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Development and Test of Digital LLRF Control Procedures and Techniques in Scope of ILC

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In order to operate the superconducting cavities at the International Linear Collider (ILC) near their maximum gradients, cavity input (PK) and cavity loaded Q (QL) have to be controlled individually (PKQL control). In this scope a fully automated PKQL operation procedure was developed and demonstrated at cavity gradients of 16 MV/m and 24 MV/m with Q_L values of 9e6 and 3e6 at the linear electron accelerator at the Superconducting RF Test Facility (STF) at the High Energy Accelerator Research Organization (KEK). During a long-time operation with beam (6.4 mA, 615 μs) the vector sum gradient and phase stabilities during the beam transient were ΔA/A_RMS= 0.009% and Δϕ_RMS=0.009° with cavity gradient stabilities of ΔA/A_(cav1,RMS)=0.041% and ΔA/A_(cav2,RMS)=0.031%.
Since in ILC the cavity gradient spread will be±20% around 31.5 MV/m the required range of loaded Q values is 3e6 to 1e7. High loaded Q operation at QL = 2e7 with a 6.1 mA beam was demonstrated at STF. The stabilities were ΔA/A = 0.008%RMS and Δφ = 0.014°RMS.
Furthermore a near klystron operation within 5% of saturation, which is an ILC requirement, was performed at STF with a 6.2 mA beam. The stabilities were ΔA/A = 0.010%RMS and Δφ = 0.009°RMS.
An FPGA-based klystron linearization algorithm for amplitude including an in the I and Q plane circular limiter was developed, implemented, and successfully tested at New Muon Laboratory (NML) at Fermi National Accelerator Laboratory (FNAL).

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