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Upgrade and Operational Status of the Transverse Feedback System at the Canadian Light Source

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ABSTRACT

The Canadian Light Source (CLS) is a third-generation synchrotron with 24 operational beamlines. To improve stability and provide additional diagnostic tools, the existing Transverse Feedback System (TFBS) was upgraded to incorporate Dimtel equipment in October 2019.

INSTABILITIES

- Driven by impedances.
- Changes in the storage ring affect the threshold associated with the onset.
- Transverse beam stability is impacted by the following[6][7][8][9]:
  - Resistive Wall Instability
  - Ion Trapping Instability
  - Fast Beam-Ion Instability

HARDWARE

There are three main parts to the Transverse Feedback System (Figure 1) [4]:

1. A Detection System to measure the beam oscillations.
2. A Processing Unit which converts the demodulated BPM signals into a series of correction signals.
3. A broad-band power amplifier and the kicker assembly which acts on the beam.

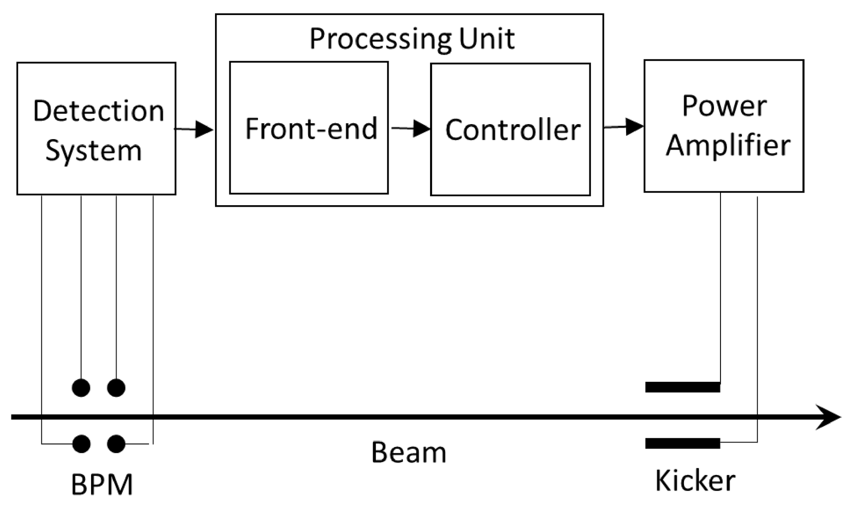

Figure 1: Transverse Feedback System hardware configuration

The major electrical components include one Dimtel FBE-LT, three Dimtel iGp12 500 MHz processing units and four R&K A009K251-505OR RF Power Amplifiers.

The Dimtel TFBS is currently used:

- To damp the betatron oscillations associated with coupled-bunch instabilities.
- For tune measurements.
- For bunch cleaning.

BUNCH-BY-BUNCH FEEDBACK

In bunch-by-bunch feedback the correction signal for a given bunch depends solely upon the past motion of that bunch. The bunches are processed sequentially, and the correction kicks are applied on a subsequent turn [2].

TUNE MEASUREMENTS

The betatron tunes are critical machine parameters that impact the stability of the beam. The betatron tune can be split into two components: the integer tune, defined as the number of complete oscillations the particle undergoes during one revolution, and the fractional tune, which represents the fractional difference in phase of the oscillation from one turn to the next. The TFBS can only measure the fractional tune [11].

With the original TFBS we were not able to measure the fractional tunes during normal operation because the kick required to measure the tune caused unacceptable perturbations in the orbit. Using the Dimtel hardware we are now able to parasitically measure the fractional tune using the notch method. In closed loop operation, the spectrum of beam motion shows a notch at the betatron frequency. Tracking the location of this notch allows us to track the tune.

BUNCH CLEANING

The existing CLS gun and the switching time of the video deflectors do not permit injection into a single bunch. As a result, any unwanted bunches need to be kicked out after injection [1]. The TFBS is used as a bunch cleaner in the vertical plane, where selected bunches are knocked out of the storage ring.

Cleaning approach:

1. Maintain feedback for bunches to be kept.
2. Turn off feedback for bunches to be cleaned.
3. Apply swept frequency sinewave excitation to the bunches to be cleaned.

ISSUES

After successfully running for multiple months we encountered an issue in February 2020, when noise appeared in the averaged spectrum of beam motion (Figure 2).

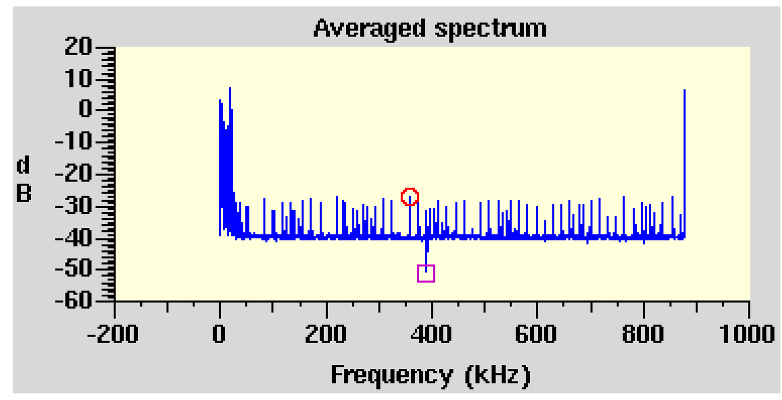

Figure 2: Transverse Feedback System showing noise in averaged spectrum

Further analysis indicated that both X and Y showed a pattern of lines centered at 50 MHz, which were the strongest lines in the spectrum. There were also dual lines spaced by 80 kHz, and multiple pairs centered at 1.4825 MHz with various offsets [5].

We:

- Tested the BPM buttons using a spectrum analyzer and did not see any interference.
- Confirmed that the hardware was not introducing the noise by using a signal generator to inject a clean sine wave into the front-end.
- Confirmed that no systems were being tested with pilot tones.

This noise persisted for one month and then disappeared from the averaged beam motion spectrum in March 2020 (Figure 3).

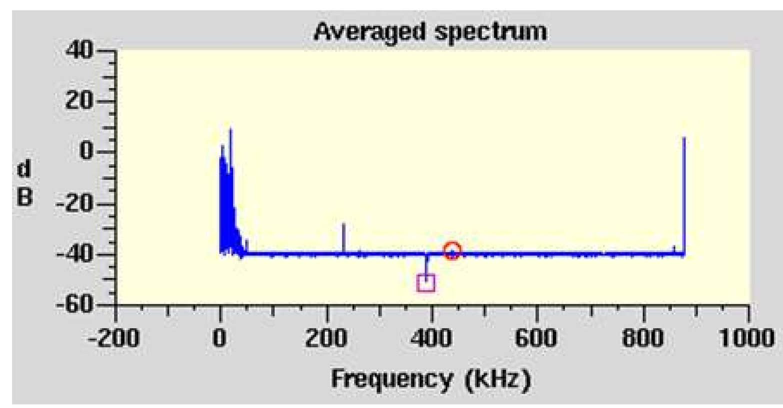

Figure 3: Transverse Feedback System showing expected averaged spectrum

FUTURE ENHANCEMENTS

- Commissioning of tune feedback control is currently underway.
- Evaluation of modal instabilities inherent in our machine.

CONCLUSIONS

Integration of the Dimtel hardware into our existing control system went extremely well. We are now able to successfully suppress instabilities that the old system could not. The enhanced features of this upgraded Transverse Feedback System will be used to learn more about our machine.

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