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Energy Storage Design Considerations for an MVDC Power System

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As part the U.S. Navy's continued commitment to protecting U.S. interests at home and abroad, the Navy is investing in the development of new technologies that broaden U.S. warship capabilities and maintain U.S. naval superiority. In particular, NAVSEA is supporting the development of power systems technologies that help the Navy realize an all-electric warship. It is recognized that a challenge to fielding an all-electric power system architecture includes minimizing the size of energy storage systems while maintaining the response times necessary for potential pulsed loads. This work explores the trade-off between energy storage requirements (ie. size and weight) and performance (ie. bandwidth and storage) in the context of a power system architecture that meets the needs of the US Navy.

To compare energy storage technologies and appropriately size them, it is necessary to find the specific energy density in Wh/kg and specific power density in W/kg requirements. The time domain results for the different load types and control delays were used to determine technology and sizing requirements by comparing the total energy and maximum power used in the simulation to a Ragone plot. Simulation results based on operational vignettes are used to identify a range of specific power and energy densities that will meet system requirements. Potential energy storage sizing can be determined by approximating where a selected technology intersects with the energy and power requirements of the system.

Another major component necessary to determine energy storage technology is the frequency domain behavior of the system. In this work, the energy storage control bandwidth is evaluated in simulation given different loading scenarios, and a trade-off between size/weight and response bandwidth is illustrated.