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OPTIMISATION OF THE SVD TREATMENT IN THE FAST ORBIT CORRECTION OF THE ESRF STORAGE RING

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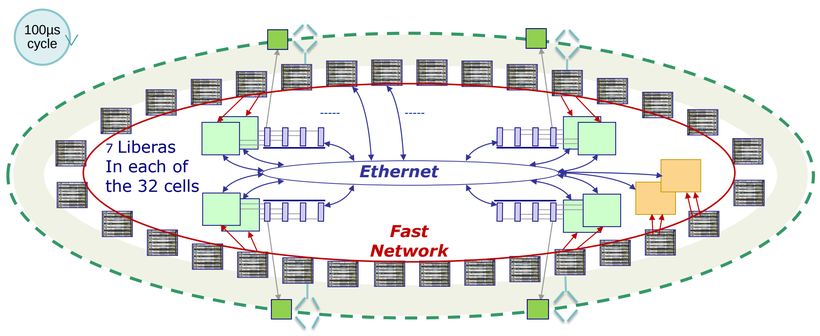
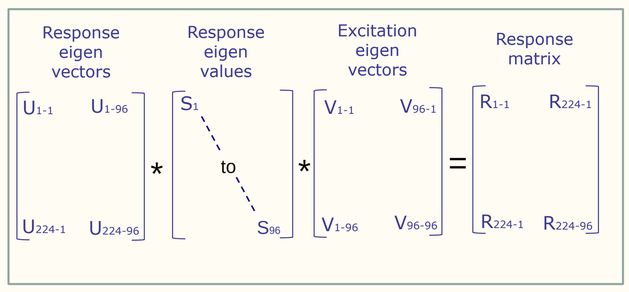
The ESRF fast orbit correction system has been in operation since May 2012. The orbit correction scheme relies classically on the calculation of a correction orbit based on the SVD analysis of the response matrix of our 224 BPMs to each of our 96 correctors. The rate of the calculation of the corrections is 10 KHz; we use a PI loop achieving a bandwidth of 150Hz completed with a narrow band pass filter with extra gain at 50Hz. In order to make the best use of the correctors dynamic range and of the resolution of the calculation, it can be useful to limit the bandwidth of loop for the highest order vectors of the SVD, or even to totally remove some of these vectors from the correction down to DC. Removing some of the eigen vectors while avoiding that the loop becomes unstable usually increases a lot the complexity of the matrix calculations: we have developed an algorithm which overcomes this problem; The test of this algorithm is presented. We present also the beneficial effect at high frequency of the limitation of the gain of the correction of the highest SVD eigen vectors on the demand of the peak strength of the correctors and on the resolution of the correction calculation.

Fast Orbit Feedback layout

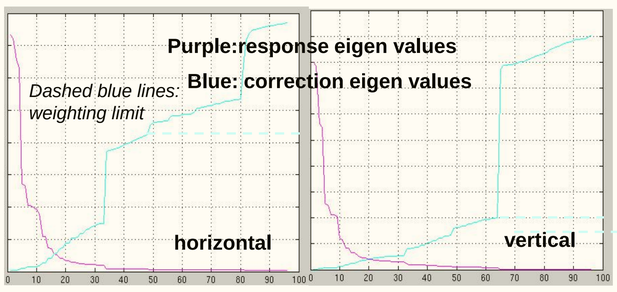
Architecture

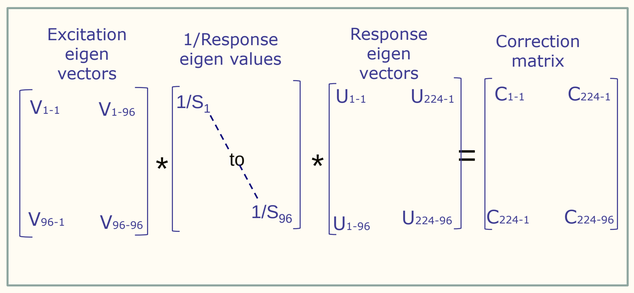


SVD based orbit correction calculation

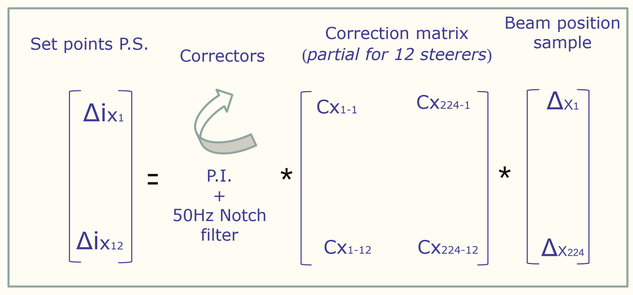


Singular Values Decomposition of the response matrix





Corrections matrix calculation



Orbit correction steps calculation

Effect of the weighting of the eigen values of the SVD

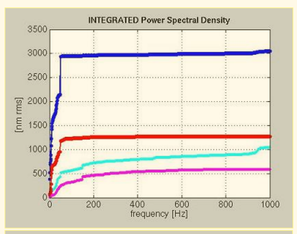
BPM position stability:
Not very significant for the ESRF storage ring (low noise of the *Libera* electronics compared to initial beam position motion

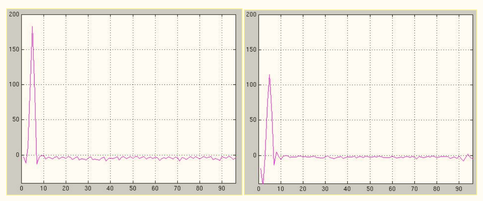
Position calculation resolution:
Better use of the data range available with our fixed point FPGA

Correctors dynamic range;
Less peak demand on the correctors during the correction of the orbit distortion caused by the fast parasitic kick produced during the injection in the SR

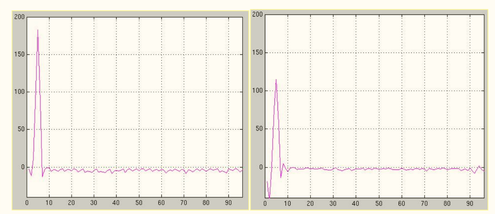
Upper plots:
Initial effect of the fast orbit correction on the orbit stability, without eigen vectors weighting
Dark blue: horizontal/ no feedback
Light blue: horizontal/ feedback active
Red: vertical/ no feedback
Magenta: vertical/ feedback active

Lower plots:
Differential effect of the weighting
Dark blue: horizontal/ no weighting
Light blue: horizontal/ with weighting
Red: vertical/ no weighting
Magenta: vertical/ with weighting

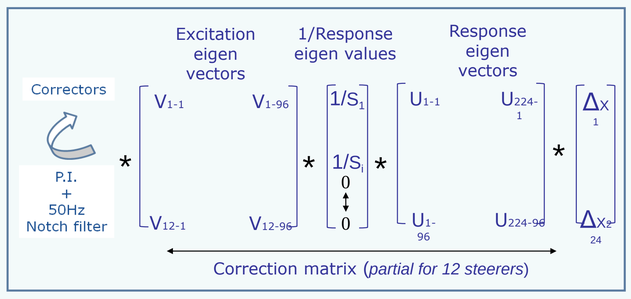




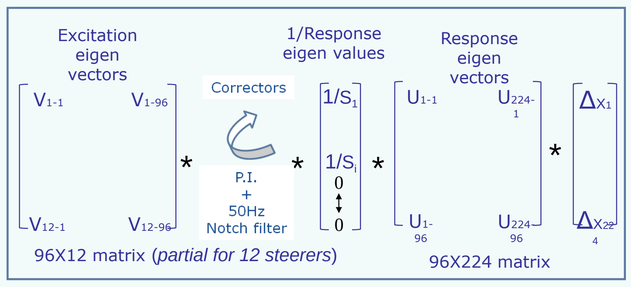
plot of the column 10 of the horizontal correction matrix, without (left plot) and with (right plot) weighting applied to the S-1 coefficients



plot of the horizontal correction applied during an injection kick (left: no weighting, right: weighting applied

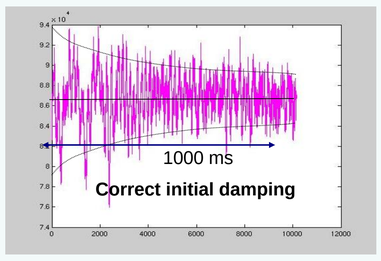


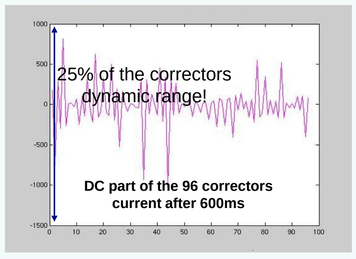
Instable orbit correction steps calculation

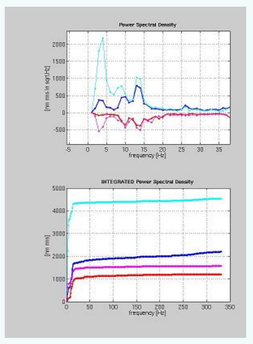


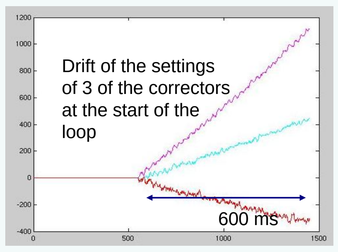
Stable orbit correction steps calculation:
big increase of the calculation complexity

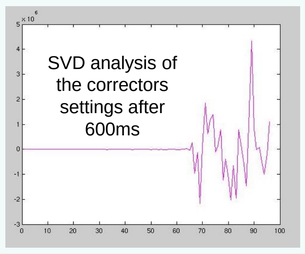
INSTABLE SYSTEM:
Vertical orbit correction system effect with a total cancellation of the 30 highest order eigen vectors and the PI iteration performed after the position to correction matrix calculation (0 to 600ms after the start of the correction)

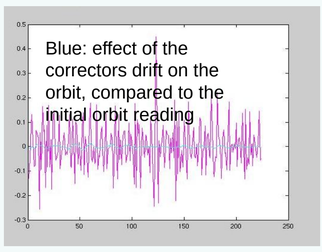




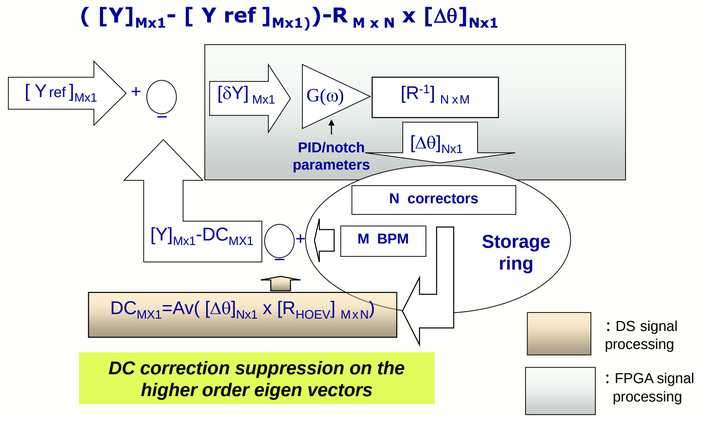








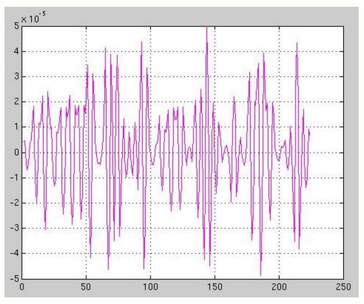
Corrected orbit =
$([Y]_{Mx1} - [Y\ ref]_{Mx1)}) - R_{M \times N} \times [\Delta\theta]_{Nx1}$



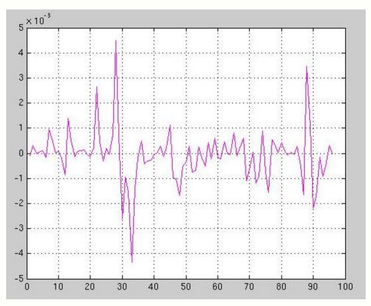
DC correction suppression on the higher order eigen vectors

Eigen vectors DC suppression without modification of the fast orbit calculation loop using a slow trim of the BPM offsets

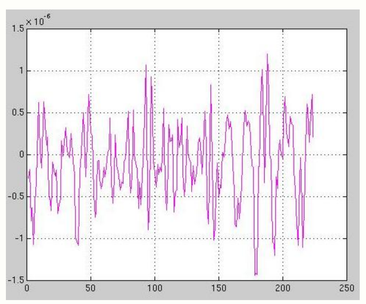
TEST OF THE ALGORITHM BASED ON THE SLOW TRIM OF THE BPM OFFSETS



BPM offsets evolution after one hour



Corrector currents evolution after 1 hour



Orbit reading evolution after one hour