Development of a Rail Traction System Load model to Test Planned FACTS Devices on the Catenary Network

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Overview

- The single-phase 25kV catenary network of a European railway network required voltage support
- Two single-phase STATCOMs were to be installed
- The STACOM controllers required controller hardware-in-the loop testing.
- Catenary network and electrical load of the train were modeled in detail on RSCAD

Catenary Network

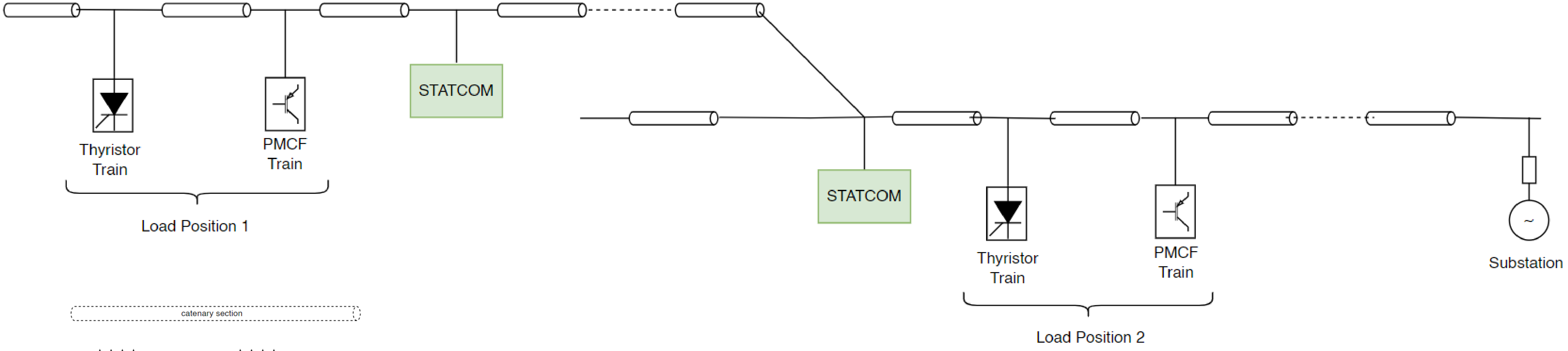


Figure 1: Example catenary network

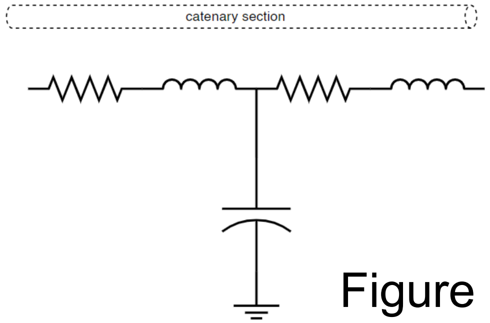


Figure 2: Catenary segment model

Testing Procedure

- Different network configurations were specified.
  - Different loads at each load position
- All train loads to be accelerated and decelerated simultaneously while the STATCOMs are in service

Test Configuration Example

Position	Load Type	No. of Units
1	Thyristor	3
	PMCF	1 of 8 PMCF
2	Thyristor	5
	PMCF	1 of 8 PMCF
3	Thyristor	0
	PMCF	2 of 8 PMCF
4	Thyristor	5
	PMCF	1 of 8 PMCF and 2 of 12 PMCF
5	Thyristor	10
	PMCF	5 of 8 PMCF
6	Thyristor	0
	PMCF	1 of 8 PMCF
7	Thyristor	0
	PMCF	4 of 8 PMCF

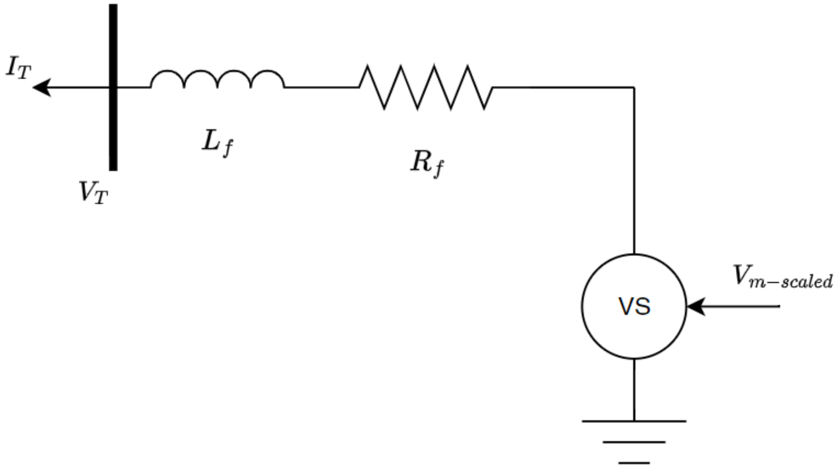
Train Load Models

- Two types of train load models were to be considered:
  - Thyristor-based train load (not within TGS Scope)
  - Single-phase inverter-based train load (PMCF)

- Loads must be scalable
  - Different load configurations at different load positions on the catenary network
  - Scaling factor = No. of trains x No. of PMCF units

Single-Phase Inverter (PMCF) Train

AC Circuit



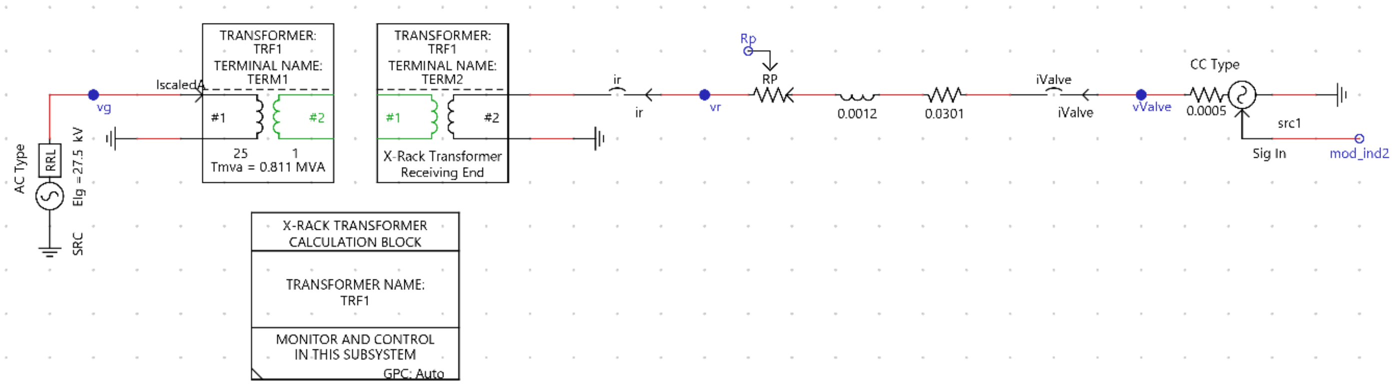


Figure 3: AC Side Circuit of PMCF Train

Single-Phase Inverter (PMCF) Train

DC Circuit

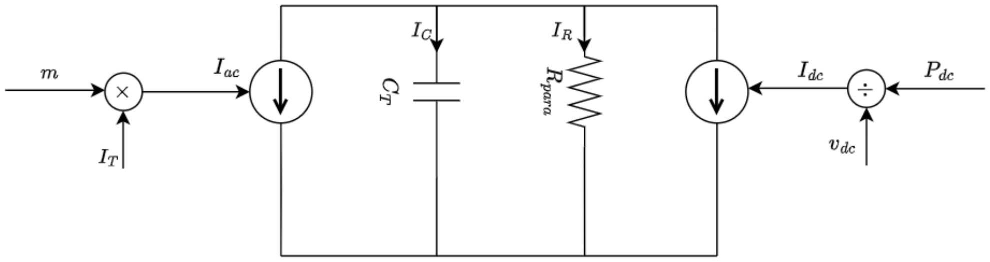


Figure 4: DC-side Circuit of PMCF Train

- Motor was not modeled
- Motor was emulated by DC power ramp-up and ramp-down
- Negative DC power represented regenerative breaking

Single-Phase Inverter (PMCF) Train

Controller

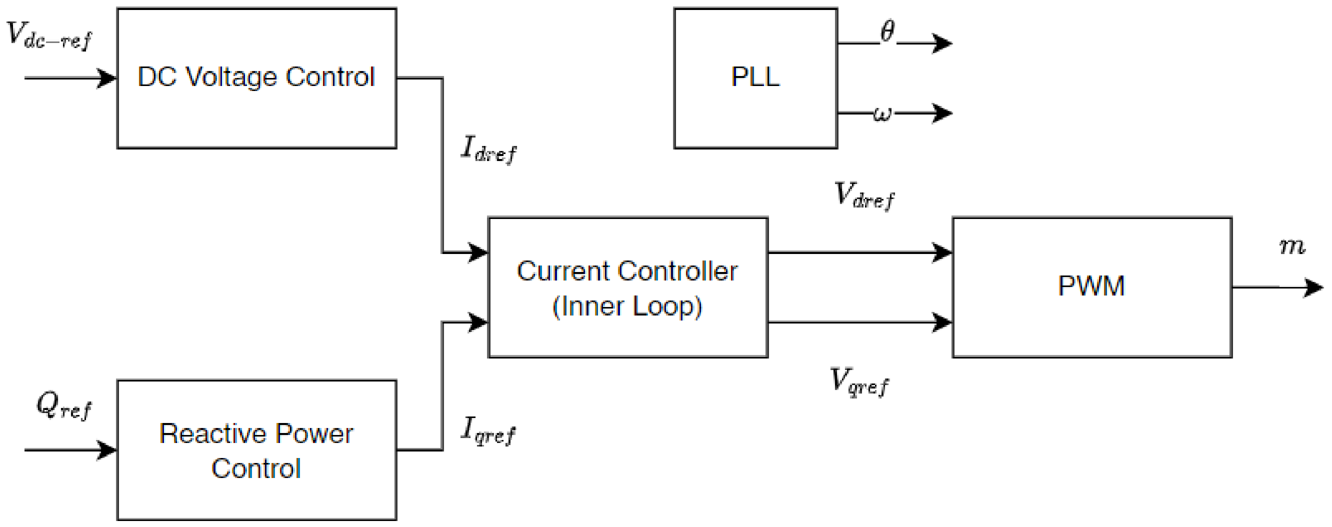


Figure 5: PMCF Controller Block Diagram

- Based on a Simulink model representing the aggregate PMCF load
- Deviations in the dynamic behavior due to the scaling transformer had to be mitigated by retuning the controller

Single-Phase Inverter (PMCF) Train

Runtime

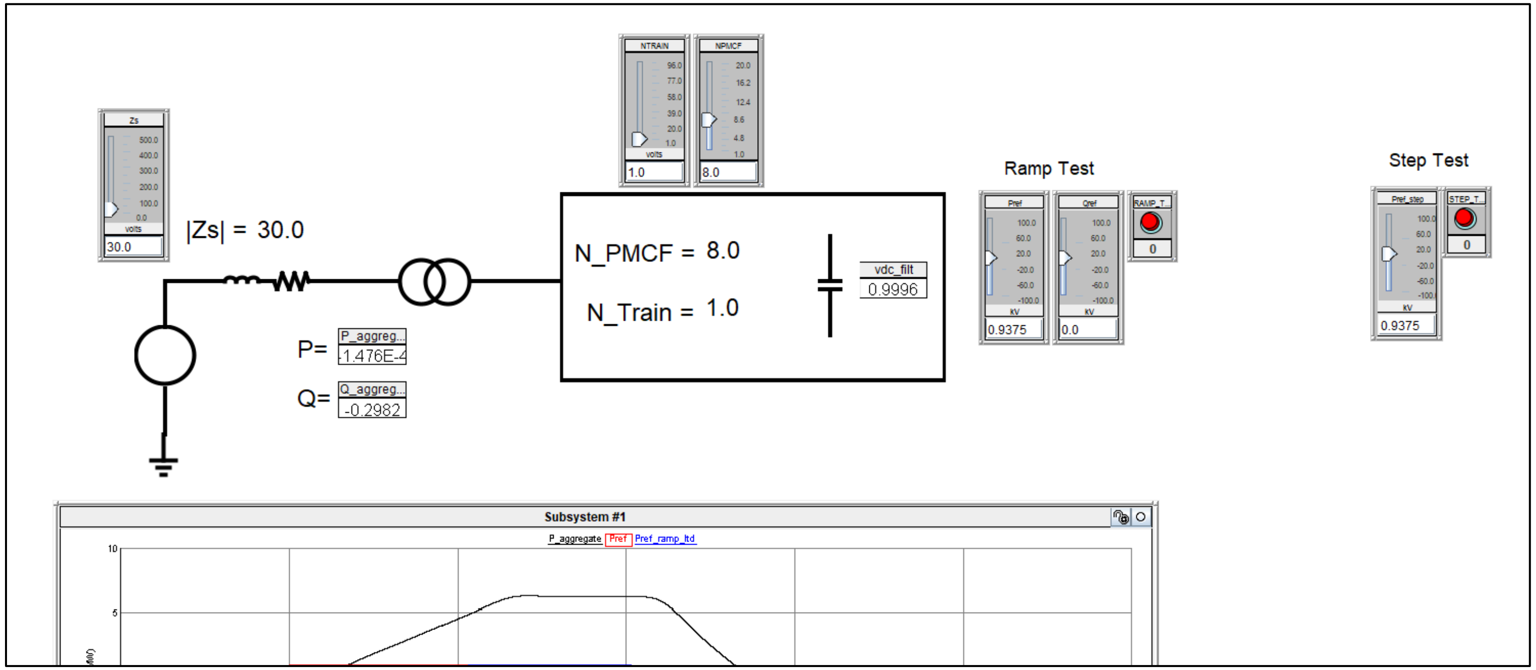


Figure 6: RSCAD Runtime

Test Results

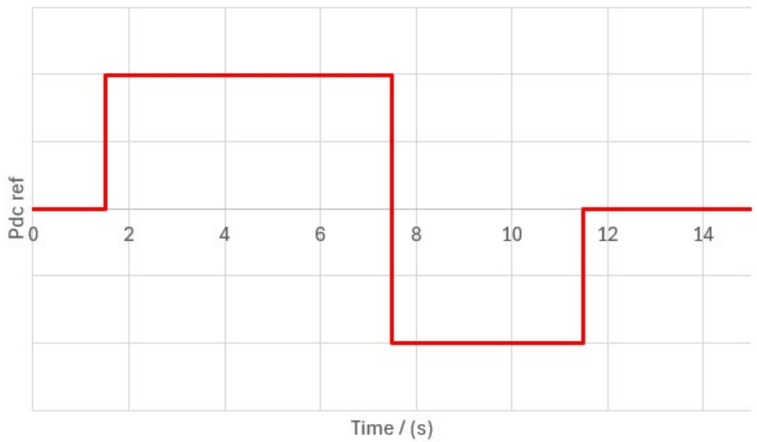


Figure 7: DC Power Reference (±6MW)

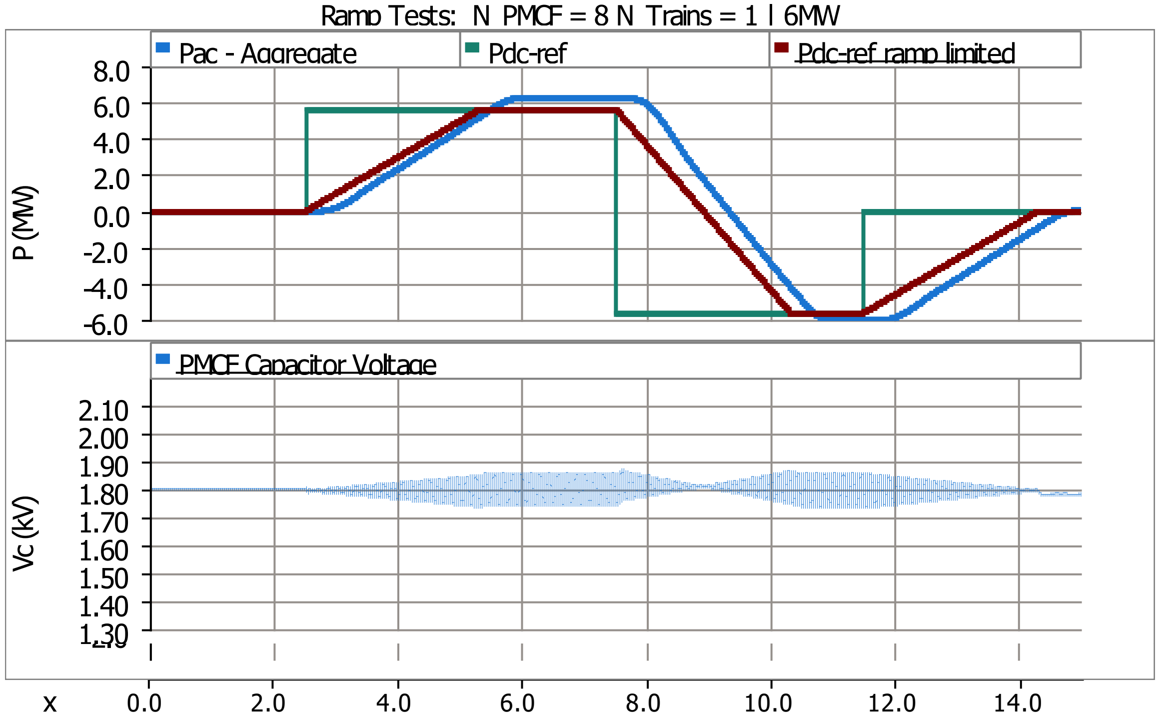
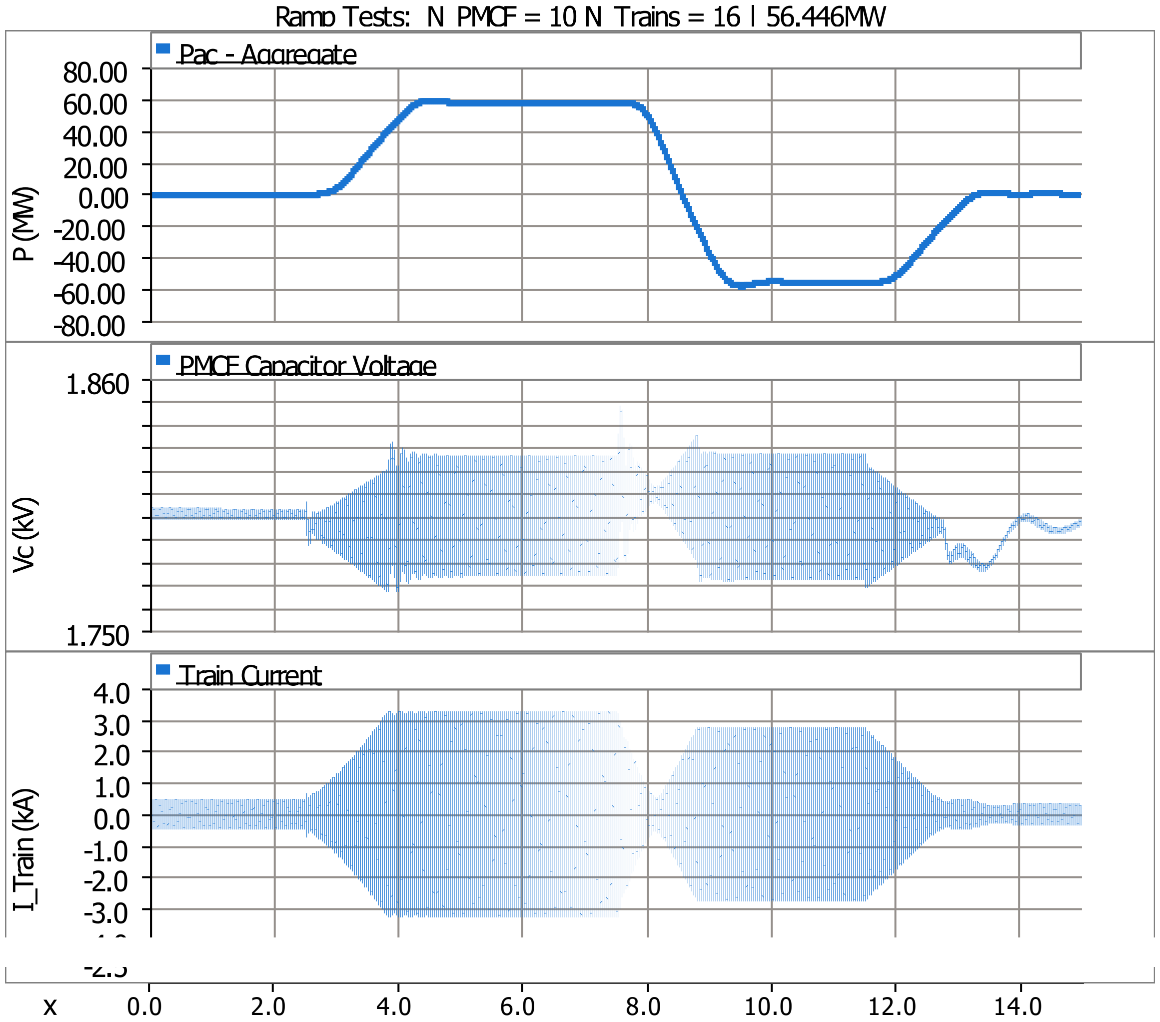
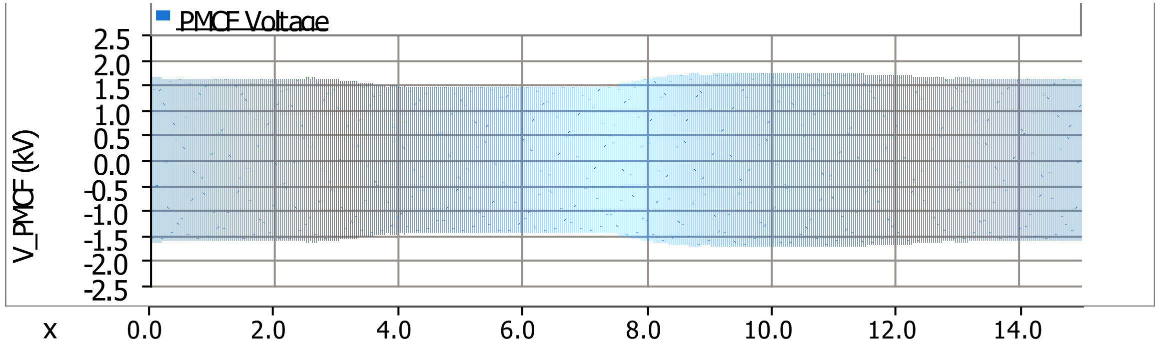


Figure 8: Power and Voltage Responses

Test Results





DC Power Reference Test – 16 trains of 10 PMCF (±56.5MW)

Conclusions

- The load model was sufficient for the purpose of testing the STATCOM reactive power performance.
- Aggregated model of an actual train can represent the dynamics of the traction system than a generic PQ load model
- Successful application of RTDS in a derisking exercise of an unconventional electrical network with unconventional load behaviours.

Thank you