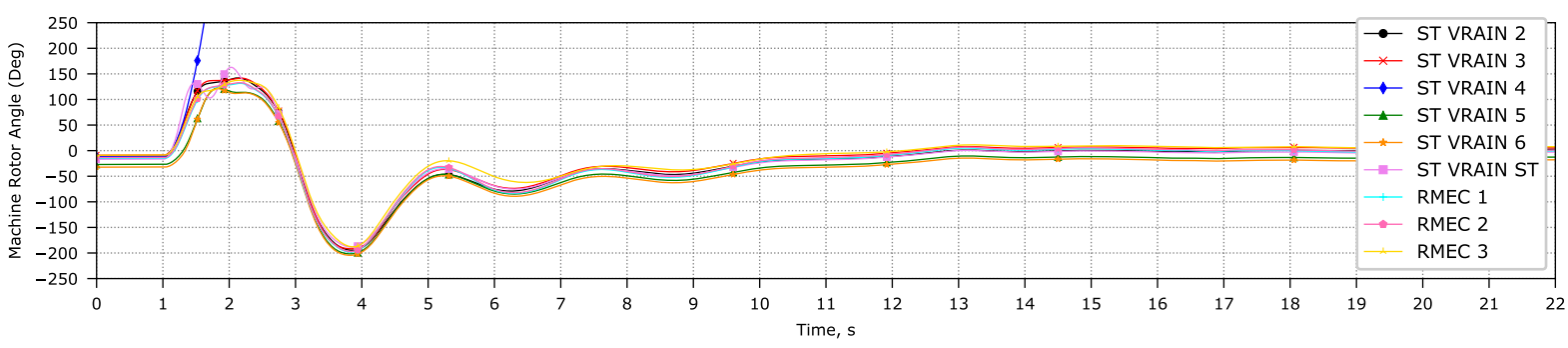


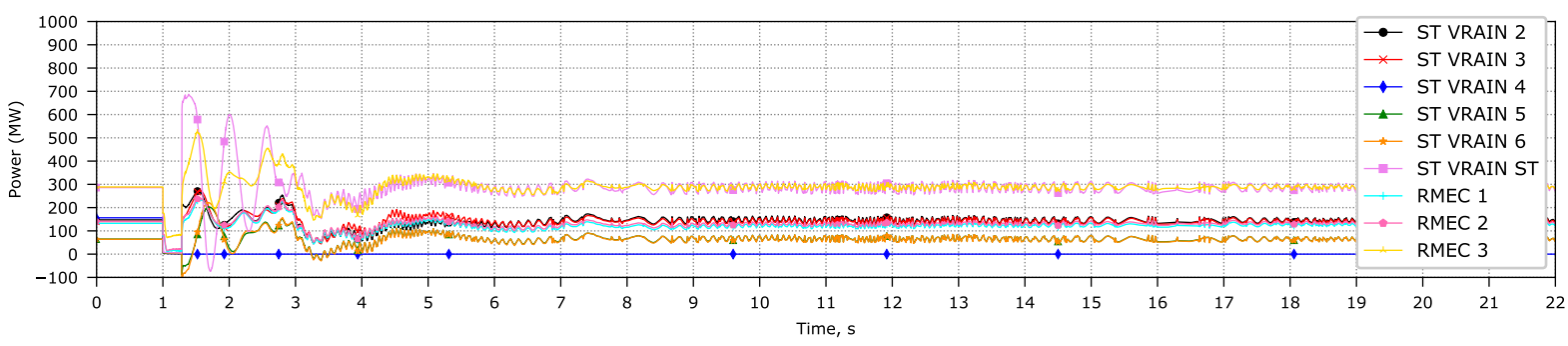




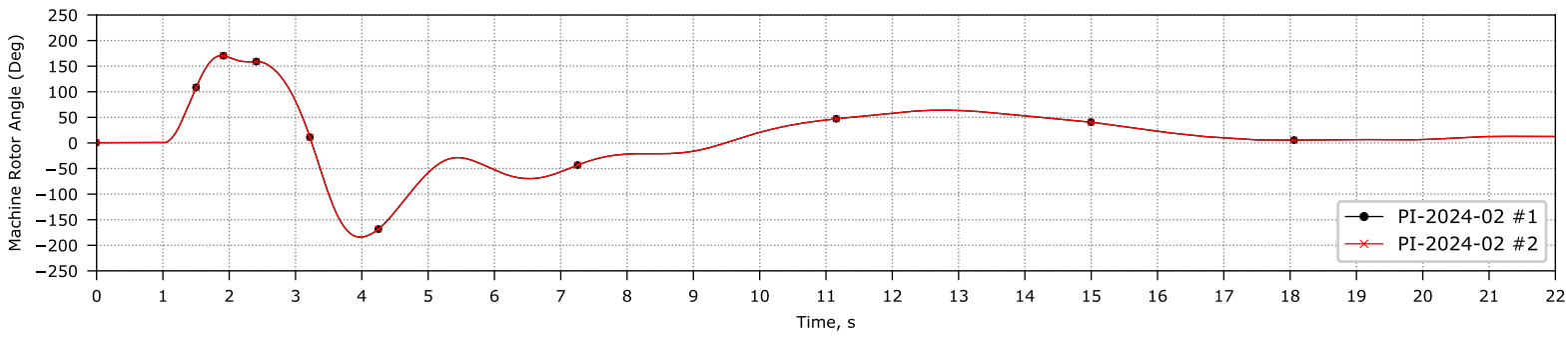


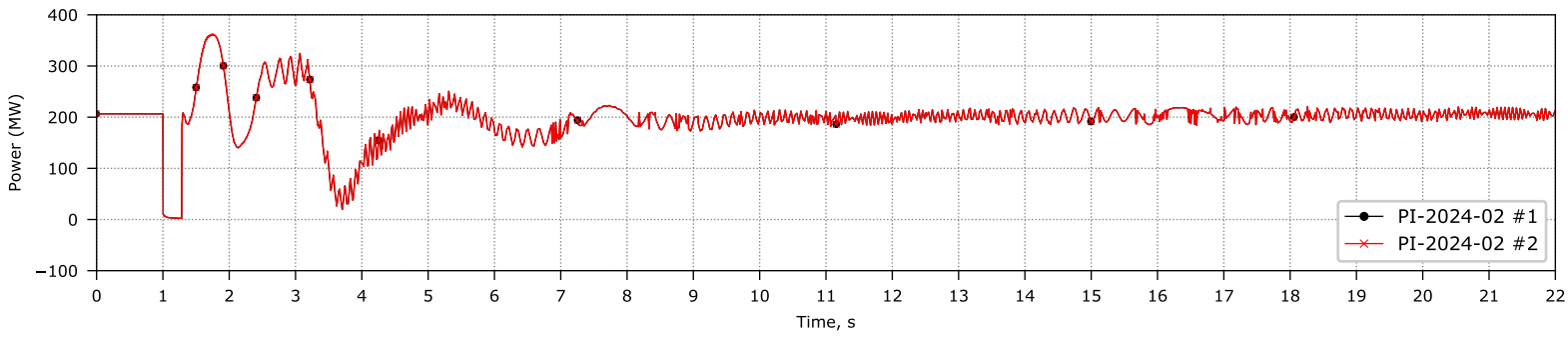


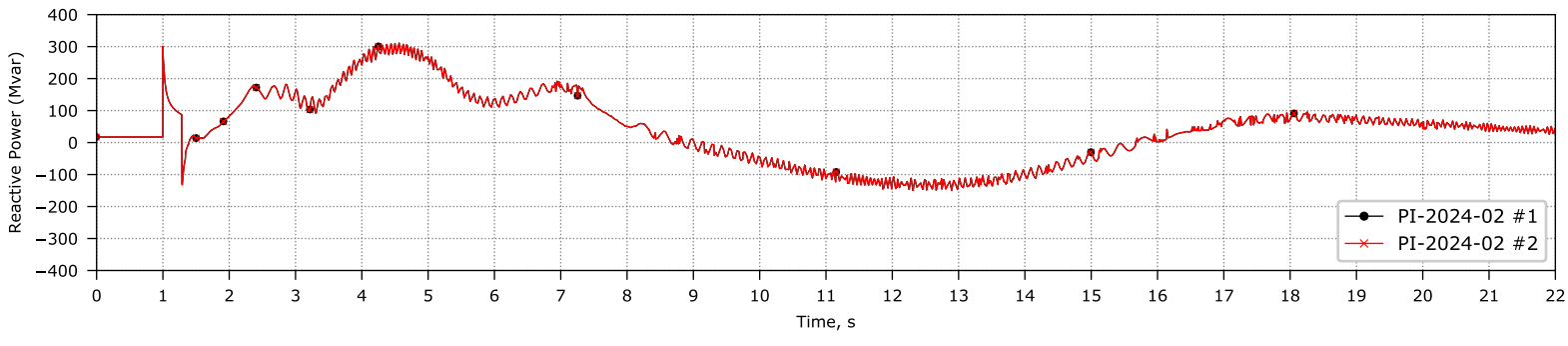


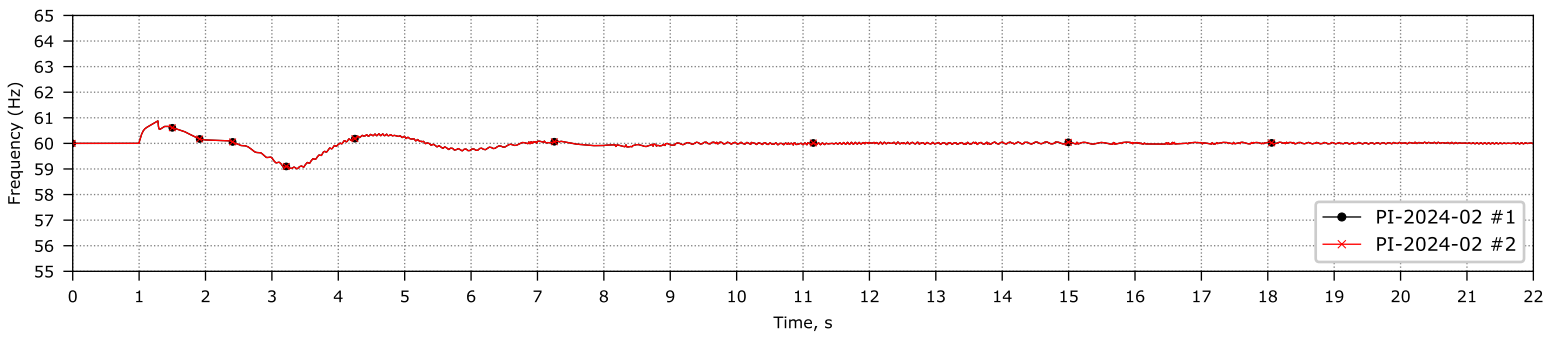


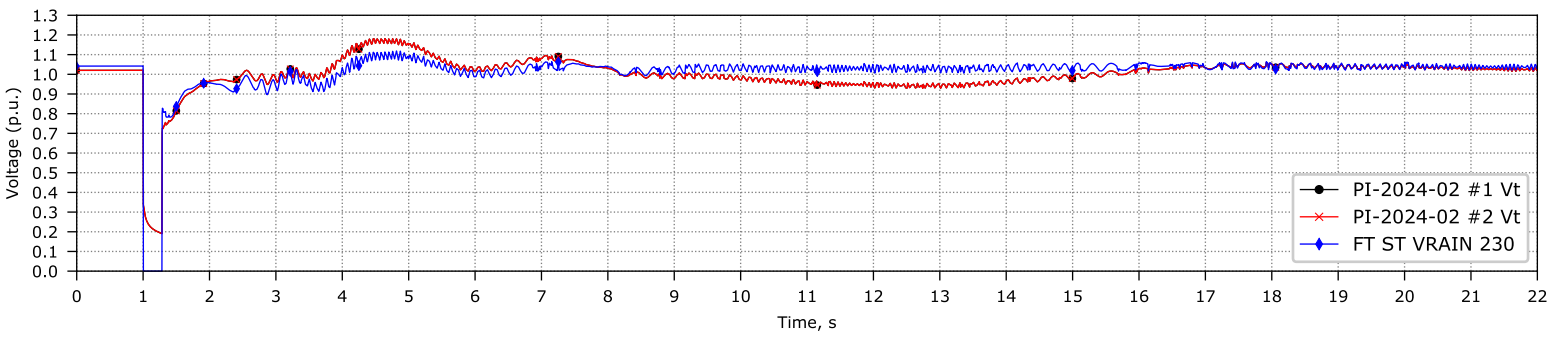
17_P4-line_219

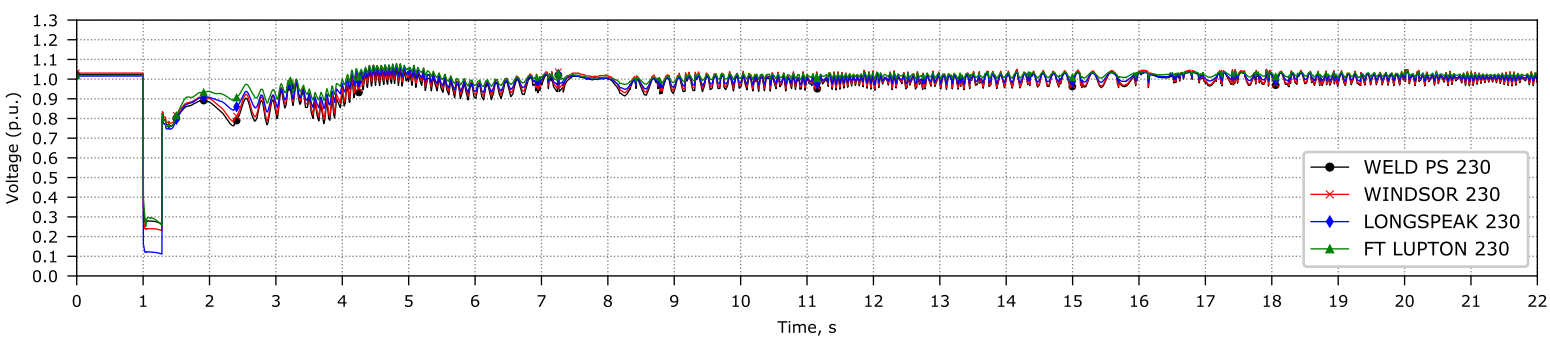


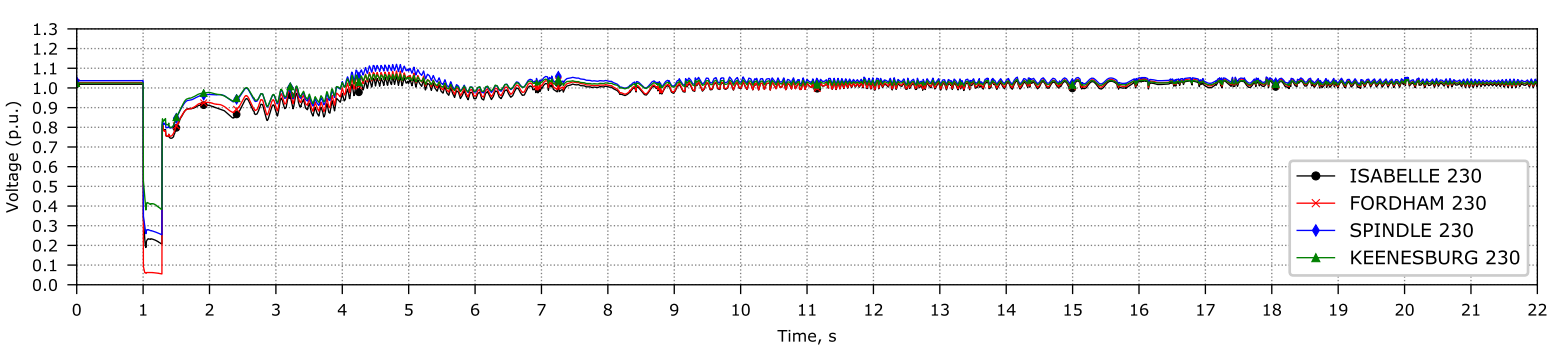


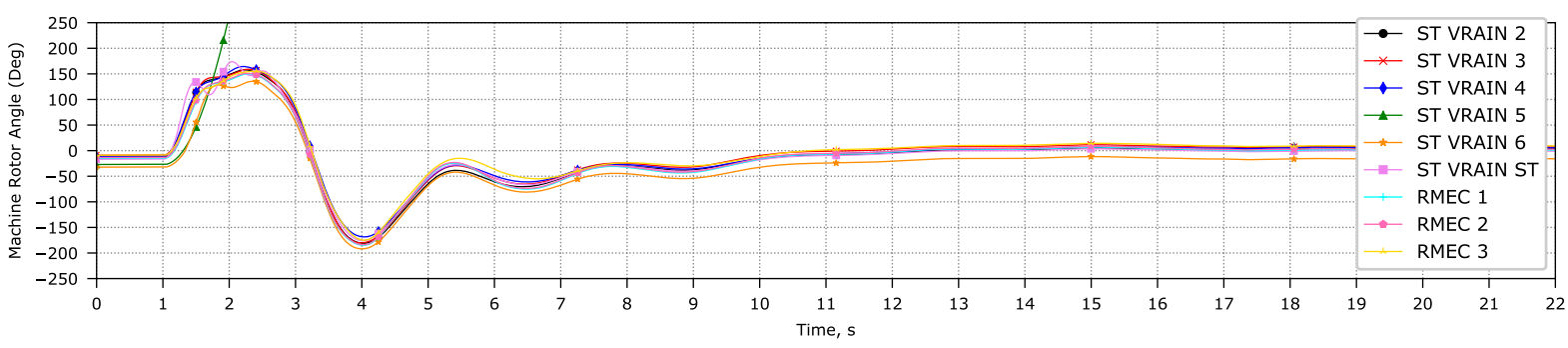


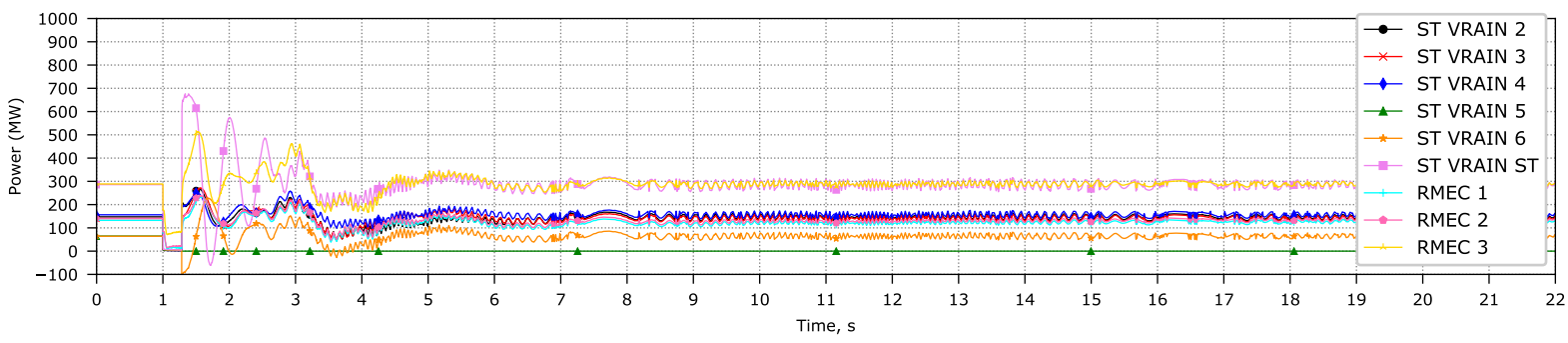




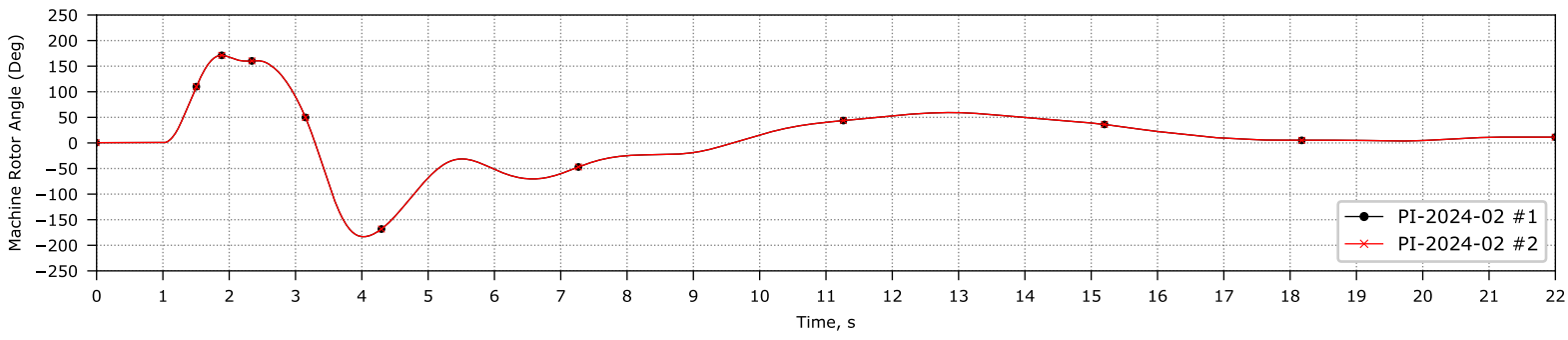


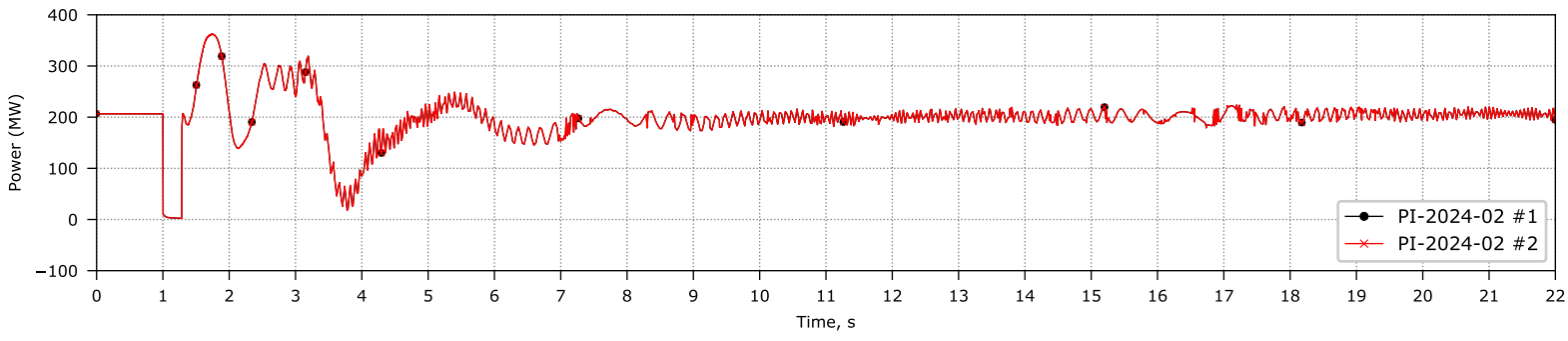


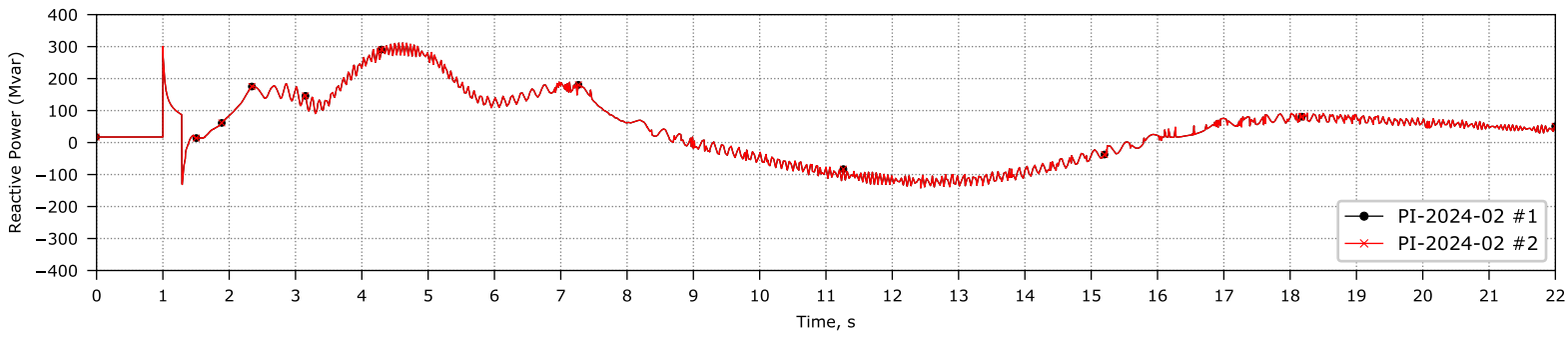


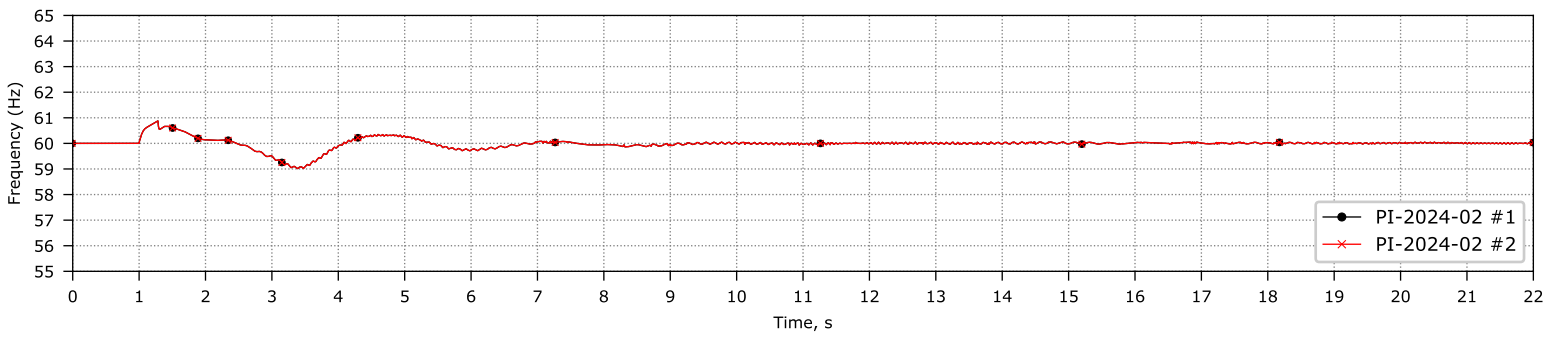


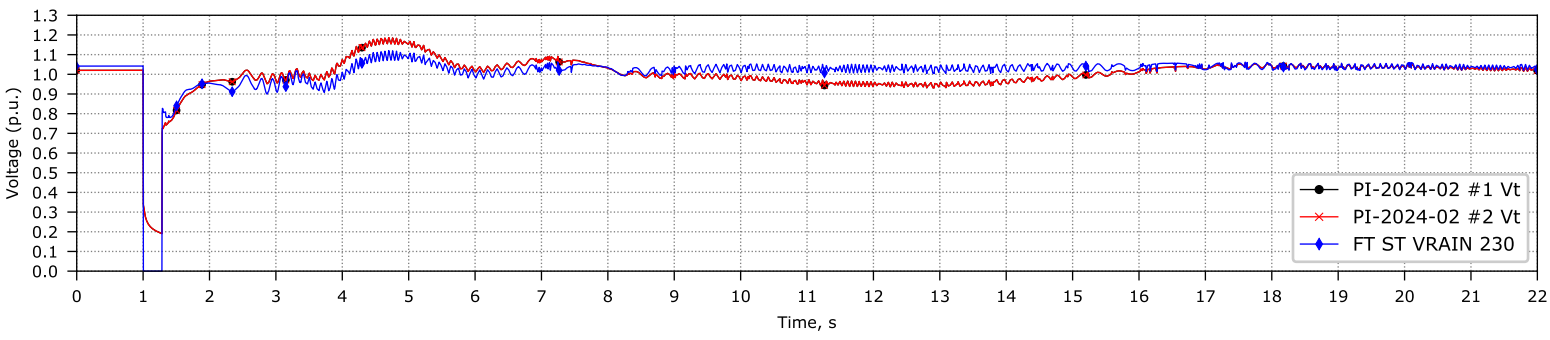
18_P4-line_220

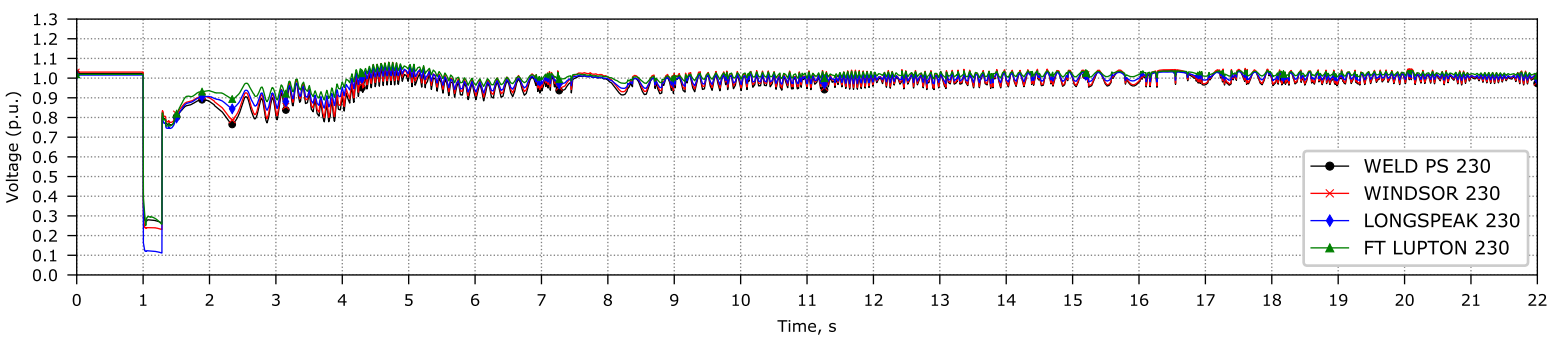


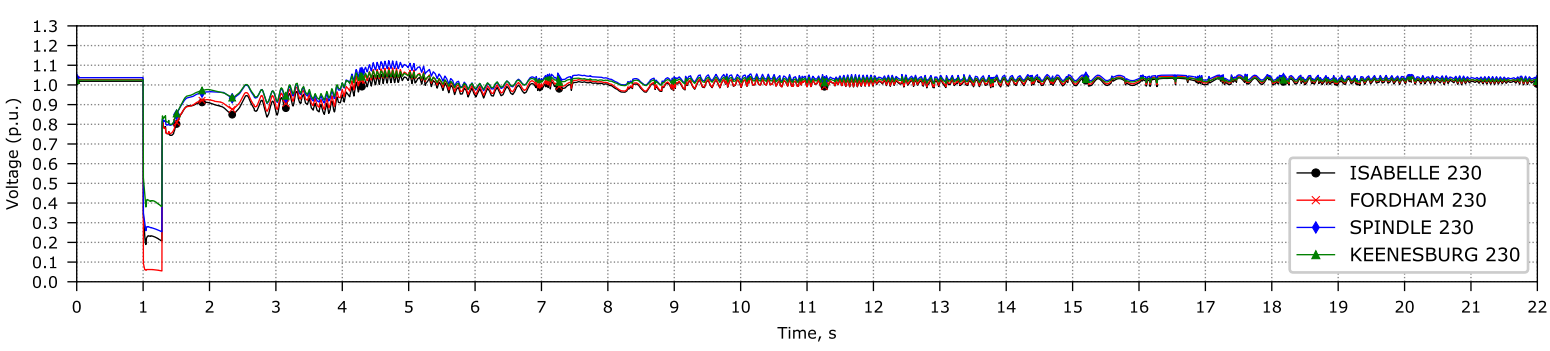


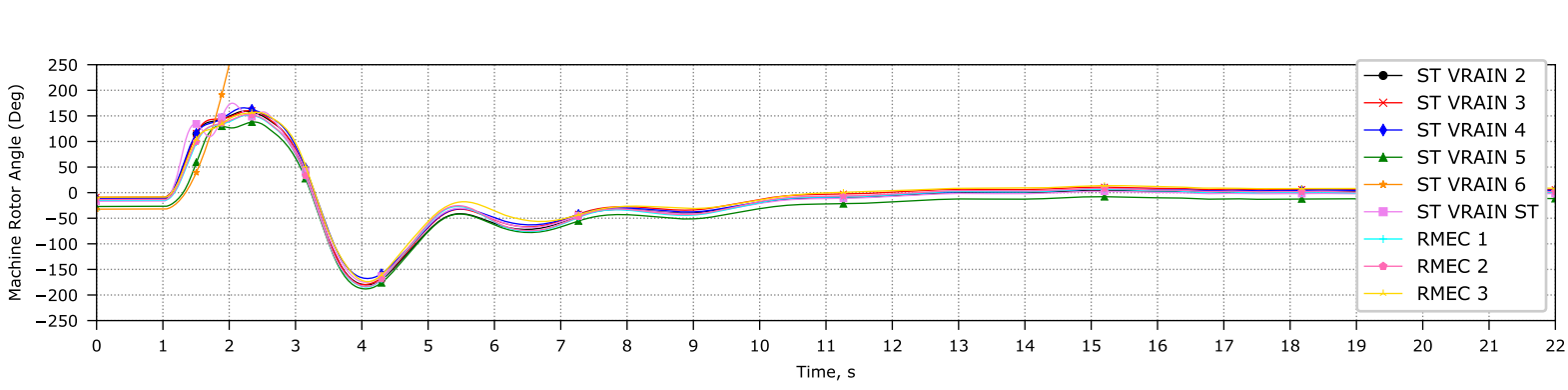


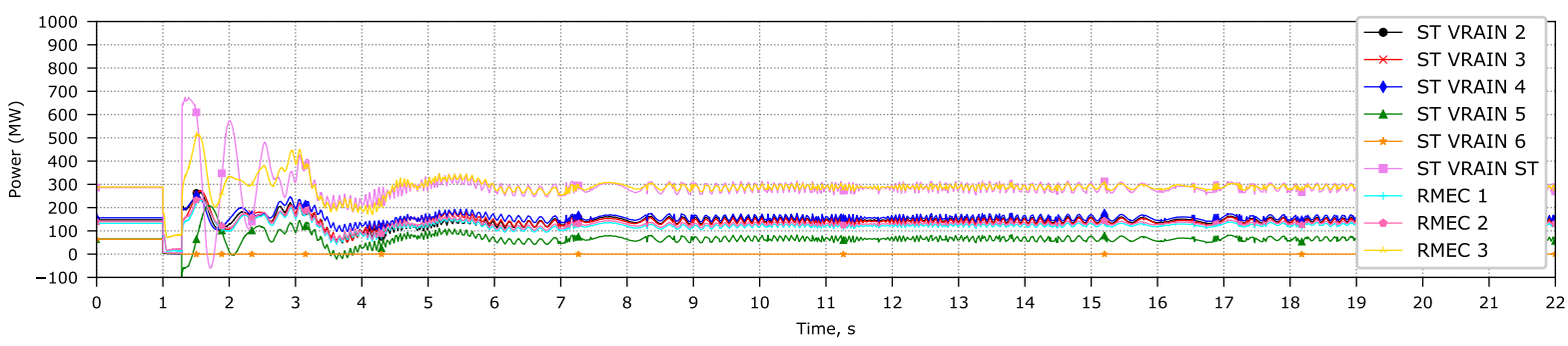












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