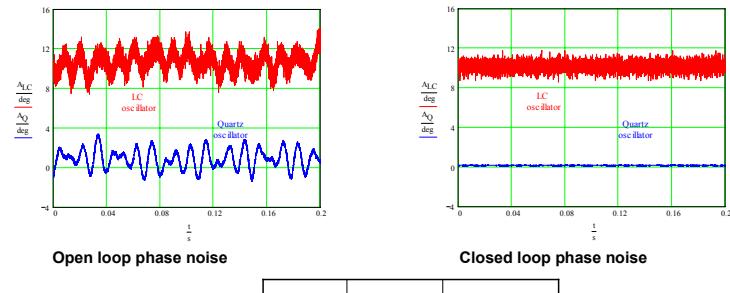


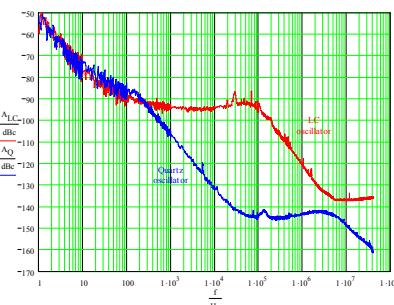
# NOISE MEASUREMENTS AT THE RF SYSTEM OF THE ELBE SUPERCONDUCTING ACCELERATOR

## Frequency Generation

The ELBE accelerator [1] needs in his final stage RF frequencies of 26 MHz, 13 MHz and subdivisions of 13 MHz for the beam pulse rate and RF frequencies of 260 MHz, 1300 MHz and 1313 MHz for the bunchers and the cavities. The frequency generation for ELBE is done from a 13 MHz master reference oscillator by phase locked loops (PLLs) as shown below.

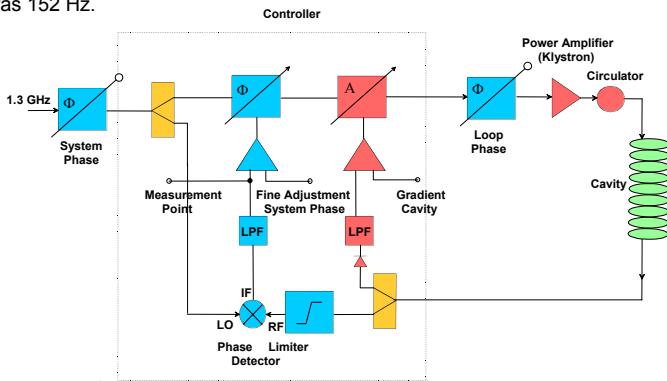


Tests were made with a LC- and a quartz-oscillator as voltage controlled oscillator (VCO) in the PLLs. The Allan variance [2,3] of the phase noise with 1 ms time constant and 100 kHz corner frequency is 2.3 ps for the LC PLL and 0.14 ps for the quartz PLL. The figure shows the measured phase noise spectra of the 1.3 GHz PLL for the two oscillators.



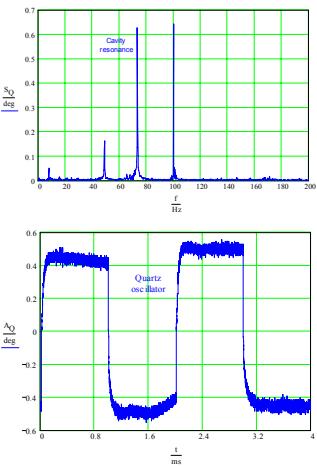
## Control Loop Measurements

Below is the block diagram for the amplitude and phase control loops for the 1.3 GHz cavities shown. The control loops for the bunchers are similar. There are several test points and switches to set operating points and to check the functionality which for simplicity are not shown. The measurements were done at the measurement point with closed and open phase loop. The operating points were maintained and the amplitude loop was open. The measured RF bandwidth was 152 Hz.



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From spectral analysis it could be concluded that the open loop phase noise with the quartz oscillator is the microphonics of the ELBE accelerator. The spectrum is shown on the right.



Below is the measured step response of the closed phase loop for the quartz oscillator shown. From the step response the closed loop corner frequency could be estimated to 9 kHz.

## Conclusions

About half of the noise of the LC oscillator is outside the controller loop bandwidth and will therefore not be rejected in the loop. But this noise reduces the dynamic range inside the loop. For the beam the oscillator noise will be filtered with the closed loop bandwidth. The Allan variance could be calculated to 0.74 ps for this case compared to 0.14 ps for the quartz oscillator. The big phase jitter and also the dynamic range reduction by the LC oscillator can not be accepted.

## References

- [1] A. Büchner, F. Gabriel, E. Grosse, P. Michel, W. Seidel, J. Voigtländer, The ELBE-Project at Dresden-Rossendorf EPAC2000, Vienna, June 2000.
- [2] D.W. Allan, Statistics of atomic frequency standards", Proc. IEEE, vol. 54, pp. 221-230, February 1966
- [3] L. Cutler, C. Searle, Some aspects of the theory and measurement of frequency fluctuations in frequency standards", Proc. IEEE, vol. 54, pp. 135-154, February 1966

