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Development status of LLRF system for KOMAC

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Introduction

A 100-MeV proton accelerator has been developed, and the beam service started at the Korea Multi-purpose Accelerator Complex (KOMAC) in July 2013. The accelerator consists of a 50-keV proton injector, a 3-MeV radio-frequency quadrupole (RFQ) and a 100-MeV drift tube linacs (DTLs). Total 9 pulsed klystrons with 1.6 MWpeak are used to provide RF power to the cavities with 350 MHz of operating frequency. As the demand for high intensity beam service increased, the feedforward controller was implemented to mitigate the heavy beam loading effect. This poster introduces the concept of a feedforward controller for KOMAC as well as the experimental results performed in low-level RF (LLRF) test stand. In addition, a LLRF system for a newly developed 200-MHz RFQ, based on non-IQ sampling techinque will be presented briefly.

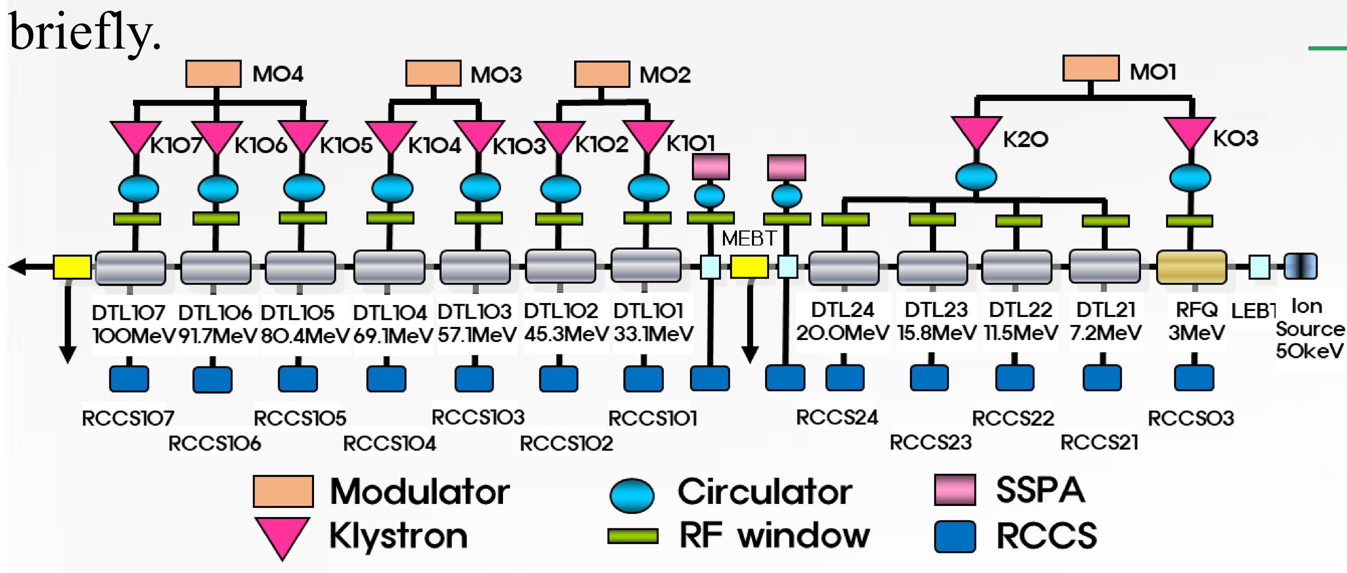

Figure 1: 100 MeV Linac RF system layout

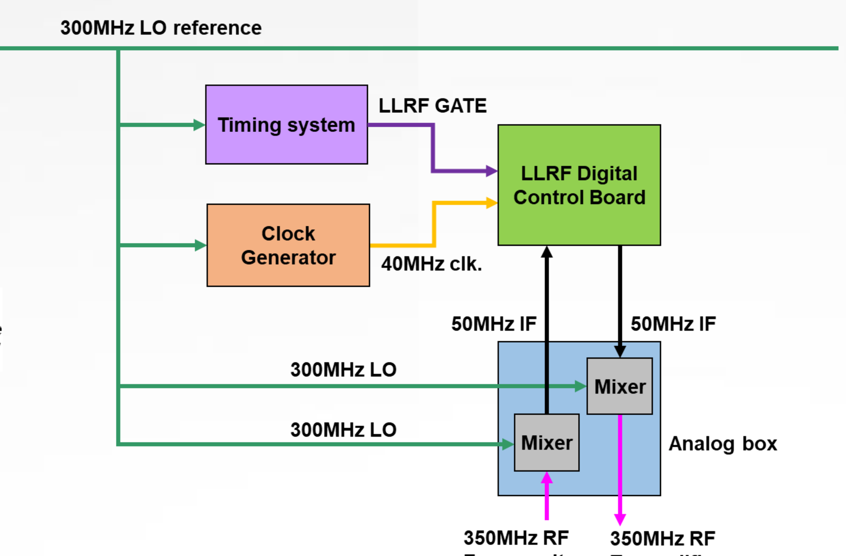

Figure 2: 100 MeV Linac LLRF configuration

Table 1: KOMAC LLRF system status

	100 MeV proton Linac LLRF	1 MeV/n RFQ LLRF
Sampling	IQ	Non-IQ
	Up/Down conversion	Direct sampling
RF	350 MHz	200 MHz
LO	300 MHz	-
IF	50 MHz	-
Sampling frequency	40 MHz	320 MHz
Logic device	Virtex-4	Virtex-5
Beginning year of Linac operation	2013	2022

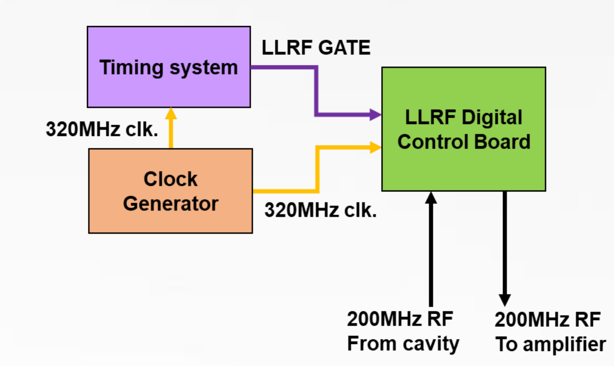

Figure 3: 1 MeV/n RFQ LLRF config.

Feedforward controller in 100 MeV Linac

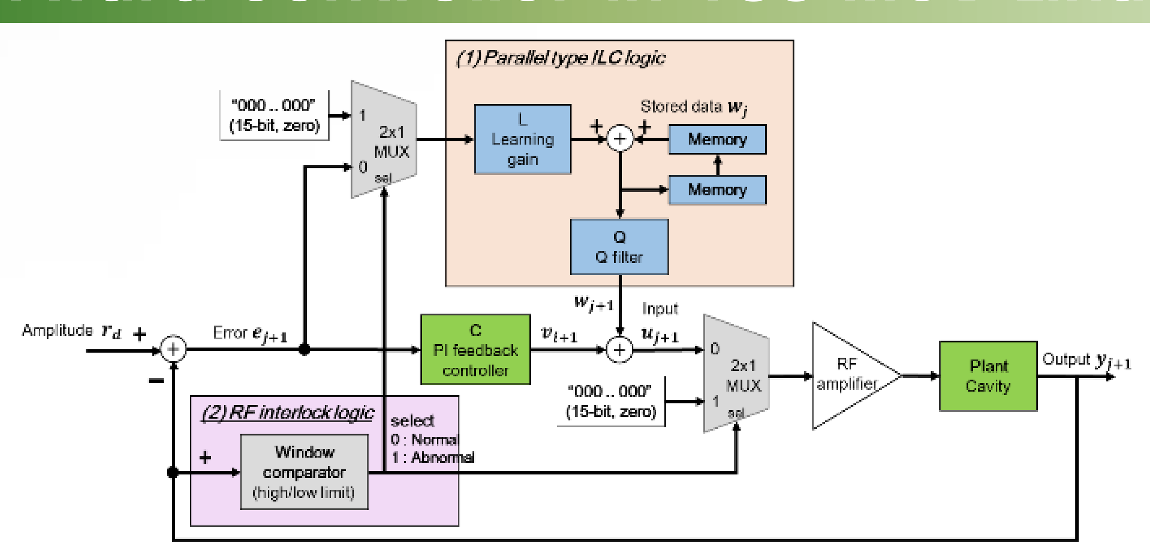

Figure 4: Implemented feed-forward control diagram

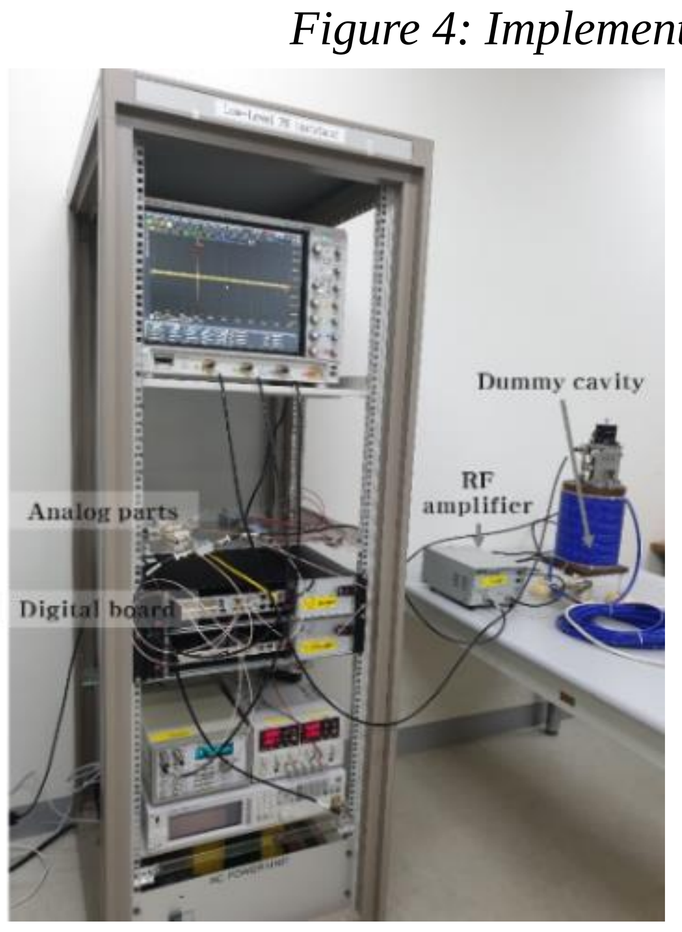

Figure 5: LLRF test stand setup

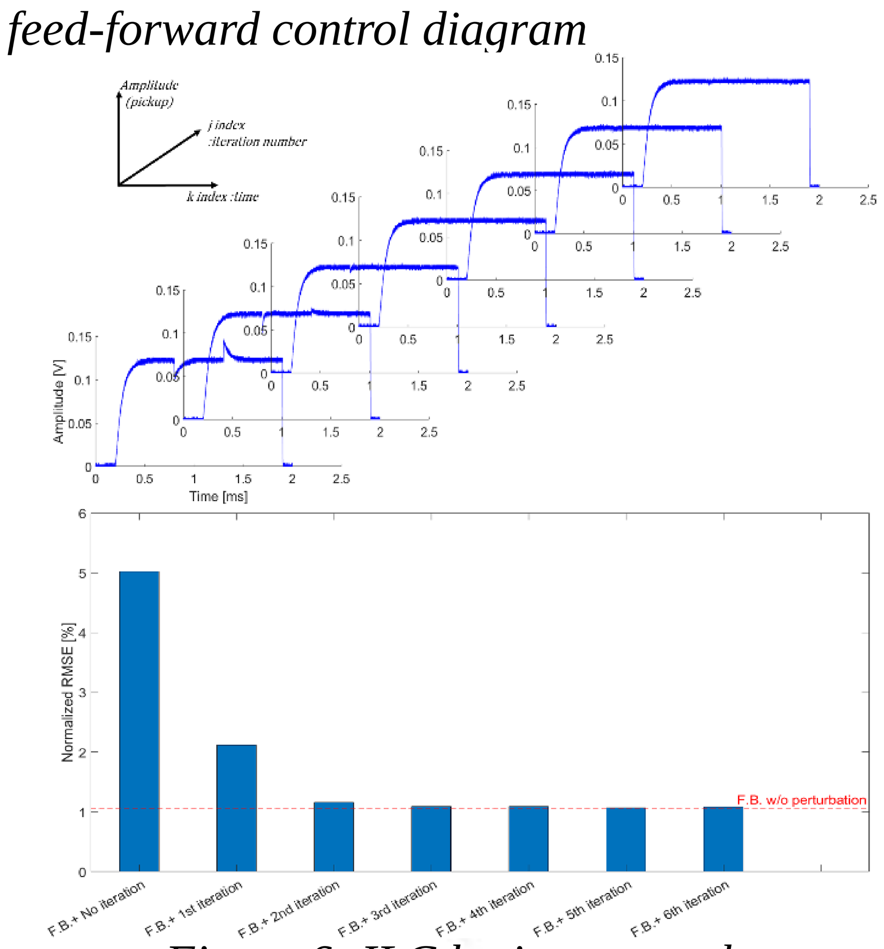

Figure 6: ILC logic test results

- The parallel type ILC(Iterative Learning Control) logic was implemented in the FPGA of digital LLRF.
- An abnormal circumstance where the RF field in the cavity becomes unstable, this logic has a feature to bypass the learning data using 2x1 multiplexer.
- The transient response of a heavy beam loading was immediately compensated with a few iterations because of the fast processing capability of the FPGA, as illustrated in Fig. 6. This test was conducted in 350 MHz dummy cavity.
- ILC with feedback control is capable of compensating for transient response to the same extent as feedback control without transient response.
- Adapt F.F. logic to single RF section of Linac. Under verifying in this month.

1 MeV/n RFQ LLRF system

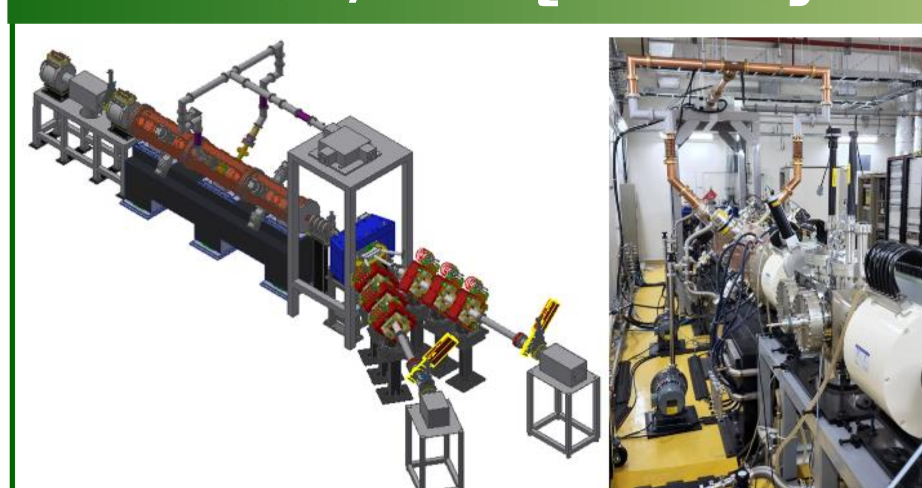

Figure 7: 1 MeV/n RFQ layout and installation

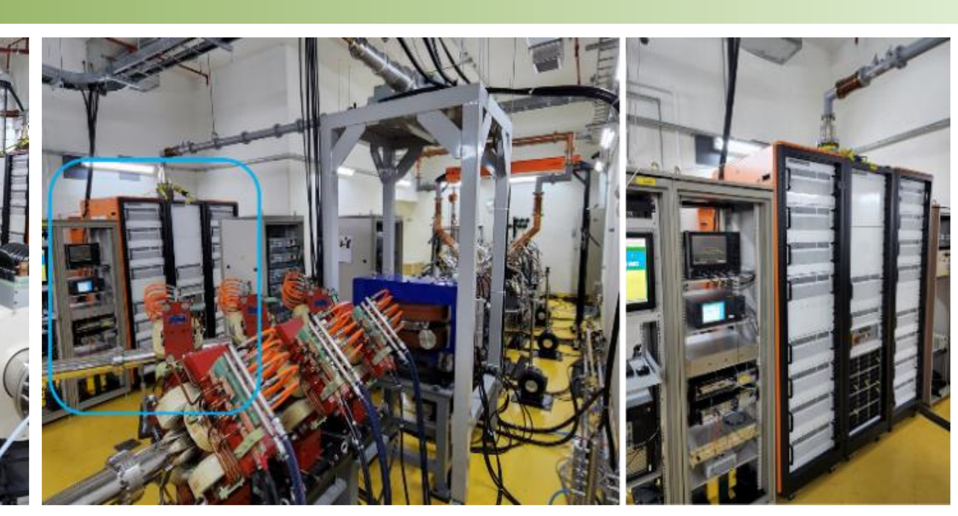

Figure 8: 200 MHz 240 kWp SSPA (TOMCO)

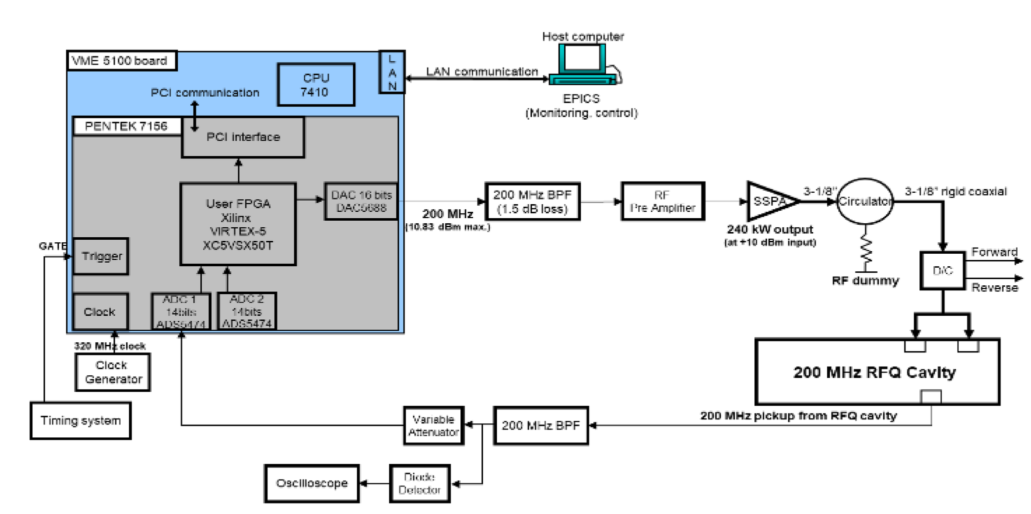

Figure 9: 1 MeV/n RFQ RF chain diagram

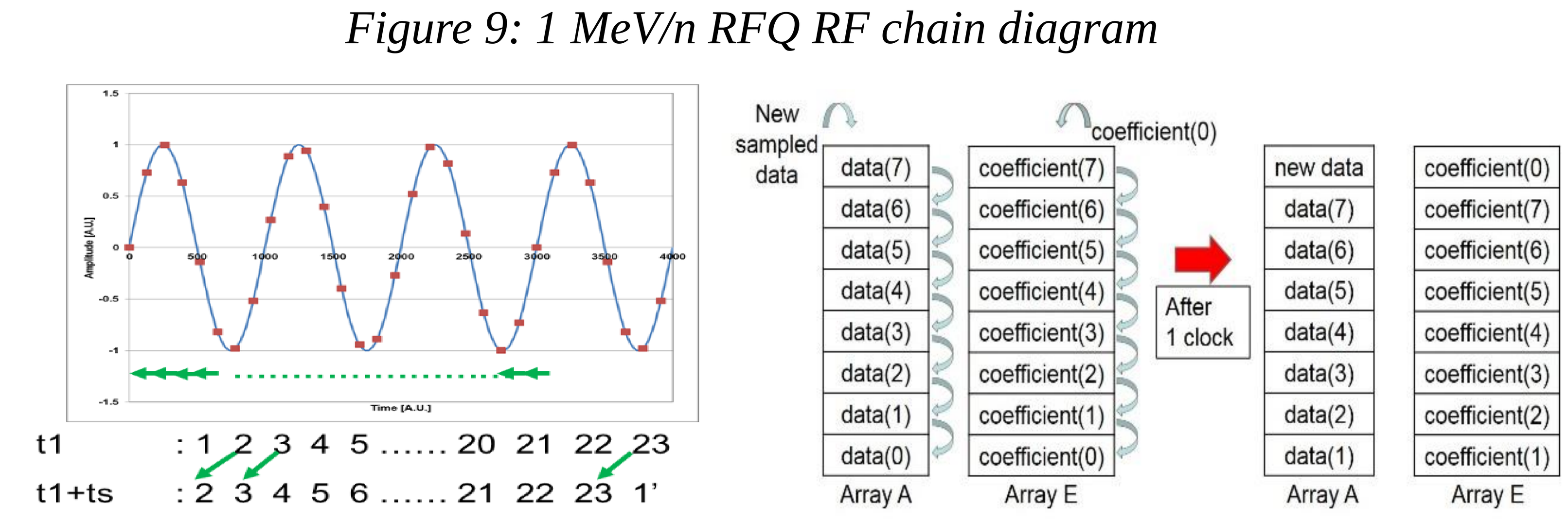

Figure 10: Non-IQ detection using fast upadate rate FIR filter

- 1 MeV/n RFQ was commissioned in 2022 and works in service as a B.T.S. (Beam Test Stand)
- Non-IQ detection implemented in FPGA (320 MHz sampling frequency)
- DDS in FPGA makes 40 MHz, NCO in DAC makes 160 MHz
- Direct RF sampling scheme makes it possible to eliminate the analog mixer.
- Using fast update rate FIR, the I&Q were obtained per every clk.

Future works

- Feedforward logic under verifying in the single section of 100 MeV Linac this month.
- After that, all cavities in 100 MeV Linac will adapt adaptive F.F. logic by next year.

References

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