Design of a Cooling System in a Medium Voltage MMC

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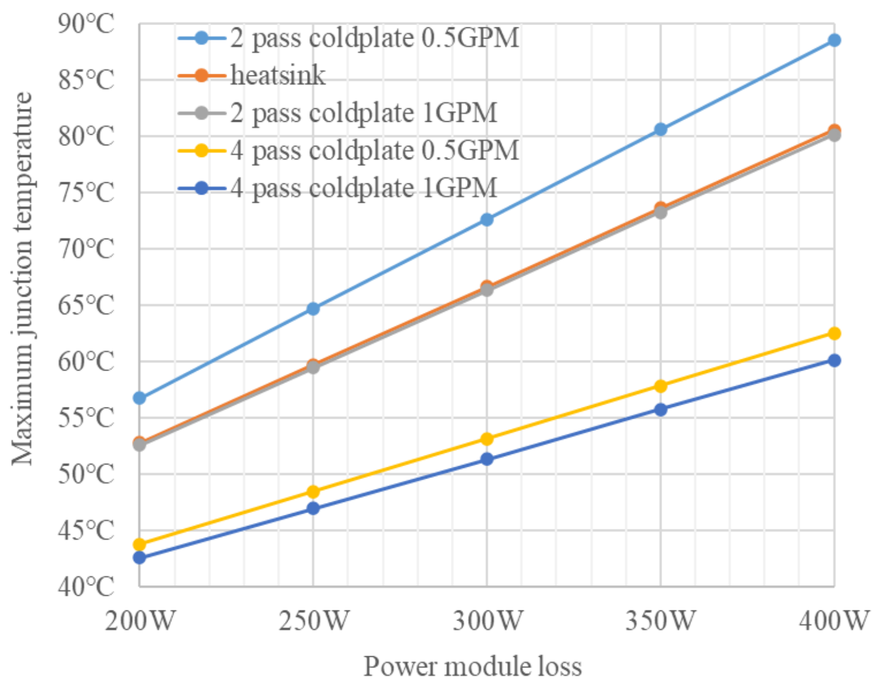
PROBLEM STATEMENT

- Sufficient cooling system designed for a MMC (Modular Multilevel Converter) based on 10 kV, 100 A power modules
- Achieve high volumetric density of 0.3 m^3/MW
- Proper high voltage insulation between the high voltage switching devices and cooling components

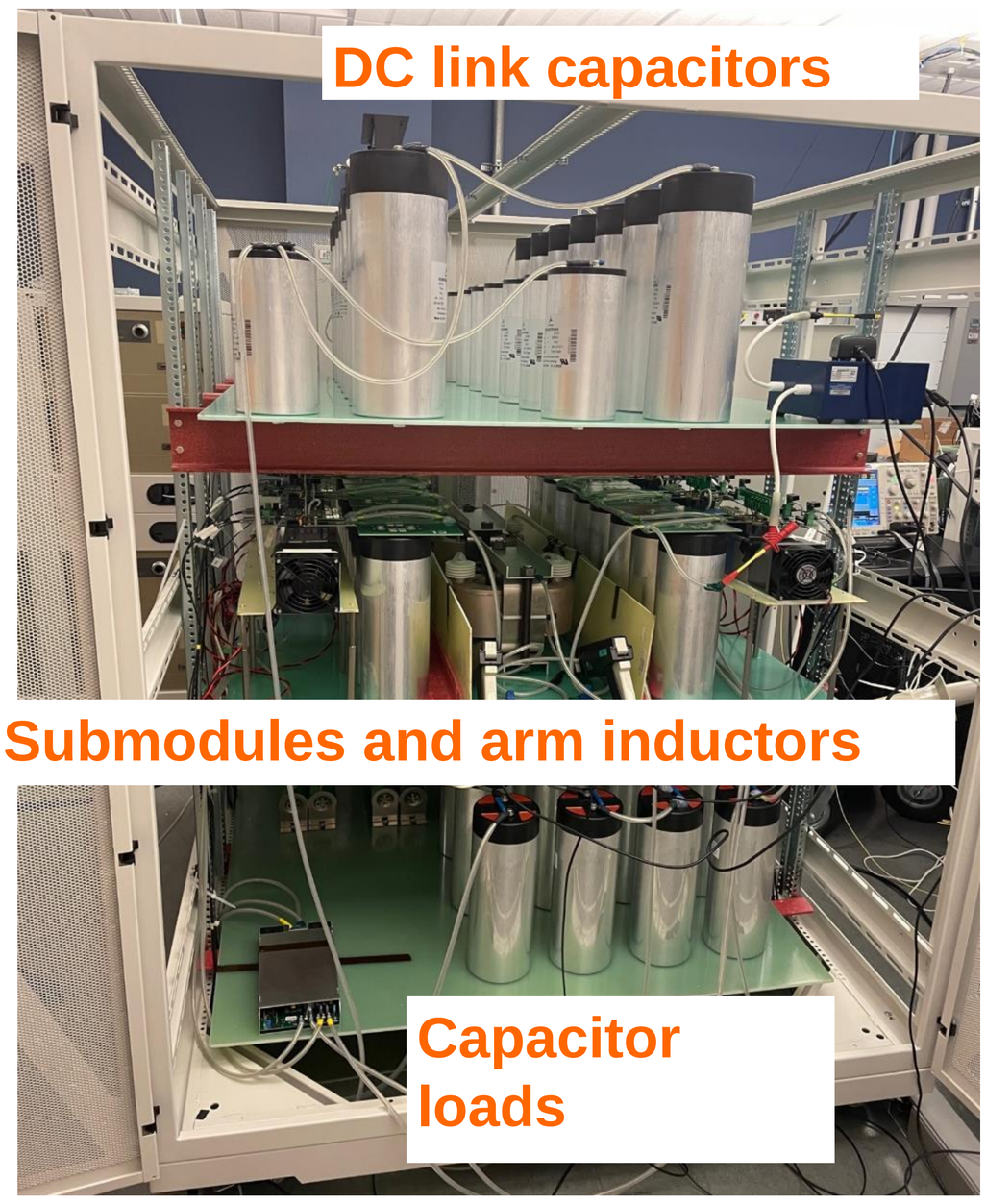
POSSIBLE SOLUTIONS – LIQUID VS. AIR COOLING

- Liquid cooling involves selection of cold plate and pump that considers flow rate and pressure drop
- Deionized water is selected as coolant to prevent charge built up
- Fans are placed 100mm away from the heatsink to ensure clearance and creepage distance.

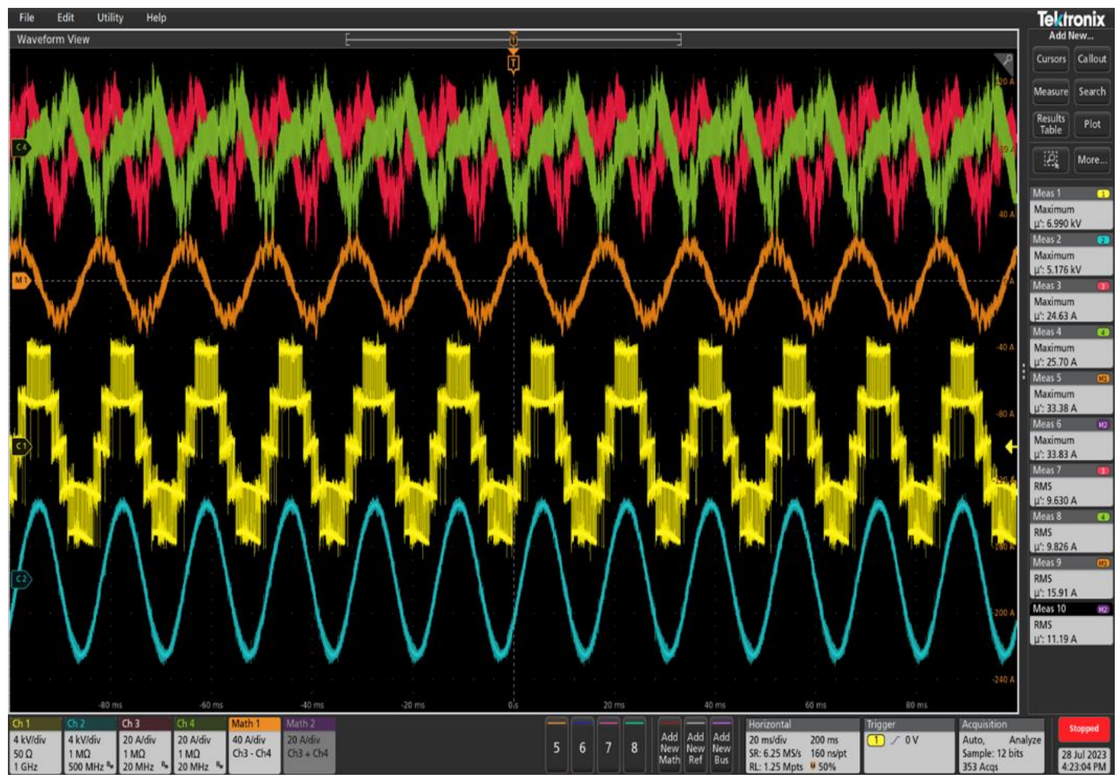


Maximum junction temperature in liquid cooling vs. air cooling

	Liquid Cooling	Air cooling
Components cost	Cold plates ($127)x24 Chiller ($14,843) Deionized filter ($848)	Heat sinks ($67.65)x24 Air duct ($75)x6 Fans ($16.7)x6
Total cost	$19,103	$2173
Size and weight	Cold plate 152x88.9x30mm (0.4 kg) Chiller 0.98x0.8x1m	Heatsink 187x152x79mm (0.75kg) Air duct 101mmx152mmx1.1m Fan 80x80mm
Voltage and current	220 V, 32 A	24 V, 1.7 A
Maximum junction temperature	59.4 ℃	66.7 ℃



MMC phase leg hardware setup



MMC test waveforms from top to bottom: upper arm current (20A/div); lower arm current (20A/div); output current (40A/div); PWM voltage (4kV/div); output voltage (4kV/div).