

RAMP RATE POWER INJECTION DEMONSTRATOR (RAPID)



PROJECT SUMMARY

Energy Storage Systems (ESS) have the potential to mitigate fluctuating power output from intermittent generation sources such as solar photovoltaic (PV) energy. However, these systems require proper ramp-up and ramp-down control to function effectively and optimally.

This project successfully developed and demonstrated two PV ramp rate control strategies: to control at the intermittent source level and at the substation level. The project has developed a 200 kW technology-agnostic ramp rate power injection demonstrator (RAPID) platform which has been offering testing and validation of near-to-market solutions for ESS control in realistic grid-like conditions. Along with a wide-area RAPID system, the developed ramp rate control solutions can reduce the energy storage capacity required for grid-wide ramp rate targets. Other ESS control functions for grid service support are also successfully demonstrated including frequency support, voltage regulation (reactive power injection) and grid forming.

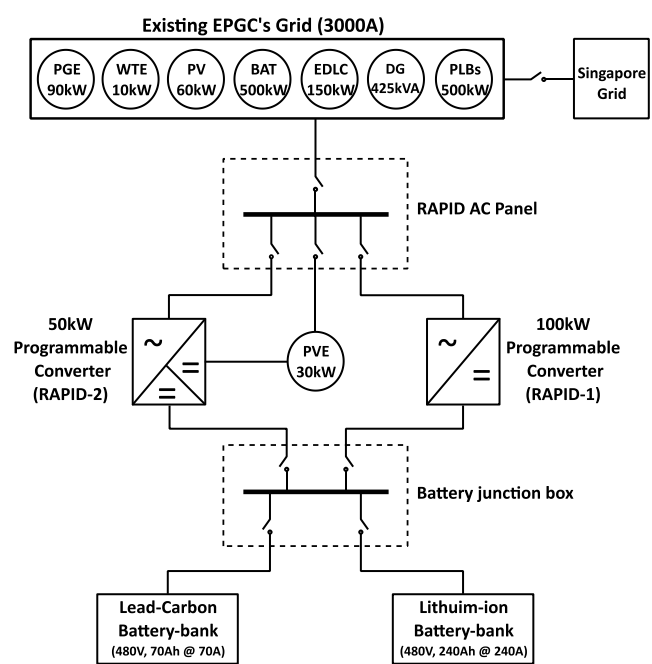


Fig. 1. RAPID platforms designed to experiment different ESS control techniques for grid applications

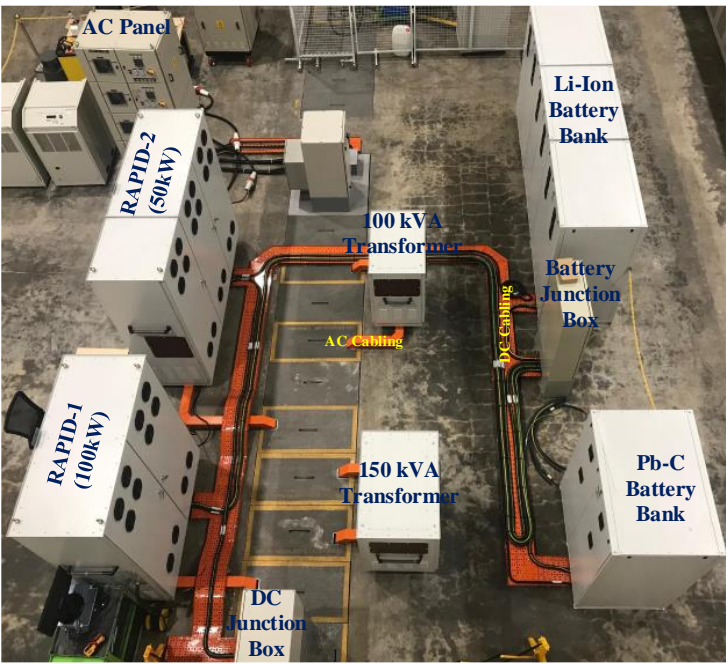


Fig. 2. Photograph of the actual in-house developed RAPID platform at EPGC, Jurong Island.

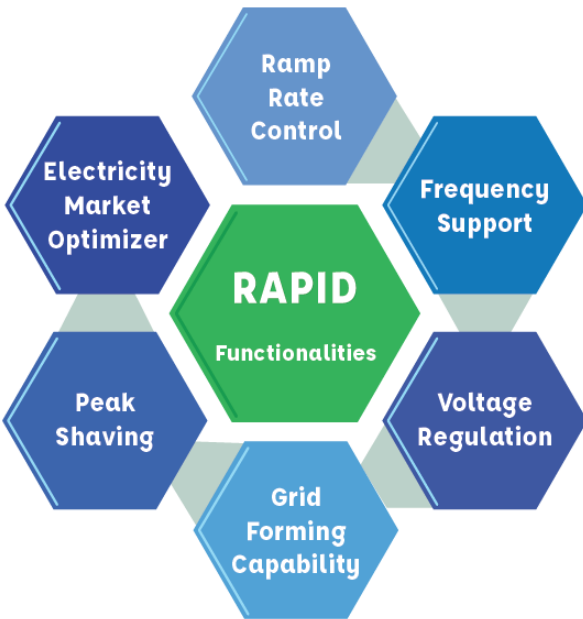


Fig. 3. Significant grid support functionalities of RAPID system

PROJECT OUTCOMES



- Ramp rate control strategies for ESS have been developed and demonstrated for two different levels – PV inverter and substation.
- ESS control functions, e.g. frequency support and PCC voltage regulation for grid support, are successfully demonstrated. Grid forming capability of ESS has also been verified experimentally.
- Since the successful completion of the project, the RAPID platform has been fully utilised and enhanced to offer testing and verifications for multiple projects such as iDemand, AGC testing and Battery EMS testing etc. for both government agencies and industries.
- As part of this project, ramp rate control algorithms using three different approaches (shown in Fig. 4) have been developed for wide area ESS application. Solar irradiance data from five different locations in Singapore have been collected, analyzed and used in developing these algorithms. The results (shown in Fig. 4) show that based on a 1% (p.u/min) ramp rate limit, the required capacity of centralized ESS is about 50% of the distributed one.

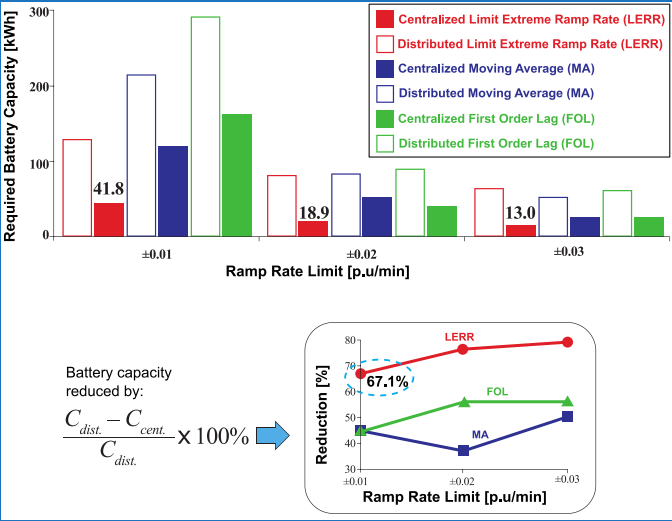


Fig. 4. Three proposed wide area ESS control algorithms and resulting centralized battery capacity reduction.

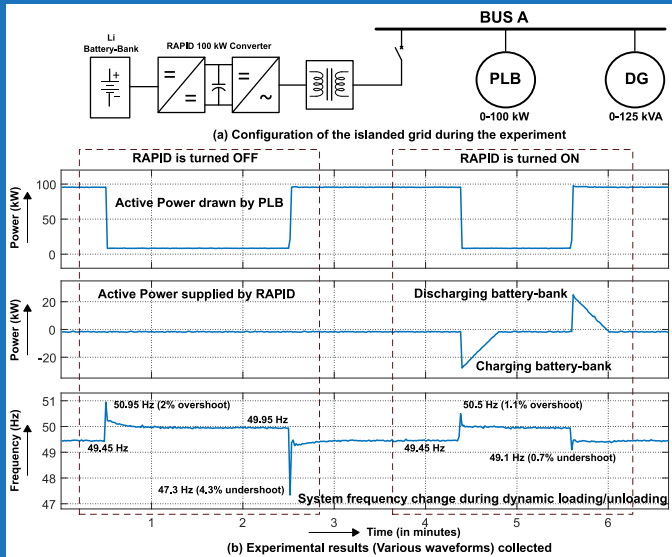


Fig. 5. Experimental results of RAPID demonstrating frequency support operation: (a) the micro-grid configuration for this experiment; (b) collected results

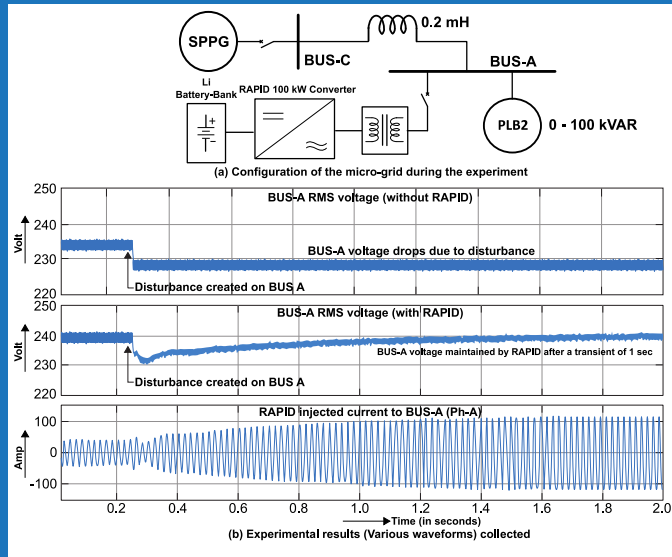


Fig. 6. Experimental results of RAPID demonstrating PCC voltage regulation operation: (a) the micro-grid configuration for this experiment; (b) collected results



Fig. 7. Picture of the 100kW converter built in-house

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Note: This work was completed when EPGC (Experimental Power Grid Centre) was part of A*STAR, Singapore