TRIUMF

Canada's National Laboratory for Particle and Nuclear Physics
Laboratoire national canadien pour la recherche en physique nucléaire
en en physique des particules

LLRF SYSTEM FOR TRIUMF 1.3GHz SRF E-LINAC

Q. W. Zheng, K. Fong, M. Laverty, *TRIUMF, Vancouver, B.C., Canada*

Abstract

The ARIEL (Advanced Rare IsotopE Laboratory) facility is a superconducting electron linear accelerator (e-linac) project and is under construction at TRIUMF. The e-linac consists of an electron gun, an injector cryomodule (ICM) containing one 9-cell accelerating RF cavity and two accelerator cryomodules (ACMs) each containing two 9-cell RF cavities. The key feature of this e-linac is 50MeV 10mA continuous-wave(CW) accelerator utilizing superconducting bulk niobium technology at 1.3GHz.

The low level radio frequency (LLRF) system is set up by using the self-excited mode for the operation of the 1.3GHz high Q SRF cavities. The heterodyne technique of up and down converter is chosen to manipulate the 1.3GHz frequency and the intermediate frequency (IF) of 138MHz for RF signal processing. This paper presents the design schematic diagrams, some measurement and preliminary testing results for the LLRF system.

ARIEL e-Linac LLRF Control

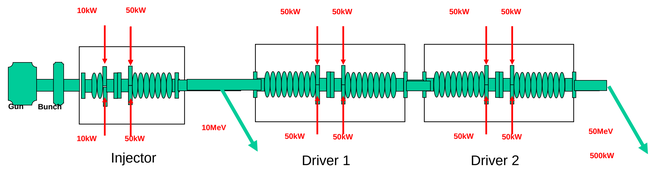

Figure 1: TRIUMF ARIEL 1.3GHz e-Linac

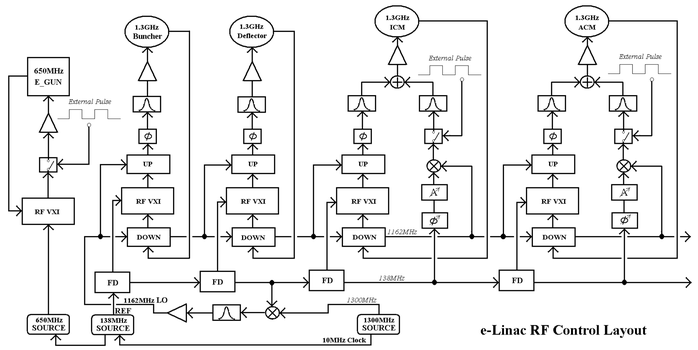

Figure 2: General LLRF control system layout for ARIEL 1.3GHz e-Linac

Figure 2 shows the configuration of LLRF control system for ARIEL 1.3GHz e-Linac. It includes a 650MHz e-Gun LLRF control unit, two 1.3GHz NC LLRF control units, one ICM 1.3GHz SC LLRF control unit and one ACM 1.3GHz SC LLRF control unit. The 1.3GHz NC Buncher and Deflector had been tested with electron beam successfully.

Self-Excited Operation Mode

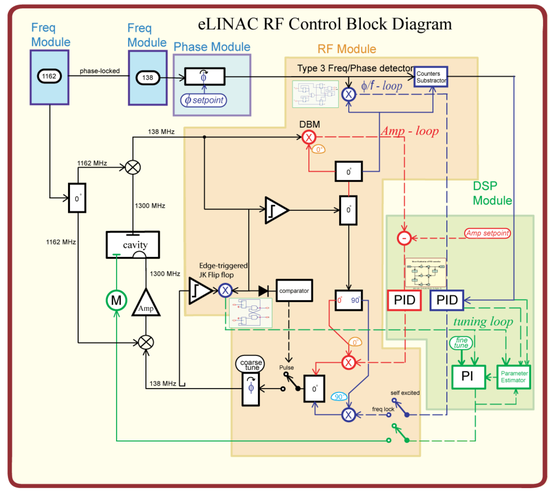

Figure 3: TRIUMF e-Linac LLRF Control Schematic Diagram.

Comparing with the frequency driven mode, the self-excited operation does not require any external frequency tracking as the frequency is determined by the phase lag of the self-excited loop. It is therefore particularly useful for testing of high Q RF cavities that do not have an automatic tuning mechanism.

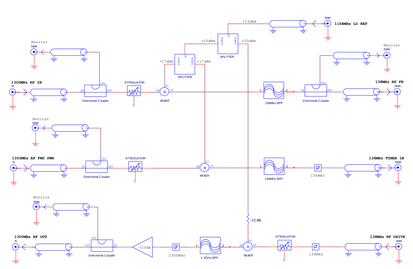

Figure 4: Heterodyne Up/Down Converter

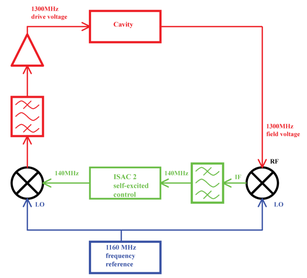

Figure 5: Simplified Self-Excited Mode

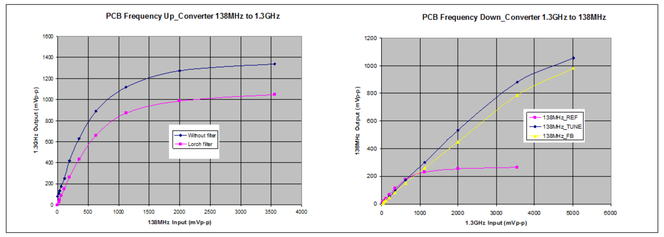

Figure 6: Up and Down Converter Input and Output Response

1.3GHz 9-Cell Cavity Testing

Table 1: 9-Cell Multiple Resonant Modes

Mode	Frequency /Hz	Separated /Hz
1/9π	1,271,096,082	
2/9π	1,273,314,701	2,218,619
3/9π	1,276,798,977	3,484,276
4/9π	1,281,025,508	4,226,531
5/9π	1,285,668,821	4,643,313
6/9π	1,289,999,347	4,330,526
7/9π	1,293,501,901	3,502,554
8/9π	1,295,906,000	2,404,099
π	1,296,647,076	741,076

The resonant frequencies were measured for the ARIEL 9-cell cavity at 2K. Special attention should be paid to the modes that are close to the pi mode.

9/9 pi mode: 1.3000070GHz

8/9 pi mode: 1.2992579GHz

7/9 pi mode: 1.2969436GHz

By means of the loop's phase advance, the pi mode was excited successfully.

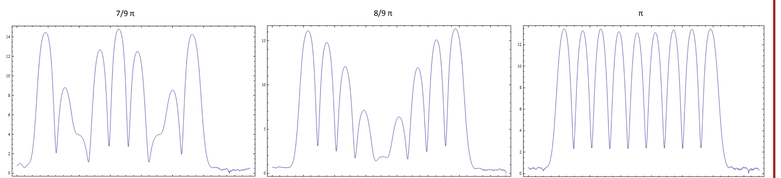

Figure 7: 1.3GHz 9-Cell Acceleration Mode and the Other Two Closest Modes Field Distribution

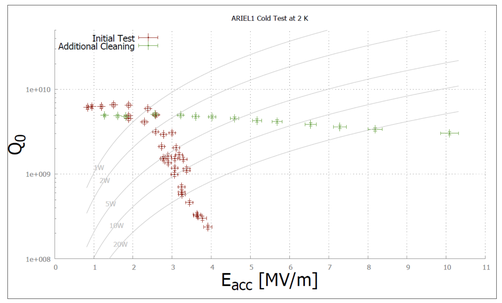

Figure 8: ARIEL 1st 1.3GHz 9-Cell SRF Cavity Q-curve Measurements

The 1st ARIEL 9-cell cavity at 2K was tested at TRIUMF. Figure 8 shows the Q-curve measurement using the self-excited operation of the selected pi mode. For compare, the generator driven operation was also tested without success. Further cold cavity RF testing are needed for both driven mode cavity conditioning and self-excited mode reliable operational performance.

Challenges for Self-excited Operation

1. Pulse conditioning 1.3GHz SRF cavity in the pi-mode
2. Reproducible/reliable turn on of the cavities in cw in the pi-mode.
3. Minimize the cross-talking interference from the reference signal
4. Stable operation with no mode hopping

References

"Self Excited Operation for a 1.3GHz 5-Cell Superconducting Cavity",
K. Fong, M. Laverty, Q.W. Zheng, R. Leewe, 2011 LLRF Workshop, DESY