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High Gradient Nb3Sn Quadrupole Demonstrator MKQXF Engineering Design

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The future upgrades of the CERN accelerator chain along with the future high energy colliders, notably the FCC, will require high gradient quadrupoles. As part of the HL-LHC project, the 11T Dipole was the first Nb3Sn magnet designed from the beginning to be compatible with the accelerator requirements and industrial production. It is based on the "pole-loading"concept, in which the Ti-alloy pole is not part of the coil, but inserted during the assembly process. This allows shimming at the pole and uses the collars more efficiently for creating the coil pre-stress. MKQXF is the further development of the "pole-loading"concept for Nb3Sn quadrupoles. The pole region of the coils is identical to the 11T dipole and the collared coil is based on dipole-type collars. This concept can easily be extended to any length and applied on both 1-in-1 and 2-in-1 configurations. For benchmarking purposes and to compare with the present base-line design of the HL-LHC IR quadrupole QXF, based on bladder-and-key concept, this conceptual study was made with identical coils and quasi-identical magnetic characteristics. The design features 140 T/m gradient in 150 mm coil aperture. This paper describes the design concept of MKQXF and the fully 2D & 3D parametric multi-physics finite element model (FEM), including the end regions. The design optimization is described and the optimized assembly parameters and the effect of the manufacturing tolerances are presented.

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