TESTING THE DAE LLRF SYSTEM WITH A PIP-II SSR2 CAVITY

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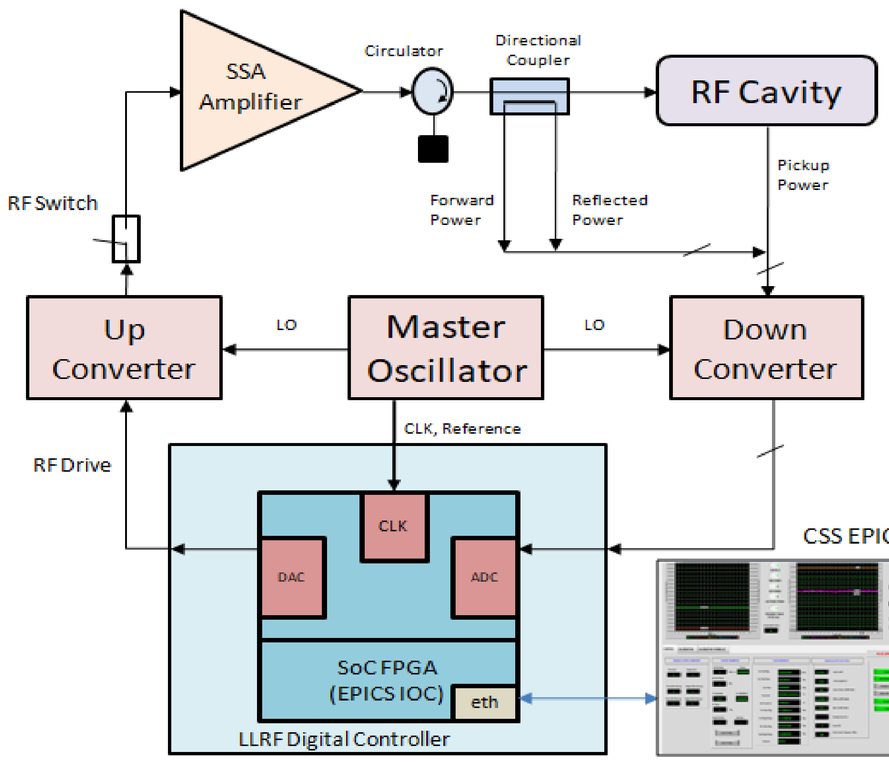
INTRODUCTION

- Department of Atomic Energy (DAE) India, Institutions, viz, Bhabha Atomic Research Center (BARC), Raja Ramanna Centre for Advanced Technology (RRCAT), Variable Energy Cyclotron Centre(VECC) and the Inter University Accelerator Centre(IUAC) are collaborating with Fermilab National Accelerator Laboratory (FNAL), USA for the design and development of several key technology components in the important area of superconducting RF accelerators under Indian Institutes Fermilab Collaboration (IIFC).
- In the R&D Phase of the IIFC project, LLRF and RCS systems jointly developed by BARC and FNAL were delivered to FNAL for testing and validation.

LOW LEVEL RF SYSTEM



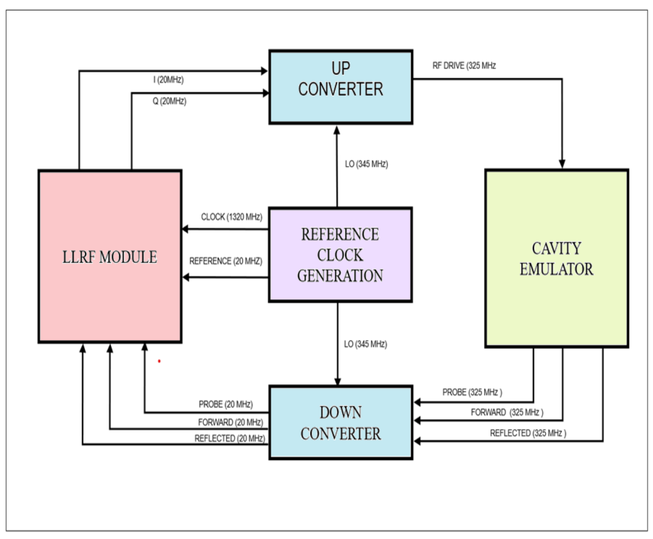
LLRF System

- The DAE Low-Level Radio Frequency (LLRF) system comprises several key components: a down-converter module, an up-converter module, a digital cavity controller, and a reference phase generator system.
- The entire system operates within the Experimental Physics and Industrial Control System (EPICS) framework [3], with the digital controller implemented as an Input/Output Controller (IOC).
- This architecture supports modular development, real-time feedback, remote diagnostics through EPICS based data acquisition scheme.

CONCLUSION

- The system achieved stable field gradients up to 5 MV/m in CW and PL SEL mode.
- In GDR mode with feedback engaged, the LLRF system maintained a stable cavity gradient of 5 MV/m, demonstrating robust performance under high-power operation.
- Consistent results were obtained using Fermilab's LLRF system, confirming its reliability.

TESTING WITH FNAL CAVITY EMULATOR



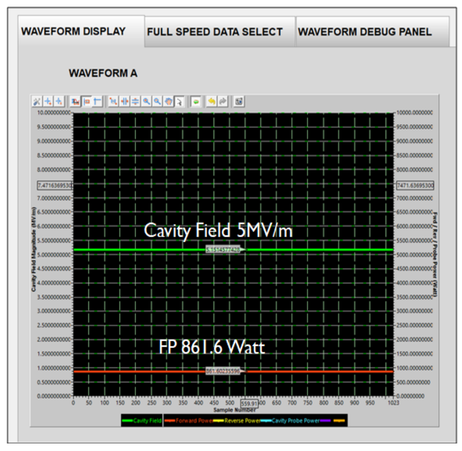
LLRF Setup with FNAL cavity emulator

FNAL cavity emulator testing results in PL mode

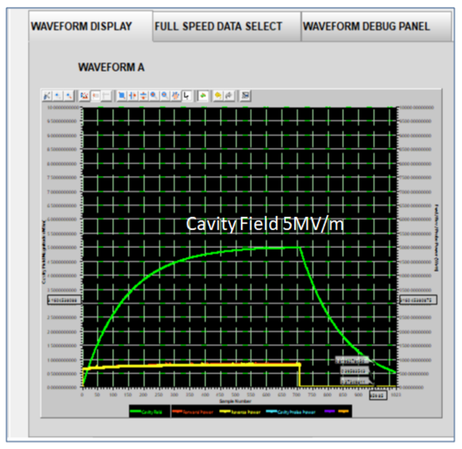
TESTING AT SPOKE RESONATOR TEST CAVE (STC)

MODE	DRIVE	OPERATION	GRADIENT
Self Excited Mode	Feedforward	Continuous	5 MV/m
	Feedback	Continuous	5 MV/m
	Feedforward	Pulsed	5 MV/m
Generator Driven Mode	Feedback	Continuous	5 MV/m

- DAE LLRF system's LLRF Digital module, up-converter module and down-converter module was deployed at STC on a 325 MHz SSR2 PIP-II superconducting RF (SRF) cavity. The SSR2 cavity under test exhibited a loaded quality factor (Q) of 4.9751e6.

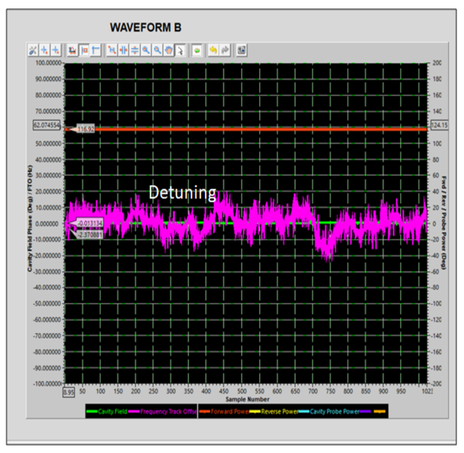


LLRF CW SEL operation: Cavity Field and FP

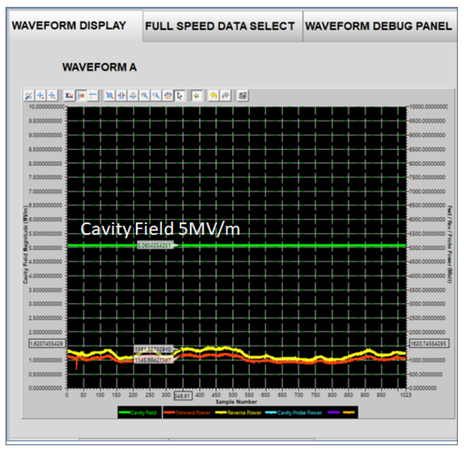


LLRF PL SEL operation: Cavity Field

DAE LLRF system installed at STC



LLRF CW SEL operation: Detuning



LLRF CW GDR operation: Cavity Field

- Resonance Control System(RCS) was also tested and demonstrated in the LAB at FNAL.

Low Level Radio Frequency Workshop-2025

12-16 October, 2025, Newport News, VA, USA