THE ISAC-II SC-LINAC OVER CURRENT MONITORING SYSTEM

A.K. Mitra, J. Drozdoff, K. Langton, R.E. Laxdal, M. Marchetto, W.R. Rawnsley, J.E. Richards,
TRIUMF, Vancouver, Canada

Abstract

A personnel protection system is used to monitor the ion beam current into the experimental hall from the ISAC-II SC-linac. Two resonant capacitive pickups in the transfer line operate at 35.36 MHz, the third harmonic of the bunch rate. Ion charge, velocity and bunch width affect the sensitivity so calibration with dc Faraday cups is needed. Each monitor has a single conversion receiver with an active mixer. LO signals are provided by frequency synthesizers locked to the accelerator synthesizer. The 1250 Hz IF signals are amplified, filtered with a 100 Hz bandwidth and amplitude detected. An antenna in each monitor loosely couples a pulsed RF test signal to each pickup. These induced signals are mixed down to 11.875 kHz, filtered, detected and used to provide watchdog signals. The measured currents are displayed through our EPICS control system which allows setting of the gain ranges, trip levels and conversion factors. The signals are also processed independently by dedicated analog comparators and CPLDs to cause the Safety system to trip the beam if the current exceeds a nominal 5 to 10 nA.

INTRODUCTION

A pair of Non-Intercepting beam current Monitors (NIMs) have been installed in the ISAC-II accelerator vault downstream of the SC-linac. Fig. 1 shows a recent calibration using dc Faraday cups downstream of each monitor. The sensitivity of less than 0.1 nA is sufficient for generating beam trips from 5 to 10 nA. The pickups have been described previously [1]. The electronics and Safety system aspects will be described here.

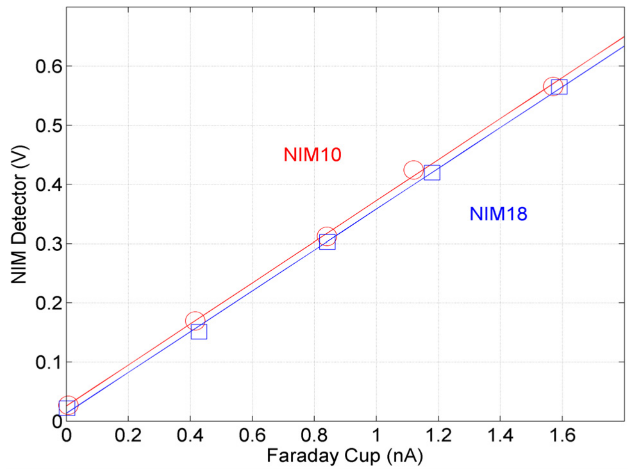

Figure 1: Calibration data using a $^{22}Ne^{+2}$ 2.7 MeV/u ion beam with straight line fits.

SYSTEM

Front End Electronics

The buffered NIM signals are brought out of the vault on Heliax solid shielded coax to the electronics racks, see Fig. 2. Each NIM signal passes through an Analog Devices AD8332 low noise amplifier. The Local Oscillator (LO), an Agilent N5181A frequency synthesizer, is locked to the 10 MHz reference from the accelerator synthesizer to minimize frequency drift. Its frequency is set to be offset from the signal frequency and multiplied by 4 to accommodate the AD8333 I/Q demodulator. The demodulator divides the LO down and

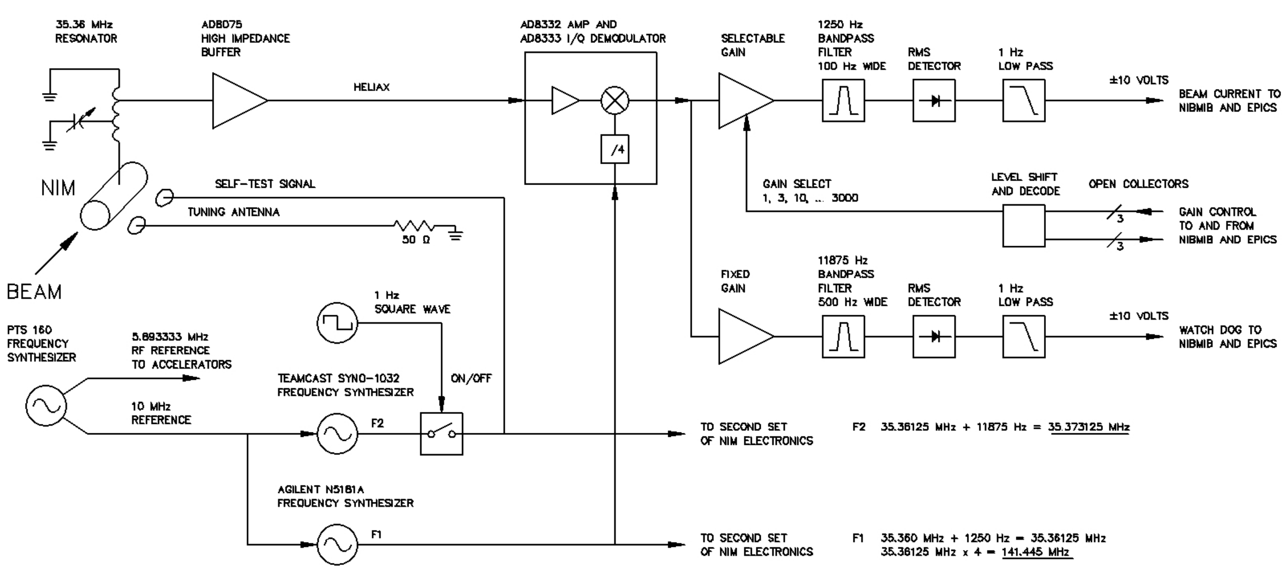

Figure 2: A block diagram of the front end electronics.

mixes it with the 35.36 MHz NIM signal to yield a 1250 Hz IF signal. Image rejection is not used as the background is due to leakage from the RFQ and bunchers which has the same frequency as the beam signal. LF356 op amps amplify the 1250 Hz signal. Wide dynamic range is provided by eight gain ranges which can be selected by the operator. The signal passes through a 100 Hz wide active bandpass filter. Amplitude detection is performed by an RMS converter followed by a low pass filter. The narrowband technique used here is similar to that of an earlier Atlas design [2].

A watchdog signal is provided by a TeamCast SYNO-1032 embedded frequency synthesizer. Its output is pulse modulated by a 1 Hz square wave and fed into the NIM by a small antenna near the capacitive pickup tube. The signal is mixed down to 11.875 kHz by the demodulator and amplified with a fixed gain. It is separated by a second bandpass filter and amplitude detected.

Interface to EPICS and Safety System

The Non-Intercepting Beam Monitor Interlock Box (NIBMIB) monitors the beam current, watchdog, and gain control signals in parallel with the VME/EPICS system, Figs. 3 and 4. The NIBMIB provides a contact closure for the ISAC Safety System based on the monitored signals. The buffered beam current signal is compared to a bipolar threshold manually set by the operators via EPICS and the result of the comparison is fed to a Complex Programmable Logic Device (CPLD), an Altera EPM3256. The buffered watchdog signal is fed into two window comparators which detect acceptable states of the signal and the results are fed to the CPLD. The CPLD monitors the watchdog to determine that it is switching between the acceptable states at a 1 Hz rate. The beam current gain control signals (three bits) set by the operators via EPICS are compared in the CPLD to the actual gain setting returned from the front-end electronics. If the beam current threshold is exceeded, the watchdog is not switching states at the correct rate, or the gain settings don't match then the CPLD opens the contact initiating a beam trip by the ISAC Safety System. A manual reset from EPICS can restore the contact closure once a safe state is restored.

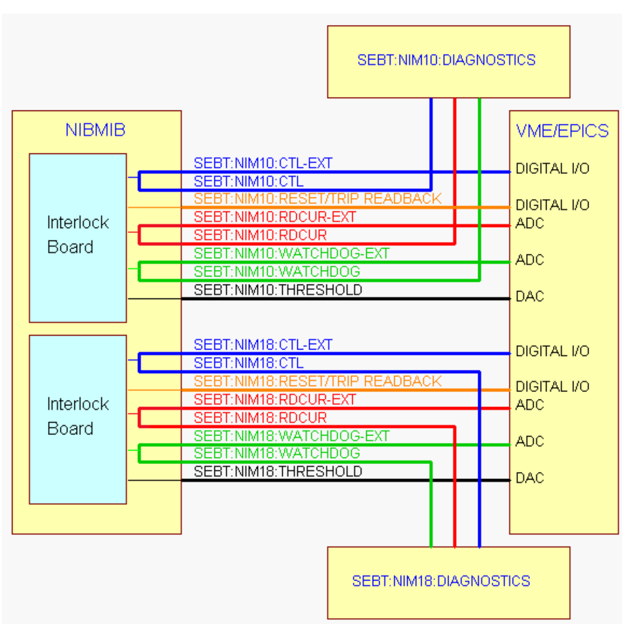

Figure 3: The system interconnections between the front end electronics, the NIBMIB and the VME/EPICS.

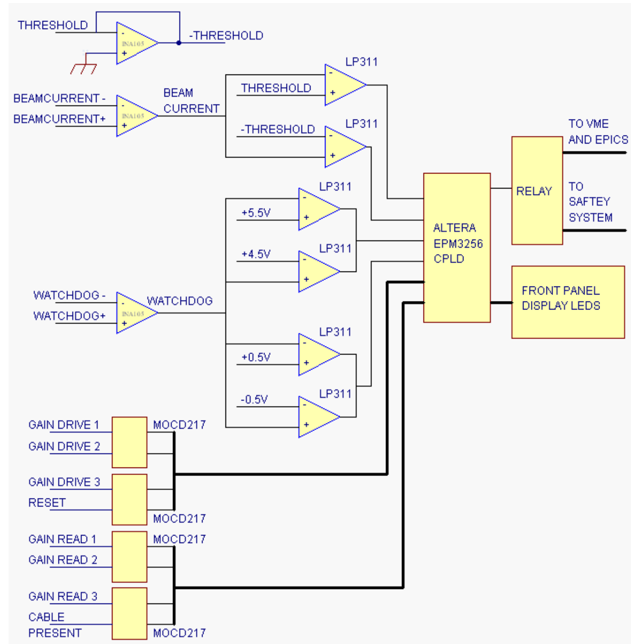

Figure 4: An Interlock Board.

The resolution of the VME ADCs is 11-bits plus sign while that of the DACs is 15-bits plus sign. The EPICS edm display for one of the monitors is shown in Fig. 5. For operator familiarity, it is very similar to that of a dc Faraday cup.

Safety System

The ISAC Safety System (ISS) interlocks ensure that beams with parameter levels above pre-determined Vault NIM set points are not transported into the unshielded Experimental Area but are instead contained in the shielded SC-linac Vault. If any NIM set point is exceeded during beam delivery to the Experimental Area the ISS generates a NIM TRIP and drives in source Faraday Cups as well as a Vault Beamblocker downstream of the SC-linac. After the ISS receives indication that the downstream Vault Beamblocker has indeed reached its in limit, ISS interlocks will allow the source Faraday Cups to be driven out, allowing beam tuning to take place in the shielded Vault. Parameter levels above setpoints must be lowered to be below setpoints before the Vault Beamblocker can be driven out again, resuming safe beam delivery to the Experimental Area. A test of the NIM trip logic using the Safety system simulator is shown in Fig. 6.

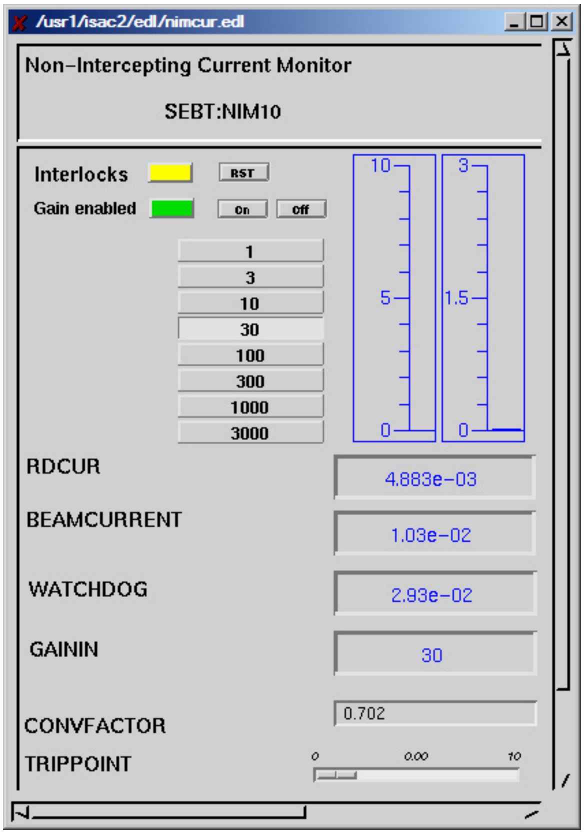

Figure 5: An EPICS edm display, beam off background.

CONCLUSION

Though the NIM system has redundancy and self-test, an independent method of beam current measurement is still a licensing requirement. We have an 11.8 MHz buncher ahead of a 35 MHz RFQ which is followed by an 11.8 MHz chopper. Since the buncher works at the third sub harmonic the time structure after the RFQ has two main peaks spaced by 86 ns and two small satellites between them spaced by 28 ns. The chopper is used to clean the time structure by deflecting the satellites onto the side of a slit while the main peaks pass through. A pickup plate with nearby biased wires will be added to the slit to allow the deflected beam current to be measured. The new pickup will be tested this Fall to determine if the ~3% deflected beam can be reliably measured and used as an indication of total beam current.

REFERENCES

[1] W.R. Rawnsley, R.E. Laxdal, A.K. Mitra, "A Non-intercepting Beam Current Monitor for the ISAC-II SC-Linac" PAC07, Albuquerque, June 2007

[2] J.M. Bogaty and B.E. Clifft, "A Low-Cost Non-Intercepting Beam Current and Phase Monitor for Heavy Ions" PAC'95, Dallas, May 1995, V4, pp. 2625-2627

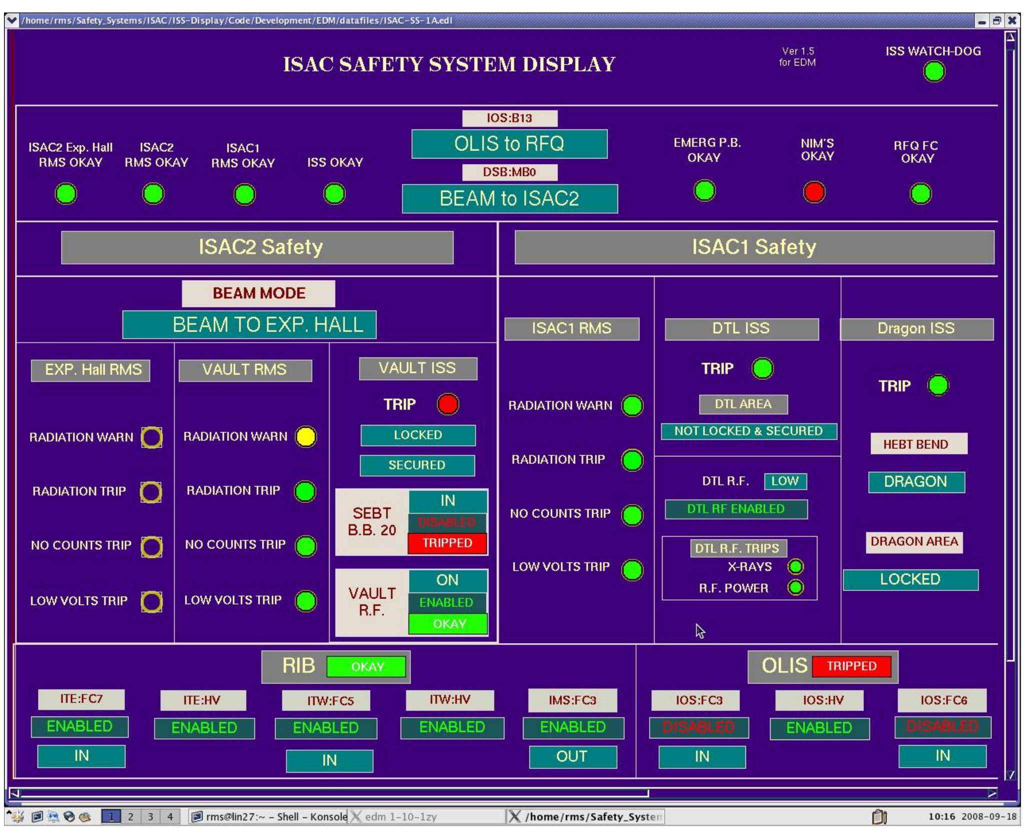

Figure 6: The ISAC Safety System simulator display screen while testing a NIM trip.