RHIC 10 Hz Intersecting Region Orbit Measurement and Feedback System Overview

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Introduction

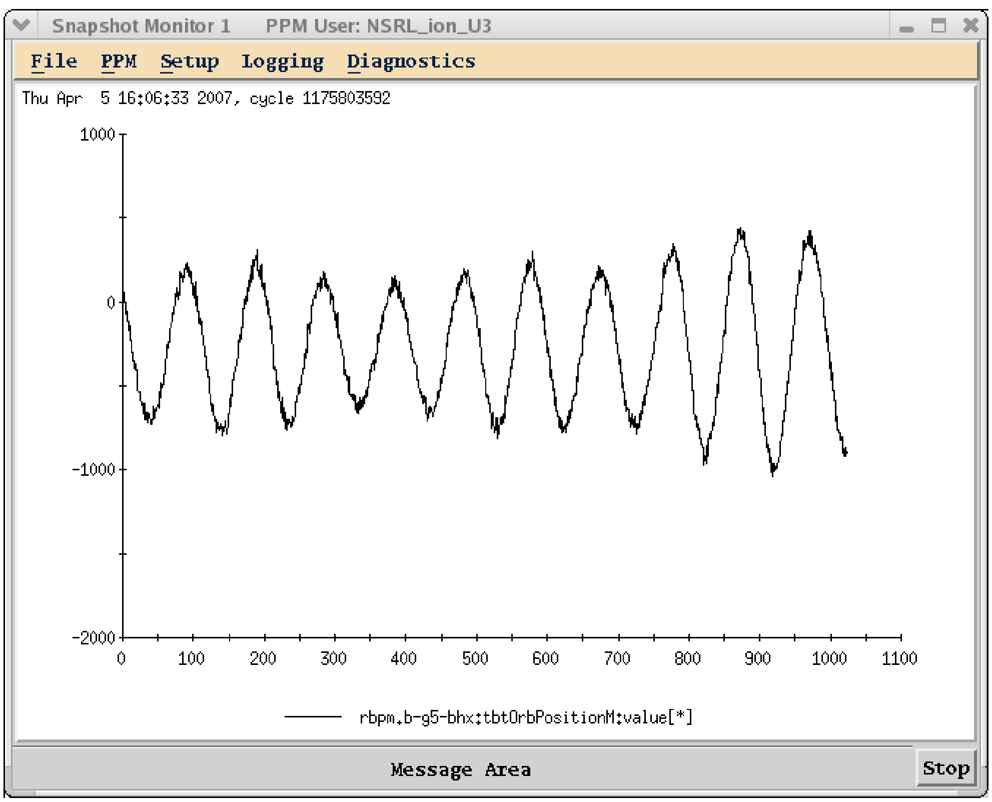
This document provides an overview description of the 10 Hz Intersecting Region Orbit Feedback system (IRFB).

Purpose of the System

Beam oscillations in the frequency range of 10 Hz are prevalent in both blue and yellow beams, and the source is suspected to be triplet magnet vibrations due to the cryogenic system.

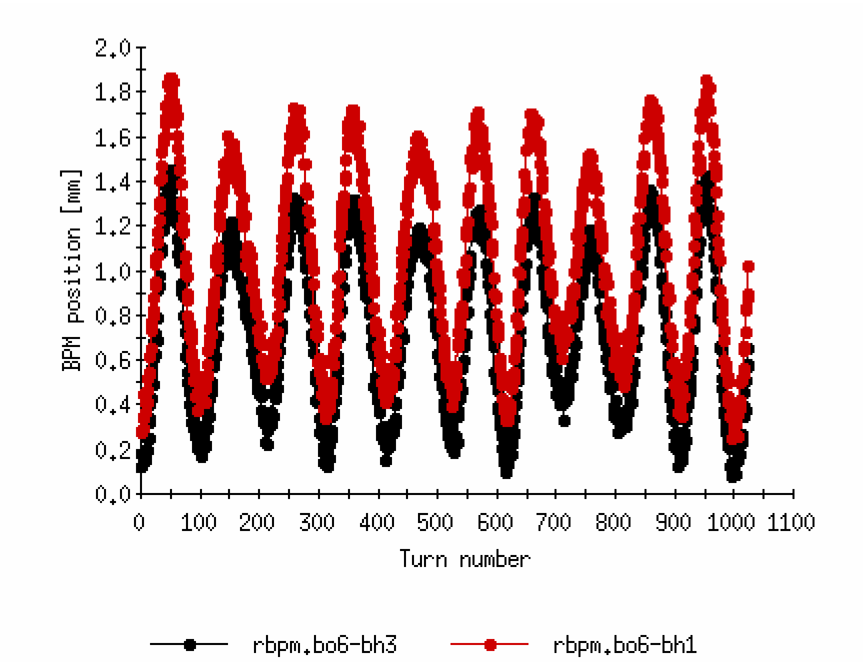
The purpose of the 10 Hz IRFB system is to apply a correction to the blue beam at the 6 o'clock and 8 o'clock intersecting points such that the difference between the blue and yellow beams is minimized.

A one second period as measured with gold beam by the blue g5-bhx IFE (integrated front end) BPM is shown below.



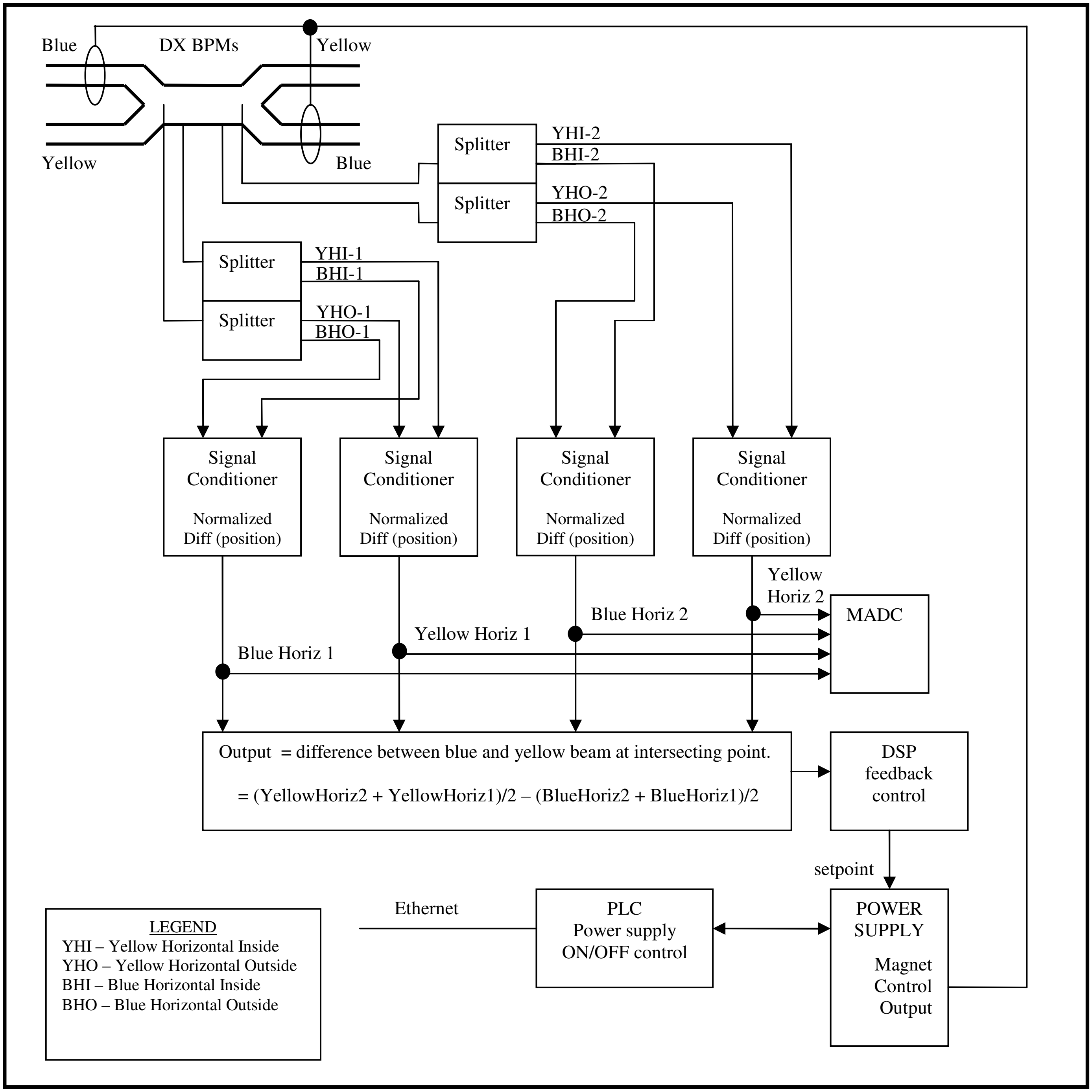
This plot is typical and shows that the peak-peak oscillations are around 1.5 mm at the DX BPM.

Another plot below shows the 10Hz oscillations at bo6-bh3 and bo6-bh1.



System Block Diagram

A block diagram of the 10 Hz IR Feedback system is provided below.



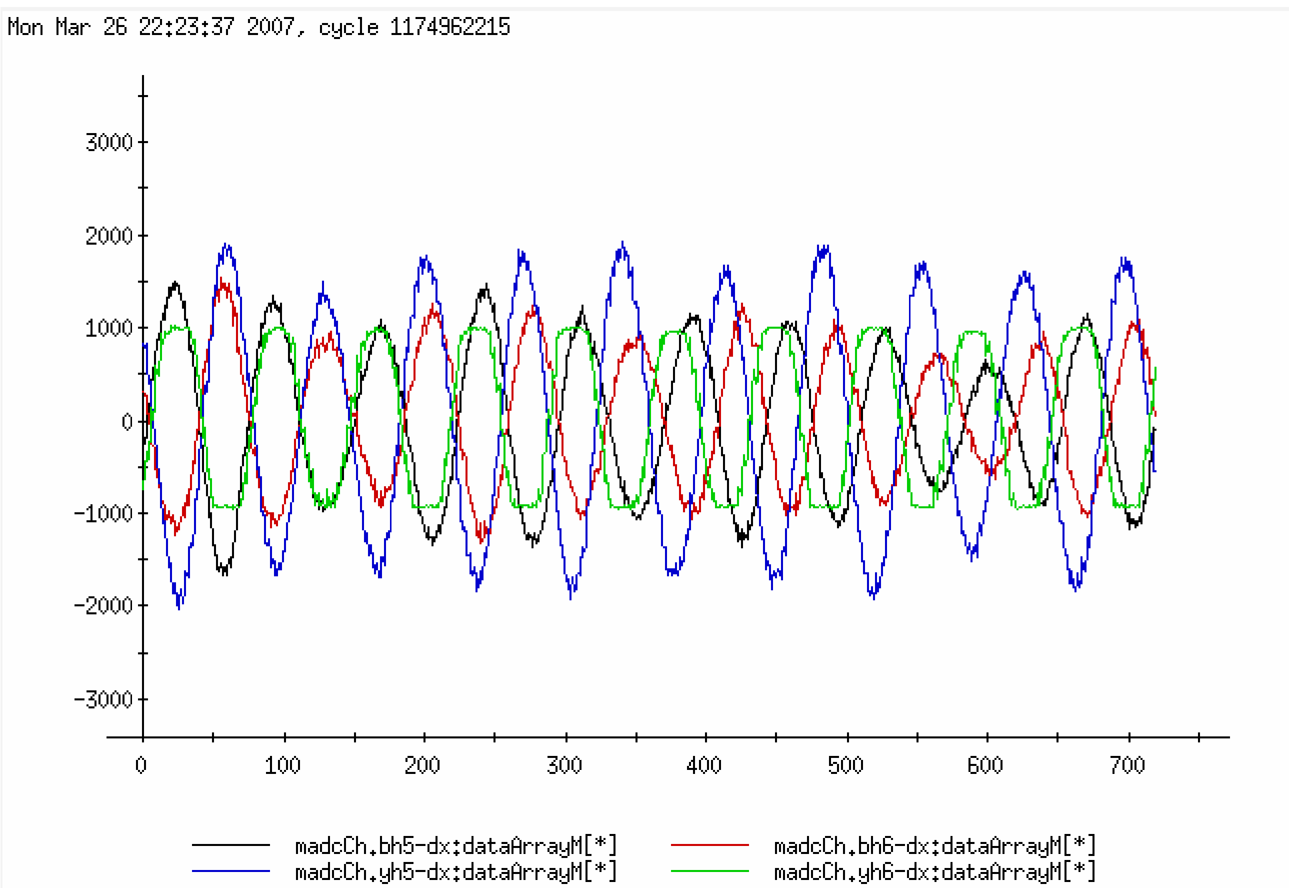
Overview of Operation

The signals from the horizontal DX BPMs on each side of the IP are split and provided as inputs to four 10 Hz signal conditioner modules to measure the position for the blue and yellow beams. The difference between the blue and yellow beams at the collision point is calculated by subtracting the average of the blue DX position measurements from the average of the yellow DX position measurements.

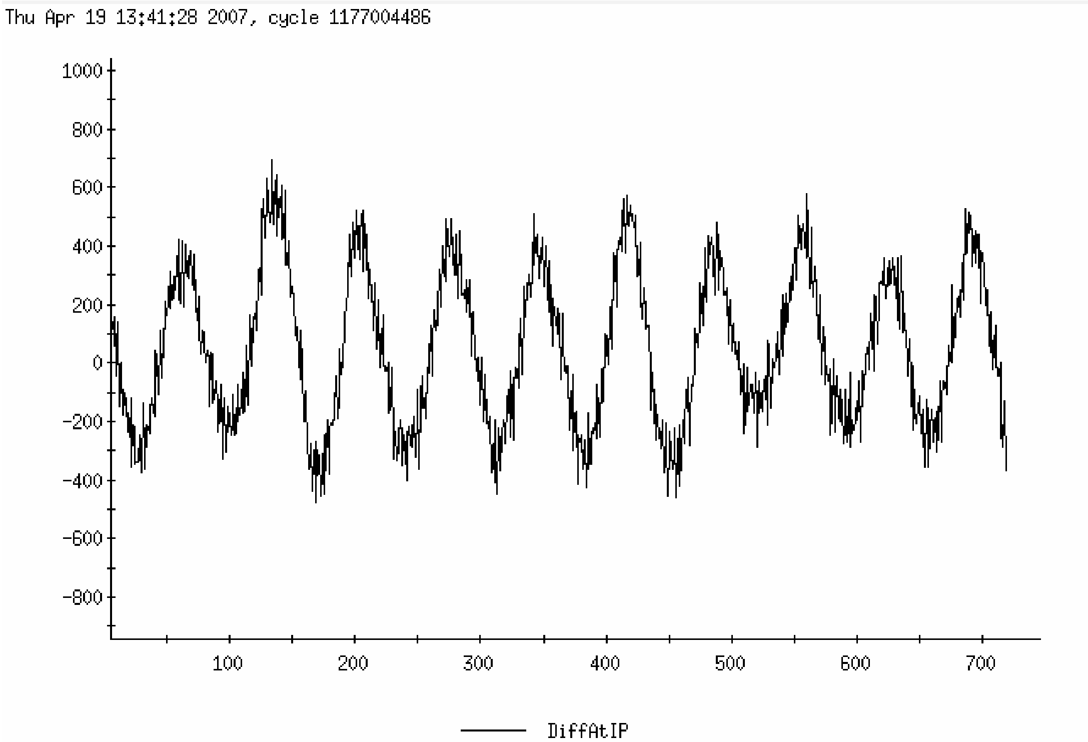
The DSP algorithm uses the beam position difference measurement to determine the magnet power supply output required to control the blue beam such that the blue beam overlays the yellow beam, thereby minimizing the difference signal.

The signal conditioner position output values are also connected to MADC channels to provide to provide logging and general purpose monitoring of the signals.

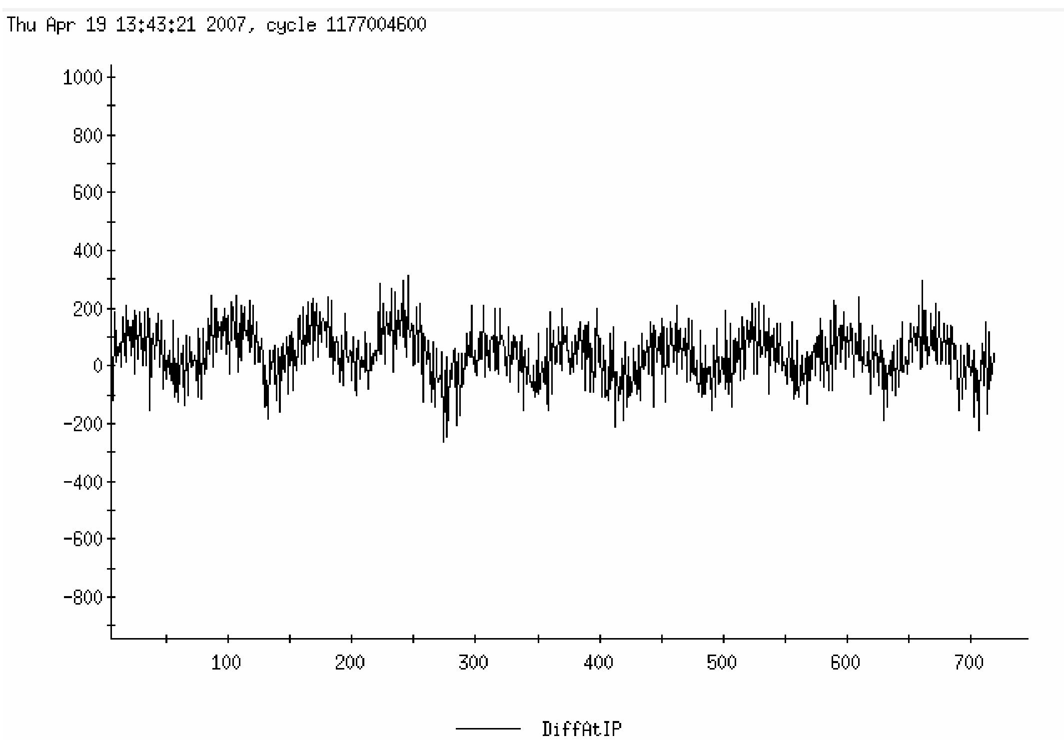
Below is a plot of the four 10 Hz signal conditioner modules in IR6 with gold beam during the 2007 RHIC Run. The Y scale is not calibrated but is roughly equivalent to 1/3 micron per count.



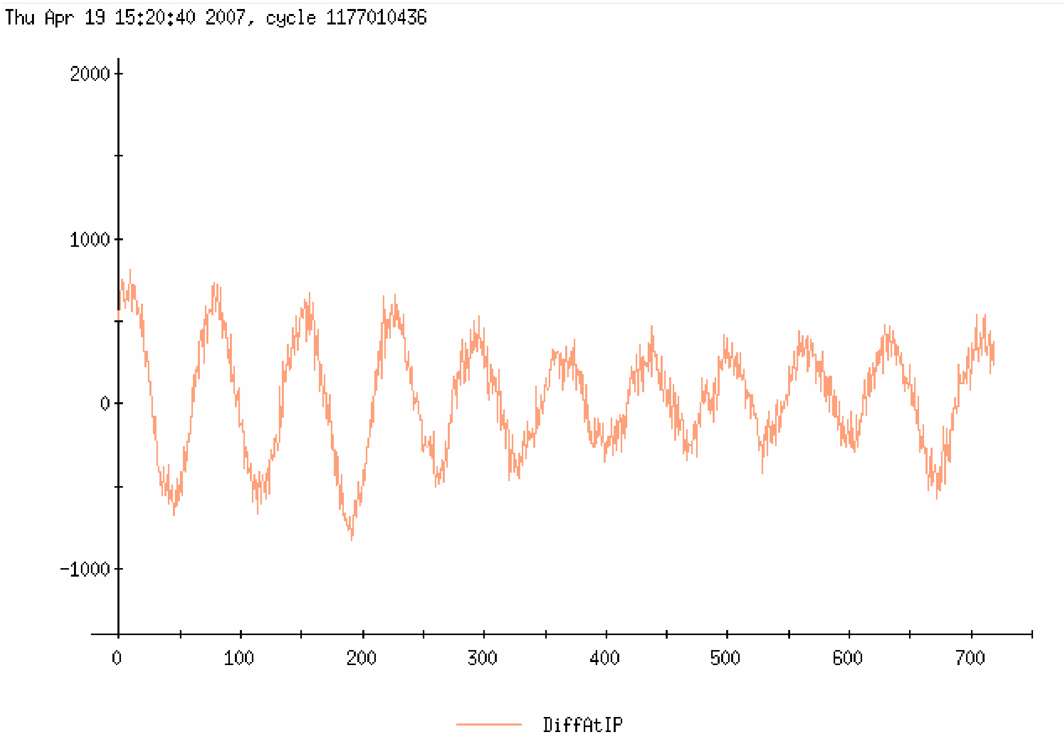
The next four plots below provide a comparison of the beam difference signal with feedback OFF and with feedback ON at the 6 o'clock and 8 o'clock intersecting regions. The Y scale is not calibrated but is roughly equivalent to 1/3 micron per count.



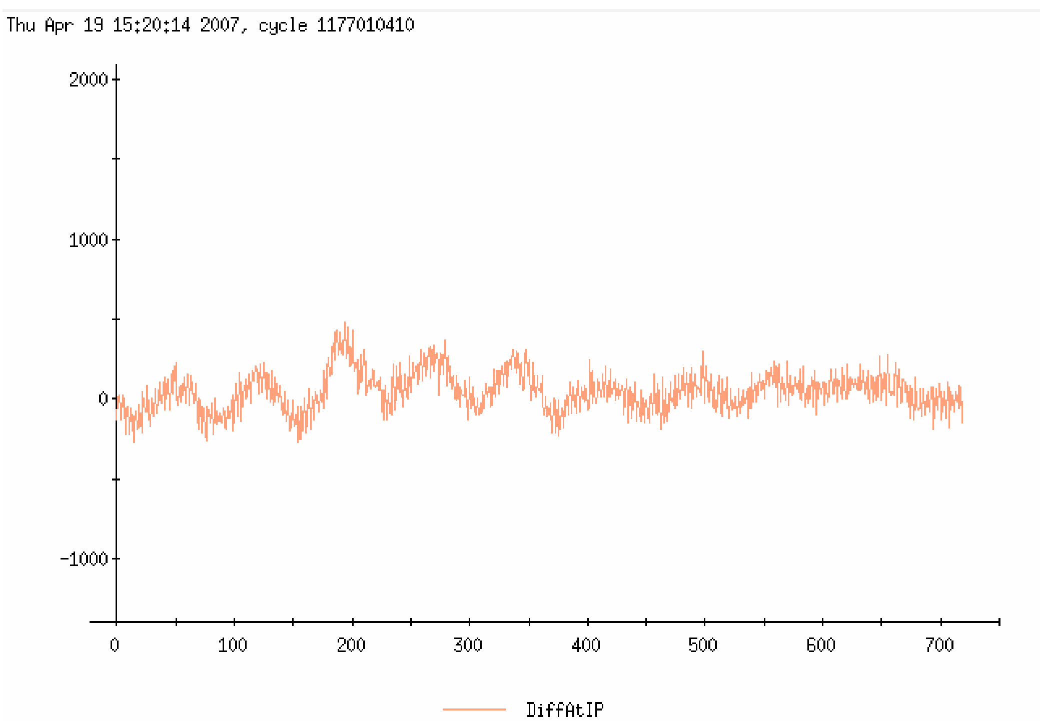
IR 8 difference between blue and yellow beams as calculated
using DX 10 Hz Signal Conditioners, with 10 Hz feedback OFF.



R 8 difference between blue and yellow beams as calculated
using DX 10 Hz Signal Conditioners, with 10 Hz feedback ON.



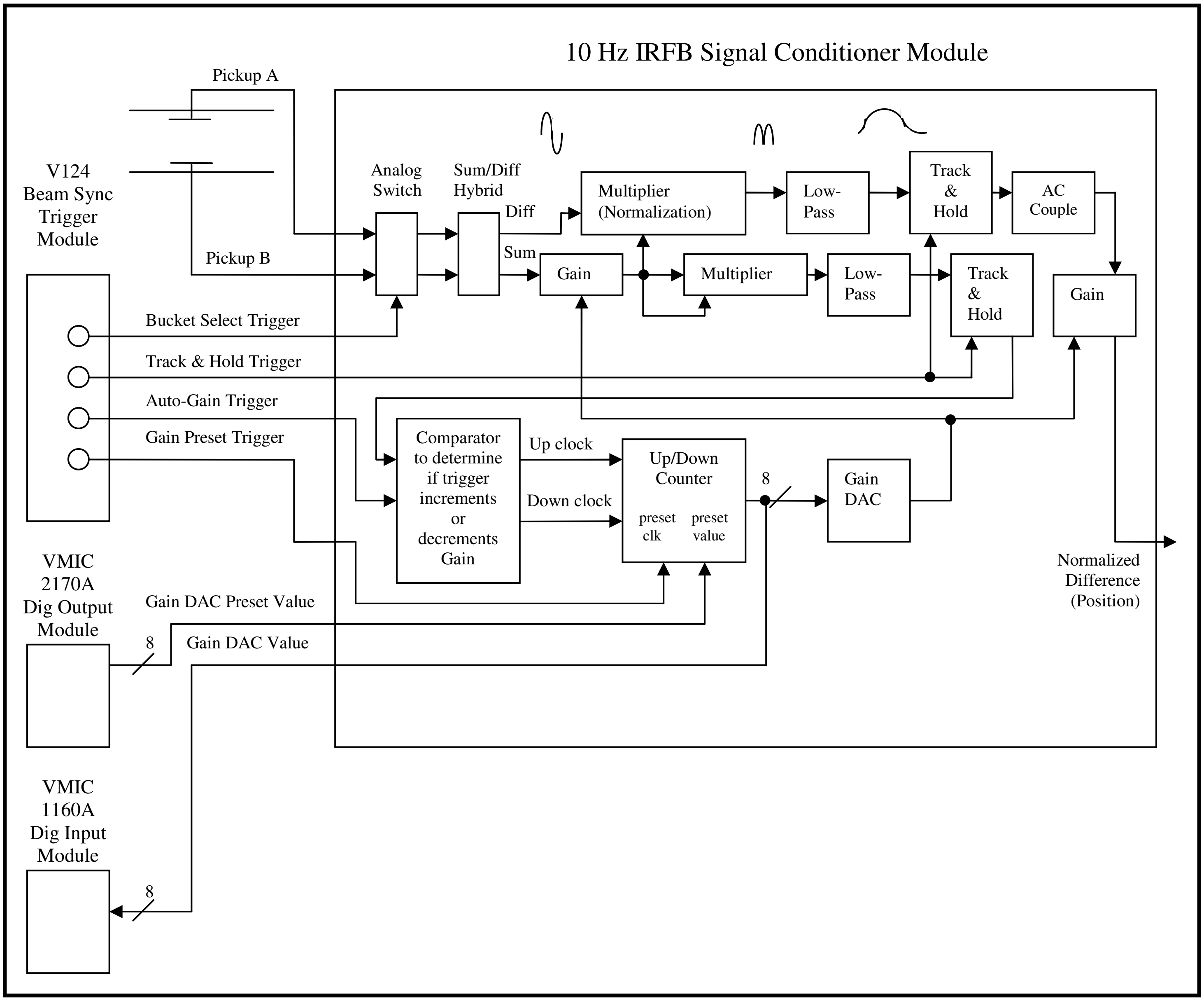
IR 6 difference between blue and yellow beams as calculated using DX 10 Hz Signal Conditioners, with 10 Hz feedback OFF.



IR 86 difference between blue and yellow beams as calculated using DX 10 Hz Signal Conditioners, with 10 Hz feedback ON.

10 Hz Signal Conditioner Block Diagram

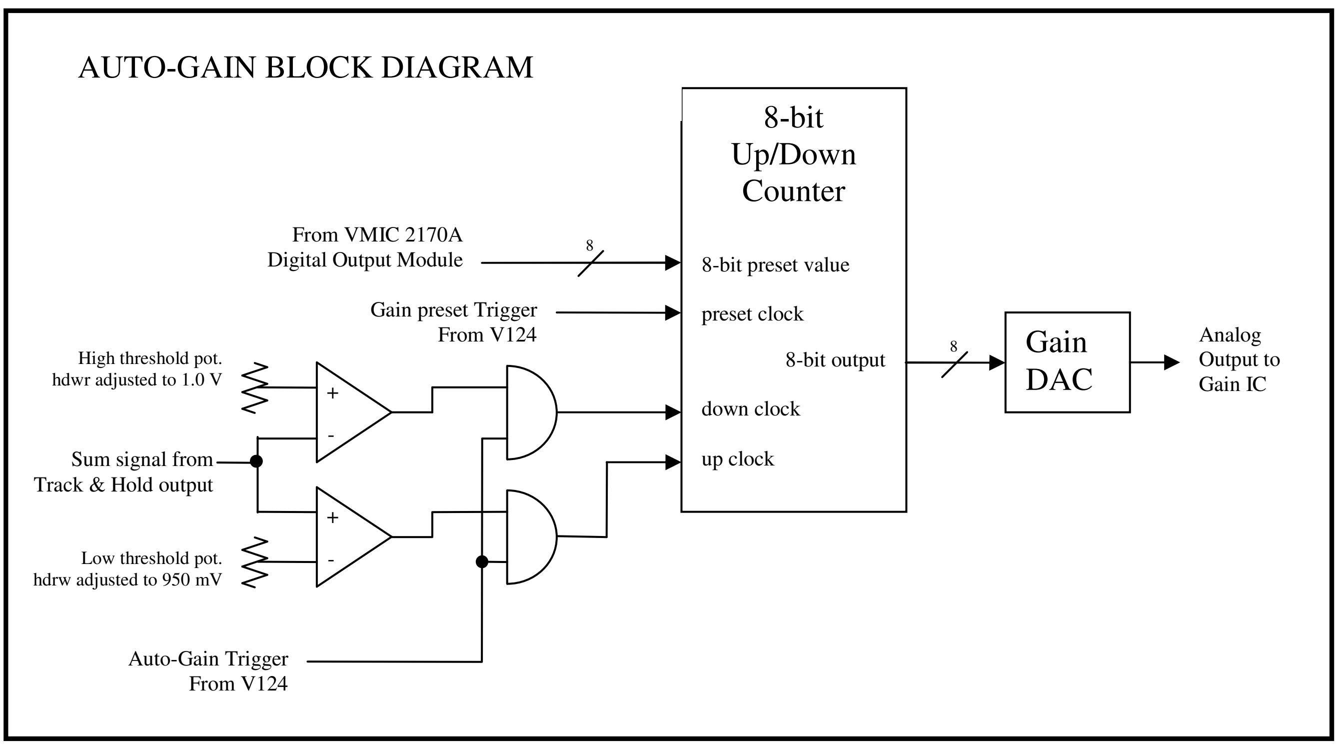
The block diagram for the 10 Hz Signal Conditioner including associated control signals is shown below.



Auto Gain

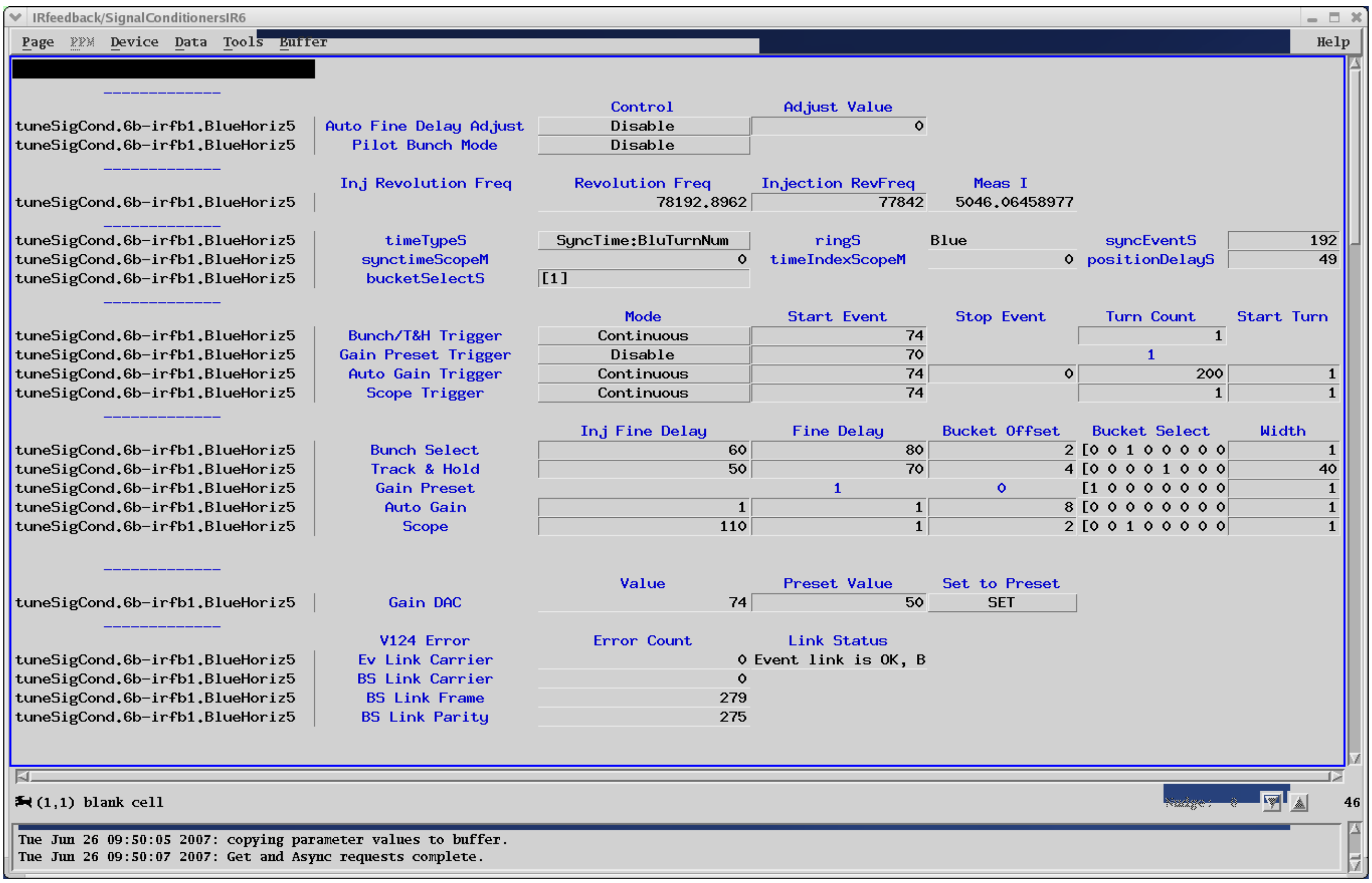
A block diagram of the auto gain circuit is shown below. The circuit increments or decrements the gain DAC value each turn to hold the BPM sum signal to a value between 950 mV and 1.0 V. Two hardware adjusted potentiometers are used to set the high and low values as shown in the diagram. On occurrence of the V124 auto-gain trigger, the up clock will be generated if the BPM sum signal is below 950 mV and the down clock will be generated if the BPM sum signal is above 1.0 V. Neither clock will be generated when the sum signal is between 950 mV and 1.0 V. The hysteresis of 50 mV may be configured to a tighter window if required.

When there is no beam in the machine, the auto-gain circuit attempts to continuously increase the gain setting. This results in a wraparound when the gain setting is incremented from 255, the maximum 8-bit value. In order to provide a reasonable gain setting when beam is injected, a gain preset value is used. The VMIC 2170A digital output provides a setting that is clocked into the counter on the occurrence of the V124 gain preset trigger, which is typically configured to the FEBbunch event. A very accurate preset value is difficult to achieve since it is dependent on intensity.



Beam Trigger Timing

The following pet page (located in the pet tree at RHIC/Instrumentation/IRfeedback/SignalConditionersIR6) is used to configure the 5 o'clock Blue Horizontal DX 10 Hz signal conditioner V124 timing. The pet page configuration is similar for all signal conditioner modules.



Four triggers are used to control each signal conditioner module as follows:

1. Bunch Select Trigger – This trigger is used to select the bunch or bunches to be used by the signal conditioner.
2. Track and Hold Trigger - This clock drives the track and hold, and is configured to the peak of the low-pass filtered bunch signal.
3. Gain Preset Trigger - The gain may be initialized on the occurrence of an event.
4. Auto Gain Trigger - This clock generates the auto gain clock and is configured to occur during the hold period of the track and hold output.

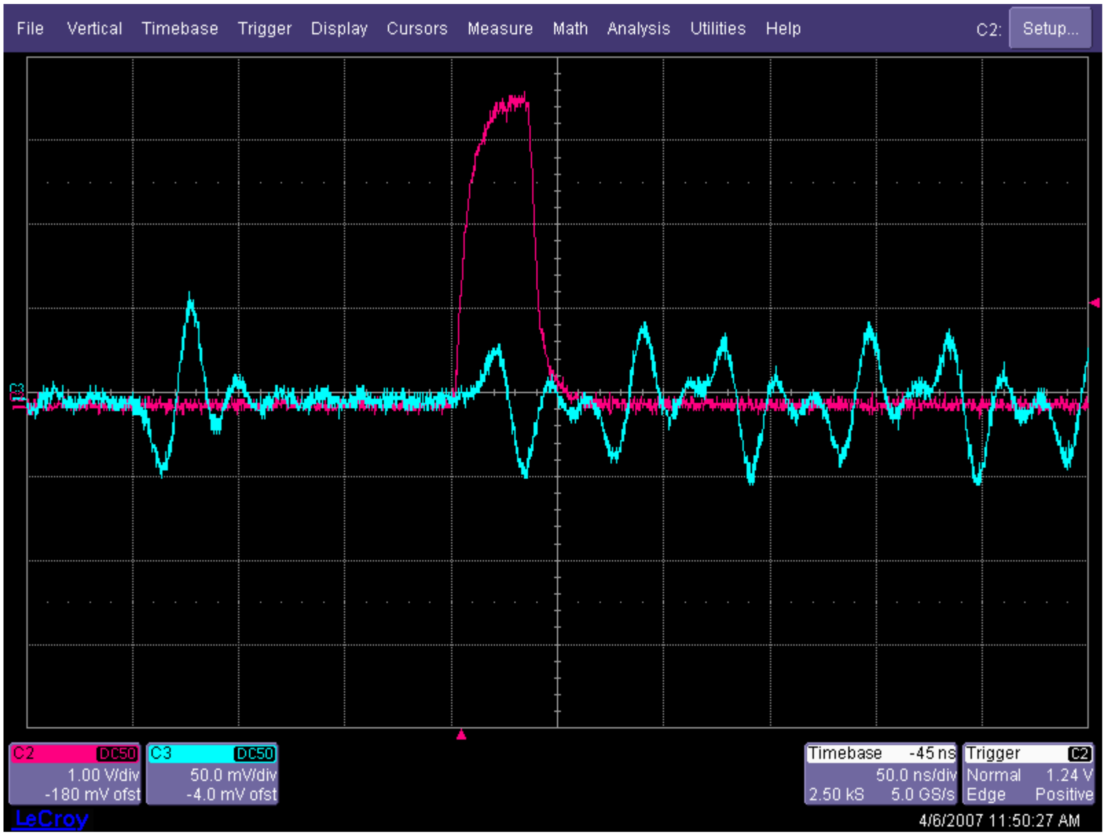
The configurable timing ADO parameter values for the triggers are:

Parameter Name	Legal Values	Description
bunchSelectInjFineDelayS trackAndHoldInjFineDelayS autoGainInjFineDelayS	1-255	Fine delay setting at injection. 1 count equals 0.5 nanoseconds.
bunchSelectFineDelayS trackAndHoldFineDelayS autoGainFineDelayS	1-255	Currently used fine delay setting. 1 count equals 0.5 nanoseconds. When autoFineDelayS is Enabled, this parameter is automatically updated every second and indicates the calculated fine delay value.
bunchSelectBucketOffsetS trackAndHoldBucketOffsetS autoGainBucketOffsetS	0-359	The trigger outputs are shifted by this number of rf clocks.
bunchSelectPulseWidthS trackAndHoldPulseWidthS gainPresetPulseWidthS autoGainPulseWidthS	1-357	The width of the trigger pulse in number of rf clocks.

Additional ADO parameter settings that are common to the module include:

Parameter Name	Legal Values	Description
autoFineDelayAdjustS	Enable, Disable	The fine delay timing values may be modified to track beam during the ramp. The equation is: fineDelay = injFineDelayS – (fineDelayFactorS * (revFreqM - injectionRevFreqS)). This parameter Enables or Disables the function. Since the 10 Hz IR Feedback system is normally configured to operate at store only, the timing is set for store conditions and this parameter is typically set to Disable.
fineDelayFactorS	Positive floating point value	See autofineDelayAdjustS.
syncEventS	1-255	The 0.25Hz sync event code for resetting the timestamp. (Typically configured to 192)
positionDelayS	1-359	The bucket 1 position indicator is delayed from the revolution event (event code 1) by this number of rf clocks before each channel configuration delay. This value is common to all channels on the module.
bucketSelectS	Array of 1-120 values, where each value is a number between 1 and 360. Spacing between bucket numbers in the list must be 3 or greater.	The list of buckets that are selected for trigger generation.

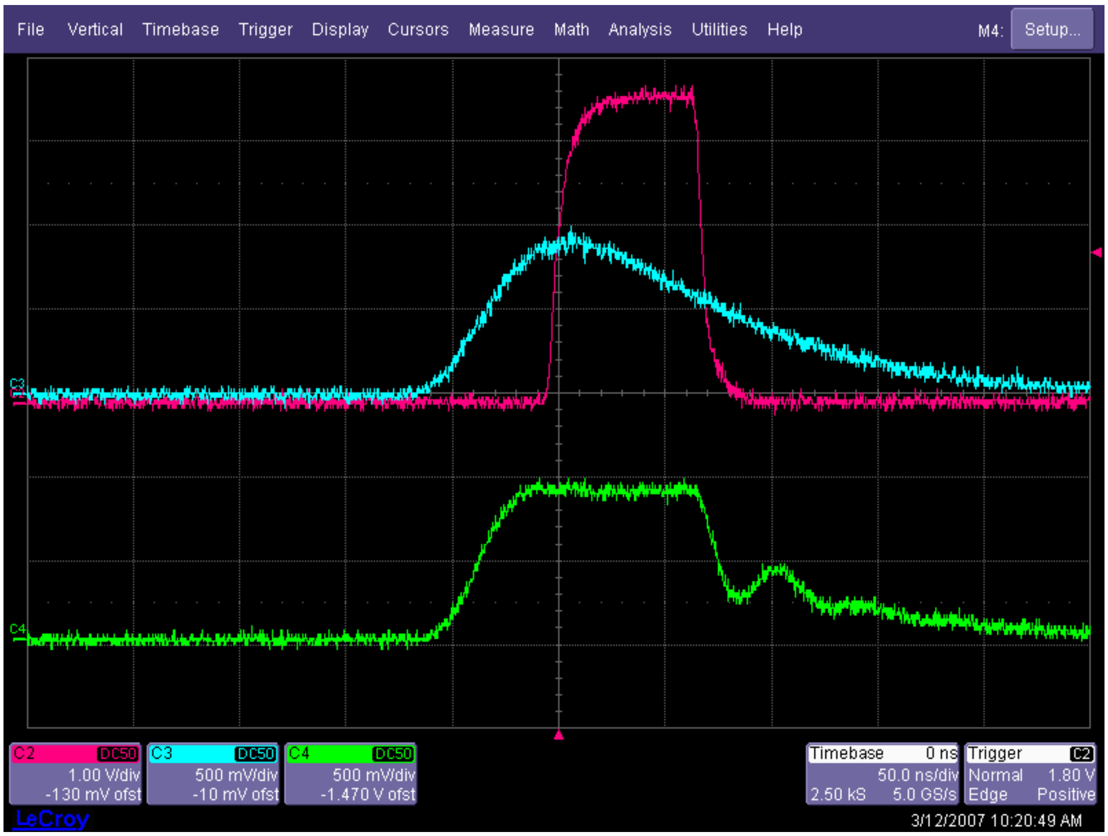
The scope image below shows proper bucket select timing for the blue 5 o'clock DX 10 Hz signal conditioner. The bucket select trigger (channel 2) overlays the first blue bunch. The blue bunches are the positive going doublet pulses, while the yellow bunches are the negative going doublet pulses. The abort gap is to the left of the bucket select trigger.



Channel 2: bucket select trigger
Channel 3: Blue 5 o'clock DX BPM input signal with gold beam

The following scope image shows proper track and hold timing for the blue 5 o'clock DX 10 Hz signal conditioner. The rising edge of the track and hold trigger (channel 2) is timed to the peak of the track and hold input signal (channel 3). Note that the track and hold output level (channel 4) is held constant until the falling edge of the track and hold trigger.

The track and hold trigger for the image shown was configured to a width of 2 rf clocks. This would be the correct configuration when 60 bunches are selected. However, when one bunch is selected the track and hold clock would typically be configured to a width of 40 rf clocks.



Channel 2: track & hold trigger
Channel 3: track & hold input signal
Channel 4: track & hold output signal