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Multilevel Converters For Distribution Level Grid Connected Battery Energy Storage Systems (BESS)

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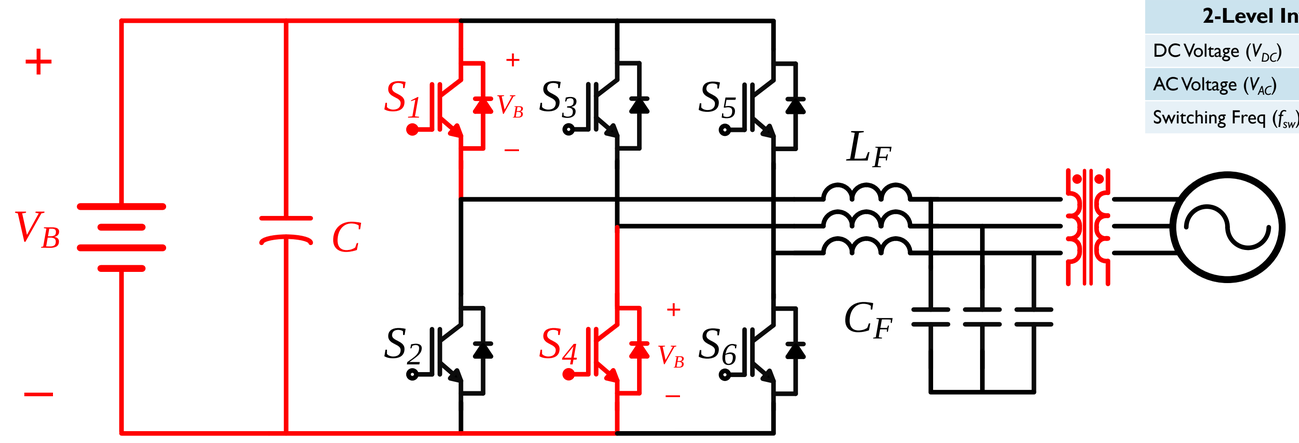
Introduction

- Commercially available inverter technologies used for battery energy storage systems (BESS) are limited to ≤1kV.
- Current BESS solutions connected to distribution level grids must go through a step-up transformer.
- Multilevel inverter are a mature technology proven to work at medium voltage (4.16kV - 69kV) in the motor drives industry.
- Multilevel inverter architectures can be used to reduce the cost and increase the efficiency of distribution level grid connected battery energy storage systems.

Two-level Inverter Problem

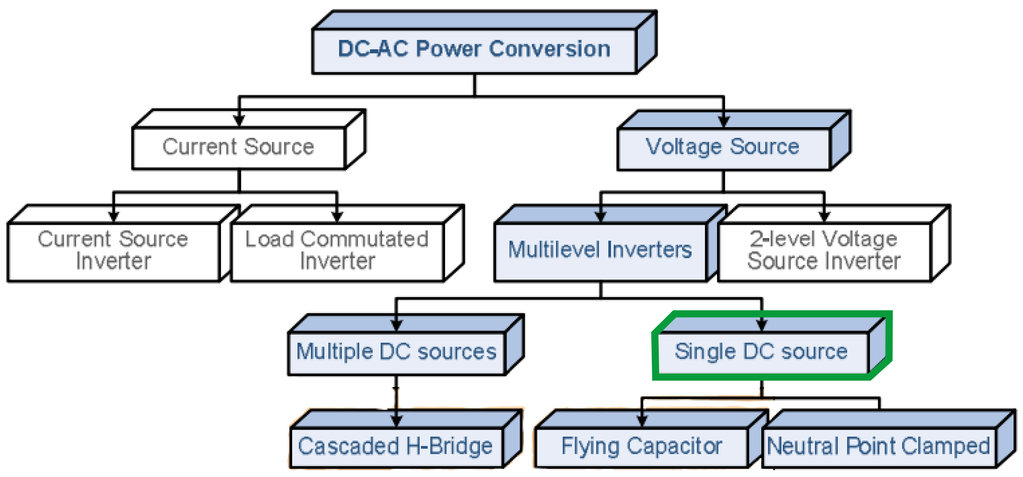


2-Level Inverter Limits	
DC Voltage (V_{DC})	1000 V
AC Voltage (V_{AC})	480 V
Switching Freq (f_{sw})	100 kHz

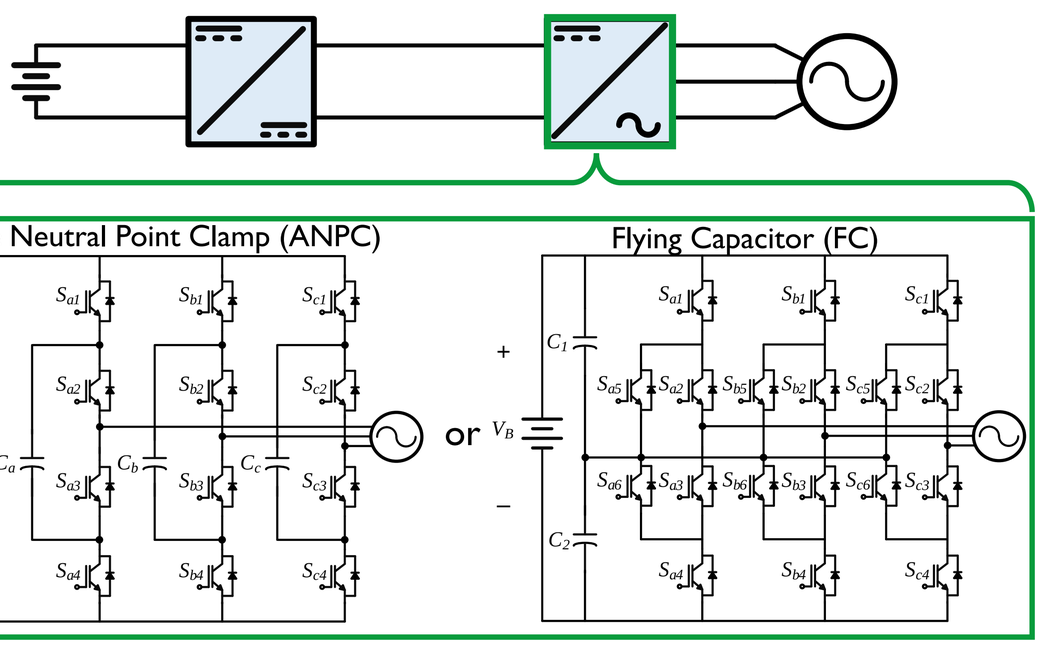
- $V_{DC} > V_{AC,pk-pk}$ to avoid harmonic distorted at the AC output.
- Each switch must me rated to handle the DC link voltage.
- Low reliability electrolytic capacitors are used on the DC link.
- This topology needs a transformer to connect to a distribution grid.

Multilevel Inverter Topology Solutions

Multilevel inverter Classifications and Types [1]



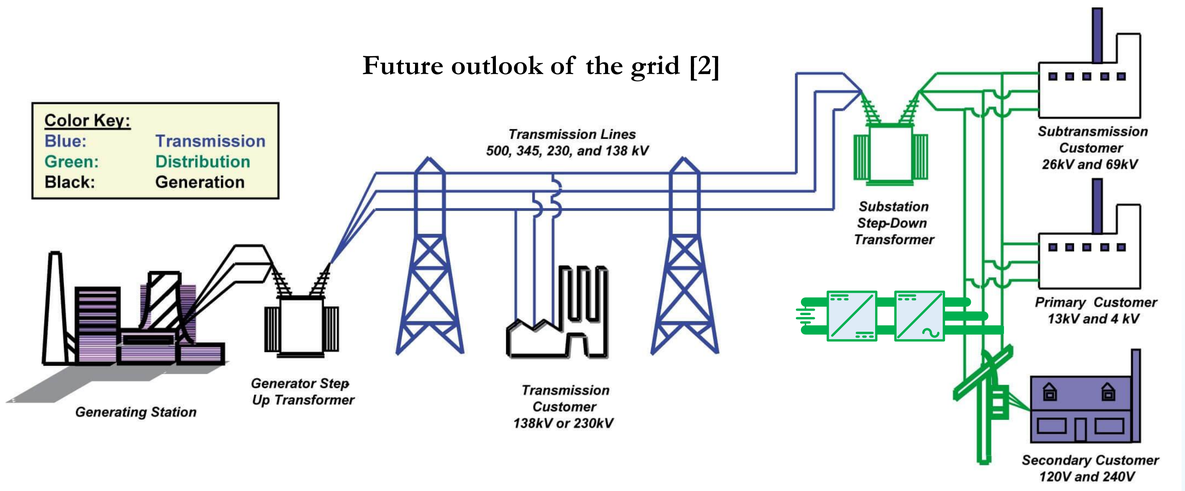
DC/DC Converter + Multilevel Inverter



- Multilevel inverters are not limited by device voltage ratings or DC link voltage due to their modular structure, therefore are scalable to higher working voltages.
- The higher working voltage of multilevel inverters allow BESS to directly connect into a distribution grid and bypass the need for a step-up transformer.
- These circuit topologies lower harmonic distortion due to the multiple voltage levels that compose the sinusoidal AC output.
- The application of these mature circuit architectures lies in the control complexities that arise when interfacing to a BESS.

Distribution Level Grid Connected BESS

Future outlook of the grid [2]



- The multilevel inverter solutions will increase BESS penetration and reduce overall operational cost.
- Multilevel inverter solutions will make the grid more efficient and reliable.
- Once this solution is proven to work it can be scaled to high voltage level applications.

Summary & Future Work

- The maturity of multilevel inverter technology can be leveraged and modified to work for distribution level BESS.
- Choosing the optimal multilevel inverter topology that provides the most controllability/scalability to connect BESS is important.
- Simulate, build, and test the chosen topology and BESS at low voltage (<1kV).
- Step voltages up to test the ESS connected multilevel inverter at medium voltages (<4160V_{ac}) and beyond (HV_{ac}).

References

1. J. Rodriguez et al., "Multilevel Converters: An Enabling Technology for High-Power Applications," in Proceedings of the IEEE, vol. 97, no. 11, pp. 1786-1817, Nov. 2009.
2. US Department of Energy (Public Domain).

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