

# 60 HZ Beam Motion Reduction at NSLS UV Storage Ring

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## I. ABSTRACT

A significant reduction in 60 hz beam motion has been achieved in the UV storage ring. From the wide band harmonic beam motion signal, 60 hz signal is extracted by tuned bandpass filter. This signal is processed by the phase and amplitude adjustment circuits and then, it is fed into the harmonic orbit generation circuits. Several harmonics, near the tune, were cancelled by employing one circuit for each harmonic. The design and description of this experiment is given in this paper. The results showing reduction in beam motion at 60 hz are also provided.

## II. INTRODUCTION

Since December 1989, a broad bandwidth, analog global feedback system [1] has been in operation in the UV storage ring at NSLS. This system uses several beam pue's to generate spatial harmonic signals near the betatron tune, and several steering magnets to generate spatial harmonic beam correction signals. Although, this feedback system has provided excellent orbit stability for the users in frequency range from dc to few tens of hertz, there remains higher frequency beam motion, 60 hz in particular. This is due to the fact that the response of the feedback system is limited to around 60 hz frequency. Figure 1 shows the frequency spectrum of the beam motion from 5 hz to 405 hz for one of 24 pues in the UV ring, with global feedback on.

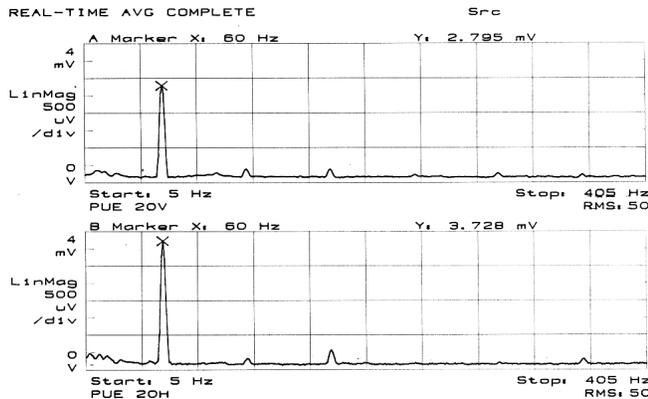


Fig 1 - Beam Motion Frequency Spectrum with Global Feedback On [1mV = 2 microns]

The upper plot is for a vertical pue signal and the lower plot is for a horizontal pue signal at a point near the largest vertical and horizontal betatron function, but not in the global feedback system. As seen in this figure, with the global feedback on, the dominant beam motion remaining is at 60 hz frequency, and there could be a significant improvement in the overall beam motion, if only this frequency of motion was removed or reduced. In the experiment, 60 hz beam motion is reduced by feeding back on the narrow band 60 hz frequency contents at a only few spatial harmonics, near the tune. The experimental set-up is given in figure 2. The wideband harmonic signal, generated by the harmonic orbit synthesize circuits, is passed into a dc block and amplifier circuits, followed by a narrow band 60 hz bandpass filter. This signal is, then, adjusted in amplitude and phase, such that when it is sent to the harmonic orbit generation circuits, the 60 hz motion is cancelled out or minimized.

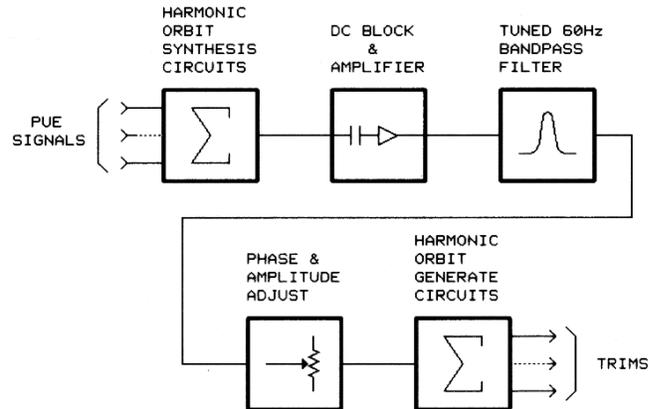


Fig 2 - Block Diagram for experiment setup

## III. CIRCUIT DESCRIPTION

Figure 3 shows the circuit diagram for processing dc block and 60 hz filter for harmonic signal. The harmonic signal is received by a differential receiver followed by a dc block amplifier to remove dc component. This signal is amplified by a factor of 20 by an amplifier so that the signal level is high enough for the filter which follows this amplifier. The narrow bandpass filter is a "switched capacitor filter" (MF10 by Maxim)[2], driven by an external 6 khz clock (60 hz x 100). There are two distinct advantages for using this type of filter over the conventional analog type filter: (1) Only few

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discrete components (3 resistors) are required to generate dual 2 pole bandpass filter, (2) the bandpass frequency depends only on the external switching clock and not on the discrete components. The external 6 khz clock is derived by feeding line 60 hz signal into a phase lock loop ( XR2212 by Exar)[3] and two counter IC's. This set up provides an excellent 60 hz line tracked bandpass filter and its performance is far superior to the bandpass filter that is built by discrete components which suffers from drift problems. The two traces in Figure 4 indicates that these circuits performed very well. The harmonic signal output, containing broadband beam motion signal, is shown in the upper trace and the 60 hz bandpass filtered signal is shown in the lower trace.

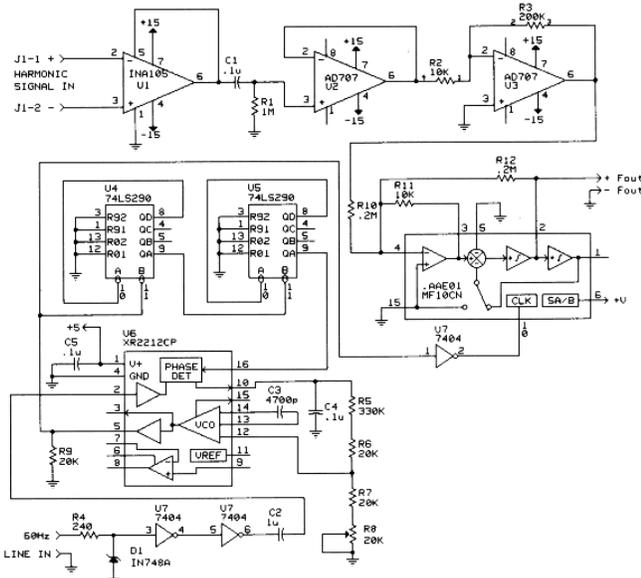


Fig 3 - Circuit diagram - dc block and filter

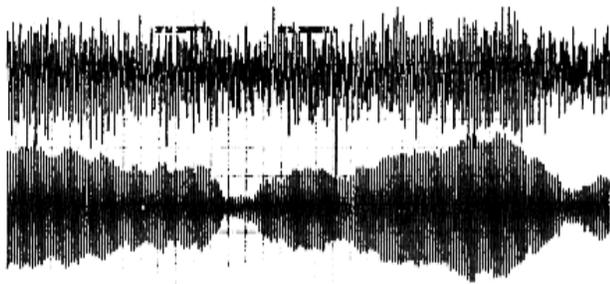


Fig 4 - Harmonic signal ( upper trace )  
Filtered signal ( lower trace )

Figure 5 shows the circuits which provides the phase and amplitude adjustments. There are two cascaded phase adjustment circuits, providing a total of more than 180 degree phase adjustment. The heart of the phase adjust circuit is an operational transconductance amplifier ( CA 3080 by RCA)[4]. The transconductance of this device is controlled by a dc bias current and this variable transconductance along

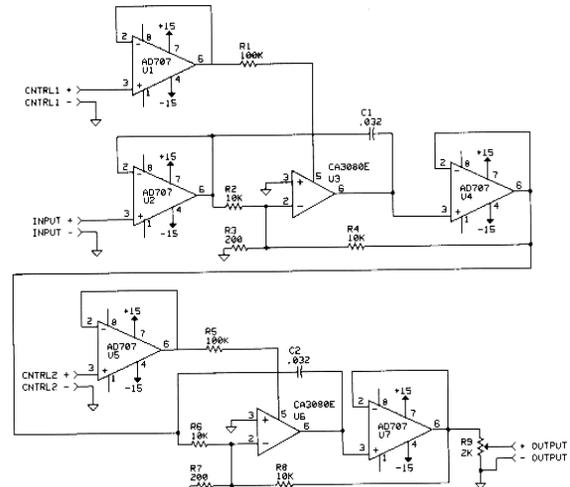


Fig 5 - Phase and amplitude adjustment circuits

with a capacitor provides a phase change without effecting the frequency. A potentiometer at the output provides the amplitude control. To determine the proper phase and amplitude, the signal is added to the broadband harmonic orbit correcting signal; the phase and amplitude of the signal are adjusted, until the 60 hz harmonic is minimized.

#### IV. RESULTS

The experiment for reducing vertical beam motion was set up to eliminate three harmonics: the average value (dc), cos1 and sin1 (vertical tune=1.2). Figure 6 shows the frequency spectrums taken from 10 hz to 210 hz and provides the improvement results for sin1 harmonic (upper plot) and for photon beam position monitor (lower plot). In both plots, the frequency spectrum before correction is shown by the upper curve (light trace) and the result of applying this correction signal as the lower curve (dark trace). The reduction of the 60 hz signal is > 6 for the harmonic signal and is > 4 for the photon monitor beam position signal.

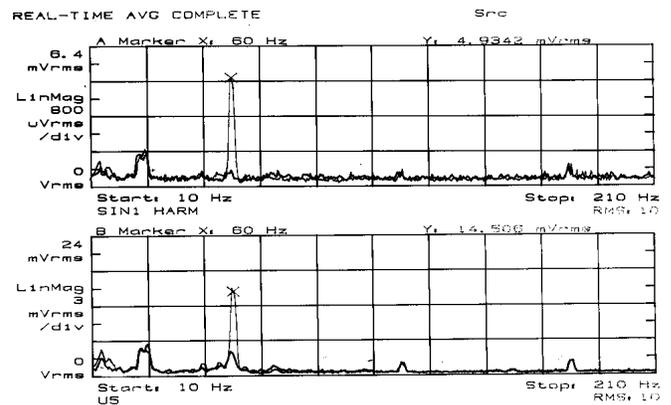


Fig 6 - Improvement results in vertical beam motion

The experiment for reducing horizontal beam motion was set up to eliminate both the sine and cosine 3rd harmonics (horizontal tune=3.14). Figure 7 provides the improvement results for sine3 and cosine3 harmonic. Again, in both plots, the frequency spectrum before correction is shown by the upper curve (light trace) and the result of applying this correction signal as the lower curve (dark trace). The reduction of the 60 hz beam motion is >3 for both harmonics.

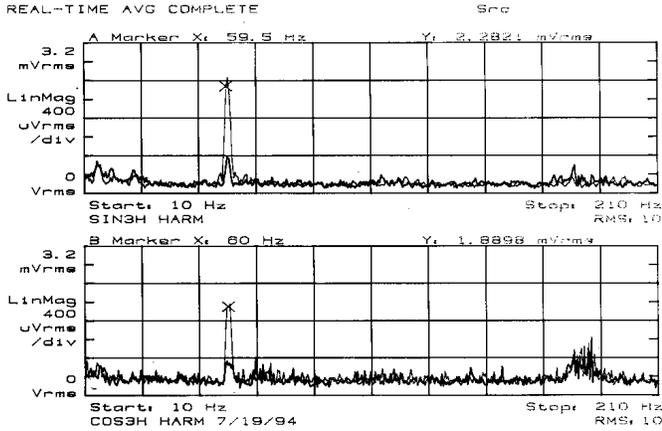


Fig 7 - Improvement results in horizontal beam motion

The beam motion at all horizontal pue's were also measured at 60 hz with and without correction and the data is plotted and is shown in figure 8. The square-mark trace shows the beam motion with correction off and the cross-mark trace shows beam motion with correction on. It is seen that by correcting only two harmonics, large improvements are seen at all the pue's. The signal reduction is greatest in the straight section where the energy dispersion is small and the betatron amplitude is large. At the other points, where the energy

### 60Hz Correction in VUV Ring (Sin 3H & Cos 3H Harmonics 7-19-94)

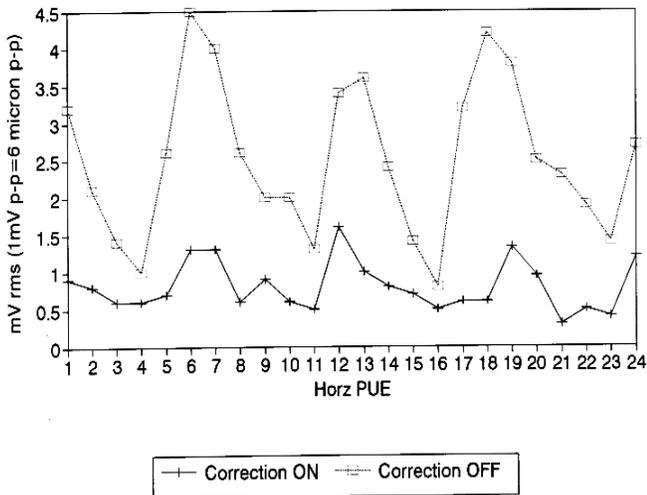


Fig 8 - 60 hz beam motion improvement

dispersion is large, the correction, although significant, is limited.

## V. CONCLUSIONS

The use of a narrow bandwidth signal processing system to enhance the gain of the global orbit feedback system was successful in reducing single frequency motion on the beam.

## VI. ACKNOWLEDGEMENTS

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## VII. REFERENCES

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