QPTS™

- Next generation high-performance electromagnetic transient (EMT) simulation tool

1 Introduction

Company Overview

Quark Power Inc., established in 2020, is a leader in next-generation EMT simulation technologies. Based in Surrey, British Columbia, Canada, we specialize in the development of next generation high-performance tools for EMT simulations, focused on improving efficiency in large-scale power system studies. Alongside software development, we offer consulting services to help clients optimize their EMT simulations.

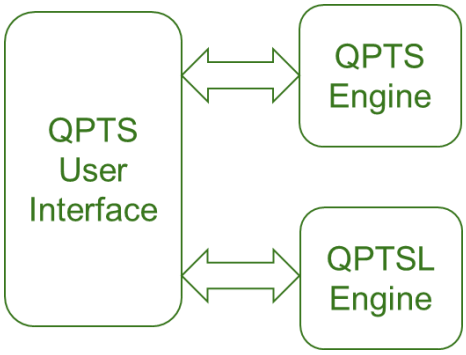
About QPTS

QPTS (Quark Power Transient Simulator) is our flagship simulation platform. It has been designed to tackle the growing complexity of large-scale EMT studies by providing a highly efficient and scalable solution. The dual EMT engines allow users to perform detailed simulations with both small and large timesteps, achieving high precision and efficiency.

www.quarkpower.ca

QPTS Key Features:

- ❑ Dual EMT engines: QPTS for small (~μs) and QPTSL for large (~ms) timestep simulations.
- ❑ Auto-parallelization for enhanced computational efficiency.
- ❑ Optimized for systems with large numbers of IBRs, HVDC, and other power electronic devices.



2 Unique Features and Solutions

Scalability:

QPTS is built to handle large-scale systems, offering scalability that has been tested with systems up to 140,000 three-phase buses. This ensures that whether the user is working with smaller regional grids or larger interconnected systems, QPTS is up to the task.

- ❑ Real-world test cases: 70,000-bus systems with thousands of transformers, generators, and transmission lines.
- ❑ Linearly proportional CPU time to system scale, ensuring efficiency even for extremely large grids.

Efficiency:

With a speed increase of 100x, QPTS enables faster-than-real-time simulations. Whether it's small (~μs) or large (~ms) timestep simulations, users can run complex EMT studies with a high degree of accuracy.

- ❑ The small timestep engine (~μs) ensures high precision for transient studies, while the large timestep engine (~ms) supports broader, system-wide simulations.
- ❑ Fully automated parallelization reduces manual efforts, allowing engineers to obtain results faster even for the most complex scenarios.

Duration 30s	Number of threads	Time step				
		50μs	200μs	500μs	1ms	5ms
CPU time cost (s)	1	587.25	145.28	58.89	**29.44**	**5.96**
	2	332.93	84.68	33.95	**17.23**	**3.51**
	3	237.77	61.49	**24.99**	**12.52**	**2.48**
	4	186.16	48.51	**19.49**	**9.89**	**1.99**
	5	136.48	36.60	**14.59**	**7.41**	**1.49**
	6	134.44	36.12	**14.38**	**7.29**	**1.45**
	7	121.71	32.90	**13.14**	**6.70**	**1.41**
	8	114.37	30.72	**12.13**	**6.09**	**1.37**
	9	112.68	**29.64**	**11.87**	**6.12**	**1.34**
	10	104.31	**27.48**	**11.27**	**5.72**	**1.23**
	11	107.72	**26.64**	**10.92**	**5.63**	**1.20**
	12	104.57	**25.51**	**10.83**	**5.36**	**1.18**

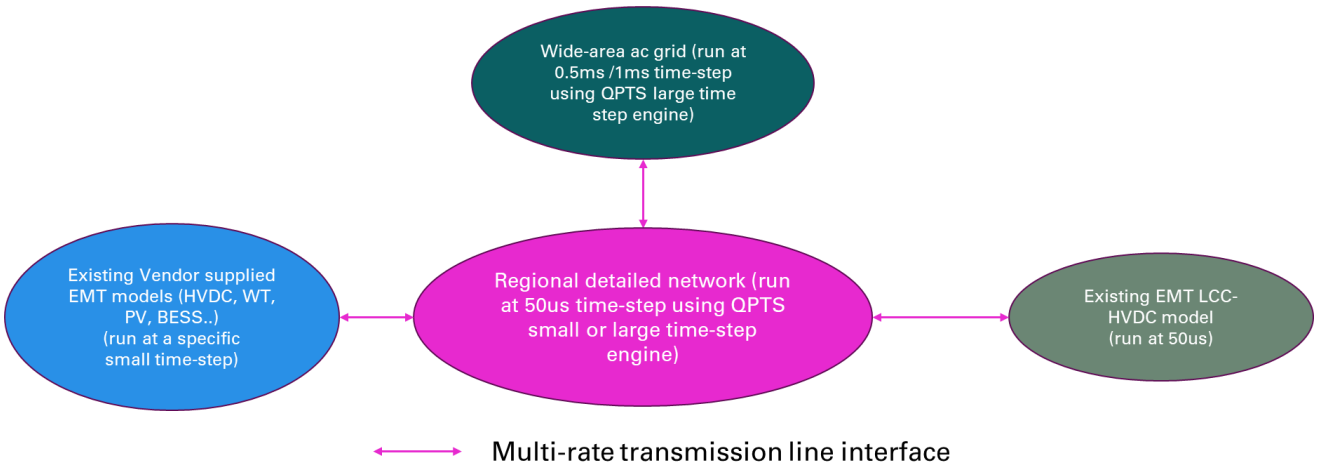
Test Case: 3147 buses, 1065 transmission lines, 2586 transformers, 107 generators, numbers in red indicates the faster-than-real-time results

3 Compatibility and Co-Simulation Features

Seamless Integration:

QPTS provides compatibility with other leading industry software, making it easier for users to transition between platforms and use multi-timestep simulations. The co-simulation capability allows different parts of the system to run at different timesteps while still communicating effectively, which is crucial for integrating IBRs and HVDC technologies.

- Integration with OEM standard and non-standard DLL models allows users to simulate specific hardware and control systems.
- Multi-timestep simulation enables detailed modeling of certain regions and components such as IBRs and HVDCs (at 1-50 μs timestep) while simulating the rest of the system adequately and efficiently (at 500 μs to a few *ms* timestep).
- Built-in data conversion from PSS/E .raw and .dyr files.
- QPTS integrates seamlessly with PSCAD, allowing both platforms to run simultaneous simulations with different timesteps for optimal performance.

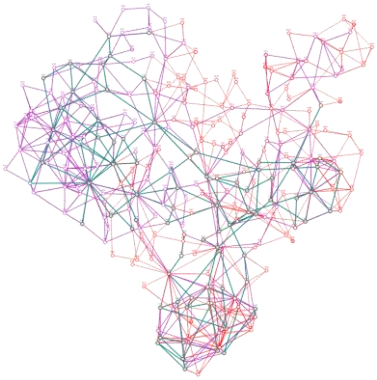


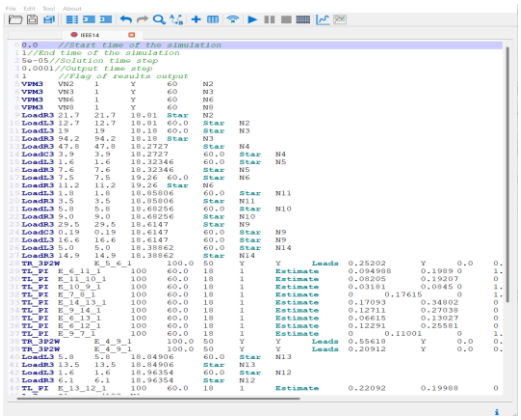
4 Usability and User Interface

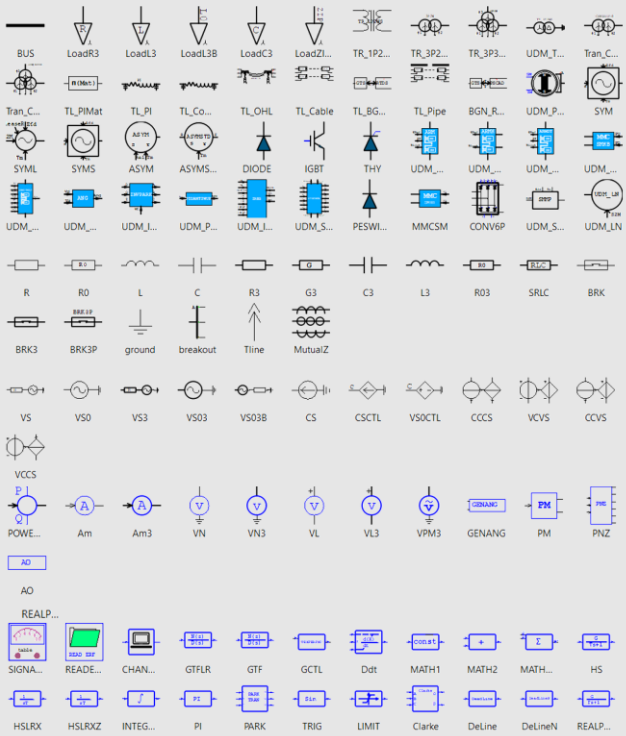
User-Friendly Interface:

QPTS has been designed with flexibility in mind. It offers both graphical and text-based interfaces to suit user preferences. The platform supports extensive automation, allowing users to script, batch-run, and automate simulations, reducing manual workload.

- ❑ Easy switching between small and large timestep engines to meet diverse simulation needs.
- ❑ Model visualization tools make it easier to analyze large systems, with views available in graphical, tabular, and textual formats.
- ❑ Batch editing and scripting support large-scale simulations efficiently.







Model and Study Support:

QPTS supports a broad range of power system models, including detailed renewable energy models (REECA1, REGCB1, etc.), power electronic devices, transformers, and transmission lines. This makes QPTS a versatile tool for various types of power system simulation studies, ranging from renewable energy integration study with detailed or generic IBR modeling, to NERC compliance studies, to impedance scanning, to continency screening and stability analysis.

5 Applications and Case Studies

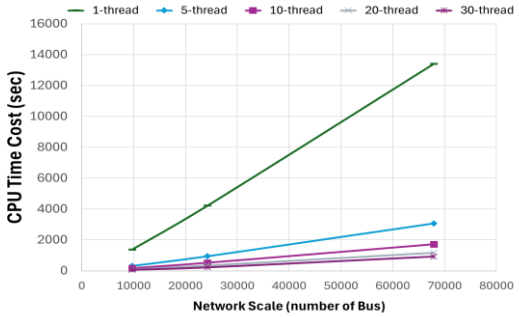
Case Study A - 70,000-Bus System[1] Simulation

QPTS was successfully used to simulate a system with 70,000 buses, including a detailed configuration of generators, transformers, and transmission lines. The simulation was run with a timestep of 50μs over a duration of 10 seconds, showcasing the tool's scalability and accuracy.

- ❑ Near-linear CPU time scaling with the system size, maintaining high efficiency across increasing network complexity.
- ❑ QPTS can efficiently perform large-scale EMT parallel simulations at high speed, making it an ideal choice for planning and EMT studies.

CPU time summary (sec)

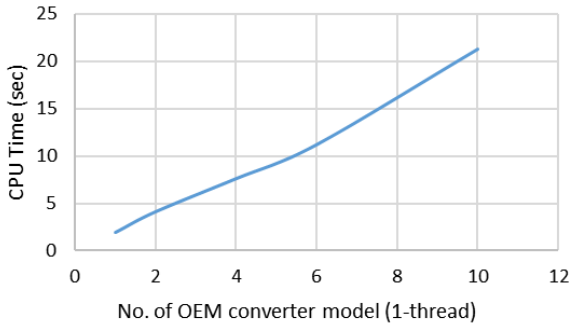
Thread Number	Buses of system		
	9700	24250	67900
1	1374.9	4221.9	13404.9
5	310.3	943.1	3068.0
10	166.3	520.6	1724.1
20	98.9	349.1	1172.8
30	72.7	226.8	**934.2s (15.5m)**



Case Study B – Multi-inverter Simulation

QPTS conducted EMT simulations featuring multiple inverters. In these simulations, the OEM provided the model for QPTS with a 5μs time step, a 1-second simulation duration, and a detailed OEM model that includes IGBT and DLL components.

- ❑ Near-linear CPU time scaling with the inverter number in the test,



1. Synthetic Grid models from TAMU, https://electricgrids.engr.tamu.edu/ . This outcome may change depending on the model or hardware used

QUARK POWER

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