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Stability and limitations of the EuXFEL 3rd harmonic cryomodule in CW and LP operation

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Future high duty cycle operation scenarios of the European X-ray Free Electron Laser (EuXFEL) promise increased bunch repetition rate and photon delivery, at the cost of changing system requirements and moving away from the proven mode of short pulse operation. To assess the applicability of the currently installed 3rd harmonic cryomodule, key parameters of its spare sibling installed at the Accelerator Module Test Facility are examined for long pulse (LP) and continuous wave (CW) operation. For RF related energy efficiency, the cavity resonance tuning precision and the loaded quality factor tuning range are investigated. As performance indicators, limitations on attainable cavity gradient and RF stability are quantified. The results show that the module in its current design is not sufficient for LP and CW at the required operating points. The mechanical cavity tuner prohibits tuning precision within the intended cavity half bandwidth, and the installed 3-stub tuners only yield quality factors up to 1.4×10^7 . Also, some higher order mode couplers do not allow CW operation at required gradients. Nevertheless, closed-loop RF stability measurements with single cavity control fulfill the current EuXFEL requirements if assembled to a pseudo vector-sum.

Summary

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