Matlab Feedback Prototypes

Introduction

Beam-based Feedback systems are to be prototyped in MATLAB for the first commissioning of the LCLS system in early 2007.   There are six beam-based feedback systems to be tested in the first commissioning run.

This Beam-based Feedback in MATLAB will also be used in the second LCLS Commissioning run starting December 2007. Several new feedbacks will be implemented for this second commissioning run. It has been decided that the MATLAB Feedbacks will control and read ONLY EPICS devices (RF, Magnets, BPMs). During the second commissioning phase many devices will remain under SLC control, so the discriptions below indicate how each feedback will be implemented until all devices are under EPICs control.

A description of each feedback follows.

Bunch Charge

The Bunch Charge feedback stablizes the bunch charge of each pulse at the RF gun. This feedback is a accomplished with a set of two nested feedback loops. An inner loop, local to the laser system, adjusts the wave-plate angle, and therefore the laser pulse energy, by measuring the laser energy with a Joule meter near the cathode. An outer loop controls the energy setpoint of the inner loop, based on the total bunch charge measurement of the toroid IM01, near the RF gun. the inner loop is implemented in EPICS on the associated laser IOCs. The outer loop is a beam-based feedback implemented in Matlab.

DL1 Energy

The DL1 Energy feedback maintains a constant beam energy at DL1. the x-position reading of BPM13, a measure of relative energy, is used to calculate adjustments to the phase (or amplitude?) of the klystron L0B.

Energy at the Spec. Dump

The Spectrometer Dump Energy feedback loop is identical to the DL1 Energy loop, except it is used when the beam is directed to the spectrometer dump rather than into Sector 21.   In this case, BMPS2 or BPMS3 x-position is used to measure the relative energy.

DL1 Energy + BC1 Energy + BC1 Bunch Length

The BC1 location along the linac requires both energy and bunch length stabilization.   This feedback loop will include the energy at DL1 as well, so that the energy feedback from RF gun through and beyond BC1 work together as a single loop. BPM13 and BPMS11 are used to measure the relative energy, BL11 is used to measure the relative bunch length. These measurements are used to adjust the phase (or amplitude?) at L0B and the amplitude and phase of L1-S. In the case where BL11 is not used, the DL1 + BC1 energies alone may be stablized with this loop.

Injector Launch

The Injector Launch feedback is required to stabilize the trajectory of the beam as it enters the linac at Sector 21. The x-position and y-position measurements of BPM9 through BPM15 will be used to calculate adjustments to the desired B-field of the XCO4 / YCO4 and XCO7 /YC07 corrector magnets. This feedback attempts to stabilize the states: x-position, x-angle, y-position, y-angle of the beam.

X Cavity Launch

The X Cavity Launch feedback is required to stabilize the trajectory of the beam at the X Cavity. The x-position and y-position measurements of BPM21201 are used to calculate adjustments to the desired B-field of the XC11 / YCA11 corrector magnets. This feedback attempts to stabilize the states: x-position and y-position of the beam.

RF phase of Transverse Deflecting Cavity

This feedback is used to stabilize the phase of the beam with respect to the RF field of the cavity. This feedback is used only during a Bunch Length Measurement and is integrated into the Bunch Length Measurement application.

Gun Launch Feedback

This feedback is used to stablize BPM5 in X and Y using the XCO1 and YC01 corrector magnets.

DL2 Energy

The Energy and Bunchlength feedbacks of the first commissioning will be expanded to include energy at DL2, energy at BC2 and bunchlength at BC2. These six parameters will be maintained by a single Longitudinal feedback that is configurable. It will allow the user to choose which states, actuators and measurement devices will be used. It will also include some automatic detection of certain conditions, such as no beam past TD11 etc. The requirements are documented in the Beam-based Feedback in MATLAB Requirements Document.

NOTE: There are only 3 EPICS controlled BPMs planned for the BC2 commissioning phase (until about Nov. 2008) so the longitudinal feedback will only include DL1 energy, BC1 Energy, BC1 Bunch Length, BC2 Energy and BC2 Bunch Length, until all BPMs are under EPICS Control.

Energy at BSY

It is necessary to stabilize the BSY energy when the beam is diverted from entering the LTU at BSY.

See DL2 Energy above.

DL2 Energy + BC2 Energy + BC2 Bunch Length

See DL2 Energy above.

L2 Launch

The L2 Launch feedback is a transverse feedback used to stabilize the beam trajectory in the L2 region. The BPMs in this area are all under SLC control for the second commissioning. It was decided to leave the correctors for this feedback under SLC control as well, so that this feedback can be implemented with existing SLC feedbacks.

L3 Launch

The L3 Launch feedback is a transverse feedback used to stabilize the beam trajectory in the L3 region. The BPMs in this area are all under SLC control for the second commissioning. It was decided to leave the correctors for this feedback under SLC control as well, so that this feedback can be implemented with existing SLC feedbacks.

References

Magnet Interface: see the Magnet Application Programmer Interface document at Sharepoint Power Supplies and Control Hardware page

Magnet max B-field values: see Requirements for LCLS Dipole Steering Corrector Magnets

LLRF Inteface: see RF Actuator Information

Event System Interface:

BPM Interface:

Bunch Length Monitor Interface:

Toroid Interface:

Laser Energy Loop:

Beamline Optics: See LCLS Linac Current Beamline Design Optics Files. For the full machine see LCLS Optics/Element List, for Injector to Spectrometer Dump see 135-MeV Spect. Optics/Element List

Feedback Support Soft IOC Device and PV names: see Feedback Support Soft IOC

Machine control and Authority issues: see Machine Control and Effects on Feedback Design

Also, see requirements documents below.

Requirements and Design

The matlab feedbacks are prototypes, and as such are not subject to the rigorous documentation requirements of production-level software for LCLS. These prototypes will be used as learning tools for the final design of an EPICS-based fast feedback to be developed for the LCLS second commissioning run in early 2008.

Controls Requirements for LCLS Feedback Systemsdocuments the final requirements for the fast feedback EPICS implementation. This document is used to guide development of the prototypes.

Beam-based Feedback Software Requirements Document This documents the feedback reequirements for BC2 commissioning, starting Dec. 2007

Bunch Charge Feedback Loop

Testing

There is a development environment test setup for testing feedback loop designs before running them in the production environment. This setup includes:

- the FbckSimulator soft IOC that simulates the devices needed in each individual feedback loop to be created.
- the EDM screens for the FbckSimulator soft IOC
- the development FbckSupport soft IOC , sioc-sys0-fb0d.
- the development version of the xml configuration file needed for each feedback loop. Stored in $MATLABDATAFILES on the development nfs file system.

- the development version of the edm screens

User Guide

Beam-based Feedback in MATLAB: powerpoint presentation slides Matlab Feedback How-to.ppt attached, see Attachments tab above

Task Lists and Schedules

The Feedback Prototyping project includes several sub-projects. A task list and schedule is (will be...) included for each:

- Matlab Framework for Feedback Applications
  - add in actuator readback checking for all loops
  - find a fix/workaround for Matlab file dialog error
  - add labels to the matrix GUI so that the matrix elements are identified.
  - can we make the feedback application a totally background app - so there is no window at all?
  - in configuration application - indicate a minimum number of measurement devices needed for each feedback
- soft IOC for stored Feedback data and dynamic setpoints - called FB00 in prod, FB0D on development network
  - add feedback Gain values to the softIOC
  - Archive gains, weighting changes, mask matrix
  - create PV to alarm on Actuator saturated, major, near saturation, minor
  - DONE put saved actuator values into save/restore
  - DONE put note under Network | sioc-sys-fb00 to stop all feedbacks before re-booting
- EDM and other displays
  - DONE Remove all the purple
  - how to bring-to-front EDM displays that are up already when you push the button that is supposed to bring it up?
- Recreate the feedback simulator for testing
  - DONE remove dependancies with magnet subsystem/timing subsystem
  - add simulation for longitudinal BC2 energy, DL2 energy, BC2 Bunchlength
- Individual Feedbacks
  - Longitudinal
    - add Energy and Chirp PVs to soft IOC so that we can calculate the 24-1 phase & 24-2 phase settings that will create the Energy and Chirp (effectively)
    - develop a scanning application that will scan energy and chirp to find the lower and upper limits of the BLENs
    - Develop a BLEN calibration routine (see my notes)
    - add in and test automatic switching capabilities - via mask matrix
  - Transverse
    - add error(dX, dY - resPV), weighting, and chisq values in fit function data
    - weighting can allow Launch feedbacks to automatically ignore missing BPMs
    - evaluate other methods of dynamic reconfiguring (BPMs here)