FERMILAB SWITCHYARD RESONANT BEAM POSITION MONITOR ELECTRONICS UPGRADE RESULTS

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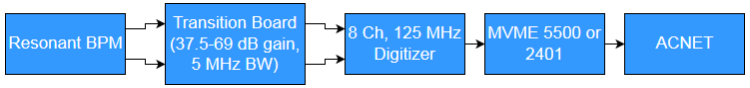
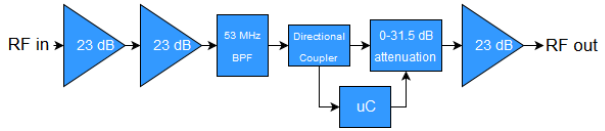
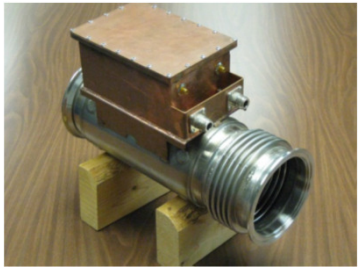
The readout electronics for the resonant beam position monitors (BPMs) in the Fermilab Switchyard (SY) have been upgraded, utilizing a low noise amplifier transition board and Fermilab designed digitizer boards. The stripline BPMs are estimated to have an average signal output of between -110 dBm and -80 dBm, with an estimated peak output of -70 dBm. The external resonant circuit is tuned to the SY machine frequency of 53.10348 MHz. Both the digitizer and transition boards have variable gain in order to accommodate the large dynamic range and irregularity of the resonant extraction spill. These BPMs will aid in auto-tuning of the SY beamline as well as enabling operators to monitor beam position through the spill.

System Description

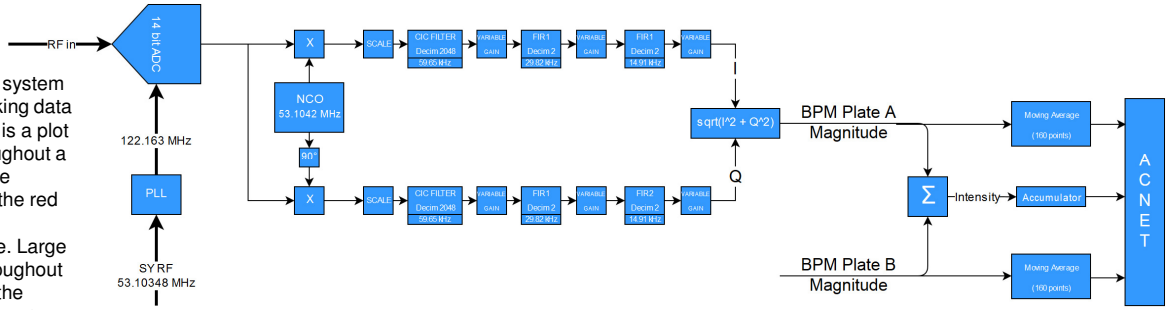


The resonant BPM signal is brought up from the tunnel through either 3/8" or 1/2" Heliax. The transition board has a fixed gain of 69 dB with 0-31.5 dB of attenuation (settable in 0.5 dB increments by a microcontroller), seen in the block diagram below. It also has a 5 MHz bandpass filter in order to increase SNR.



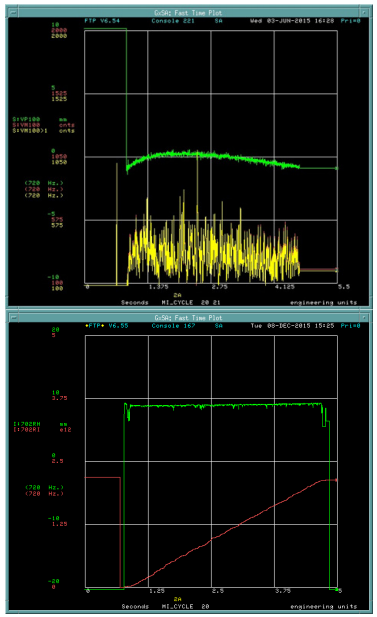


Short version of the Switchyard Resonant BPM, tuned to 53.10348 MHz using a coil inductor



This block diagram shows the details of the DSP chain the data goes through in the digitizer. The signal is down converted to near baseband by mixing with an NCO signal (along with the same signal 90° delayed, for I&Q data). The signal is then put through a decimating CIC filter and two FIR filters for a total decimation rate of 8192. This reduces the amount of data stored, making it possible to retrieve data over the entire 4 second Switchyard spill and plot in real time at 720 Hz.

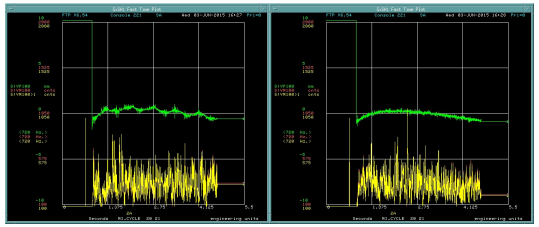
Results and Usage



Top: Position (green) with each plate magnitude (red and yellow)
Bottom: Position (green) and accumulated intensity (red)

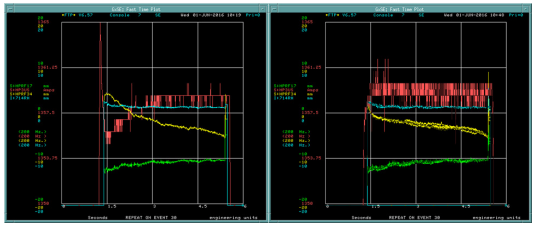
The new BPM electronics system has been installed and taking data for almost a year. Left top is a plot of the beam position throughout a spill. The green trace is the calculated position, while the red and yellow traces are the magnitudes on either plate. Large spikes can be noticed throughout the spill, which illustrates the importance of making the system sensitive to the largest dynamic range possible.

Left bottom shows the position and accumulated intensity throughout a spill. The intensity measurement still requires some fine tuning of the calibration in order to get a precise measurement, but the system has shown consistent measurements of both position and intensity.



Position oscillation issue and mitigation

The NCO frequency had to be chosen carefully, because (due to truncation errors in the DSP chain) if the down converted frequency came too close to DC, it could be seen modulating the calculated position. This was mitigated by carefully selecting the down converted frequency to be notched by the moving average filter.



Beam roll issue and mitigation

One notable use of the real time plot has been to diagnose beam roll in the beamline. The yellow plot is a BPM position reading and the red plot is power supply current for a main dipole string. Once the power supply was better regulated, the beam roll reduced.

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