NOISE MEASUREMENTS AT THE RF SYSTEM OF THE ELBE SUPERCONDUCTING ACCELERATOR

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Abstract

For the ELBE accelerator the RF system was new developed. It operates with analog amplitude and phase control. For the several microbunch frequencies which are used at ELBE it had to be very flexible. Because of the planned FEL operation at ELBE special emphasis was laid on oscillator and control loop phase noise. Measurements of a quartz oscillator and a LC oscillator were made. The phase noise measurements with closed loop will be compared with the measured microphonics.

1 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 in Fig. 1.

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

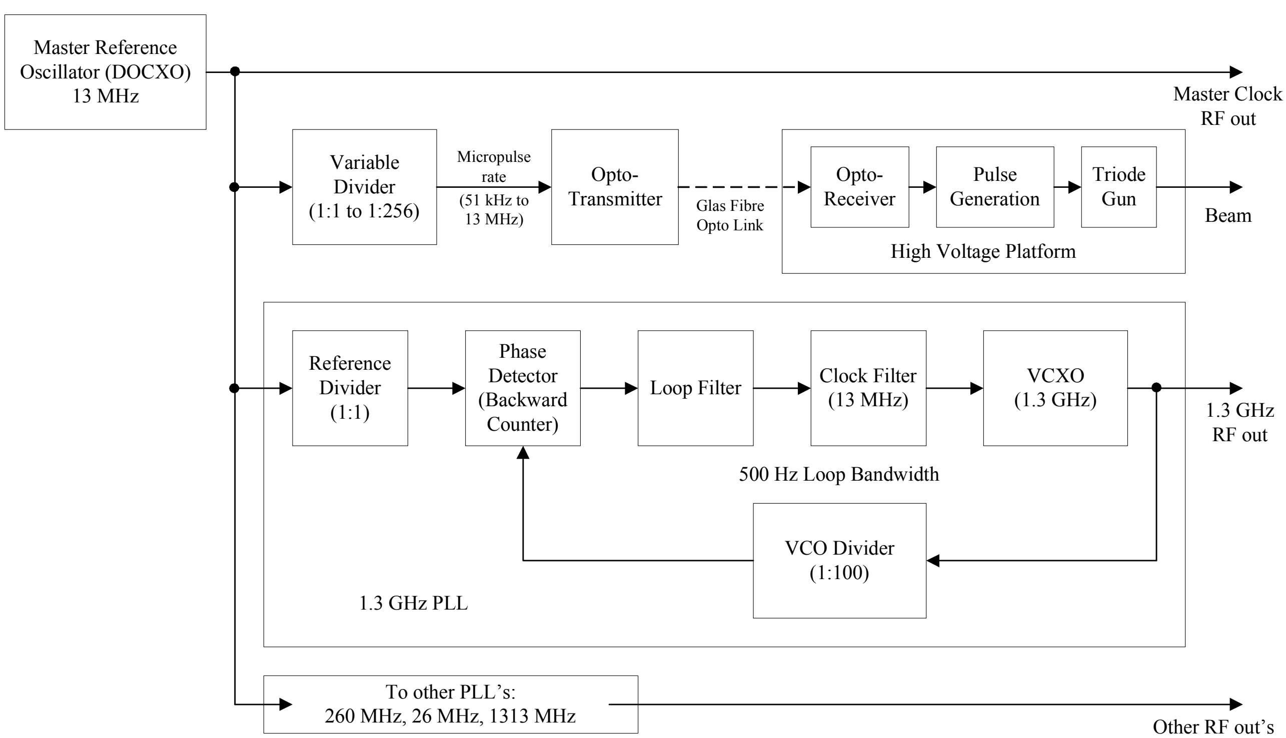

Figure 1: Principle of frequency generation for ELBE

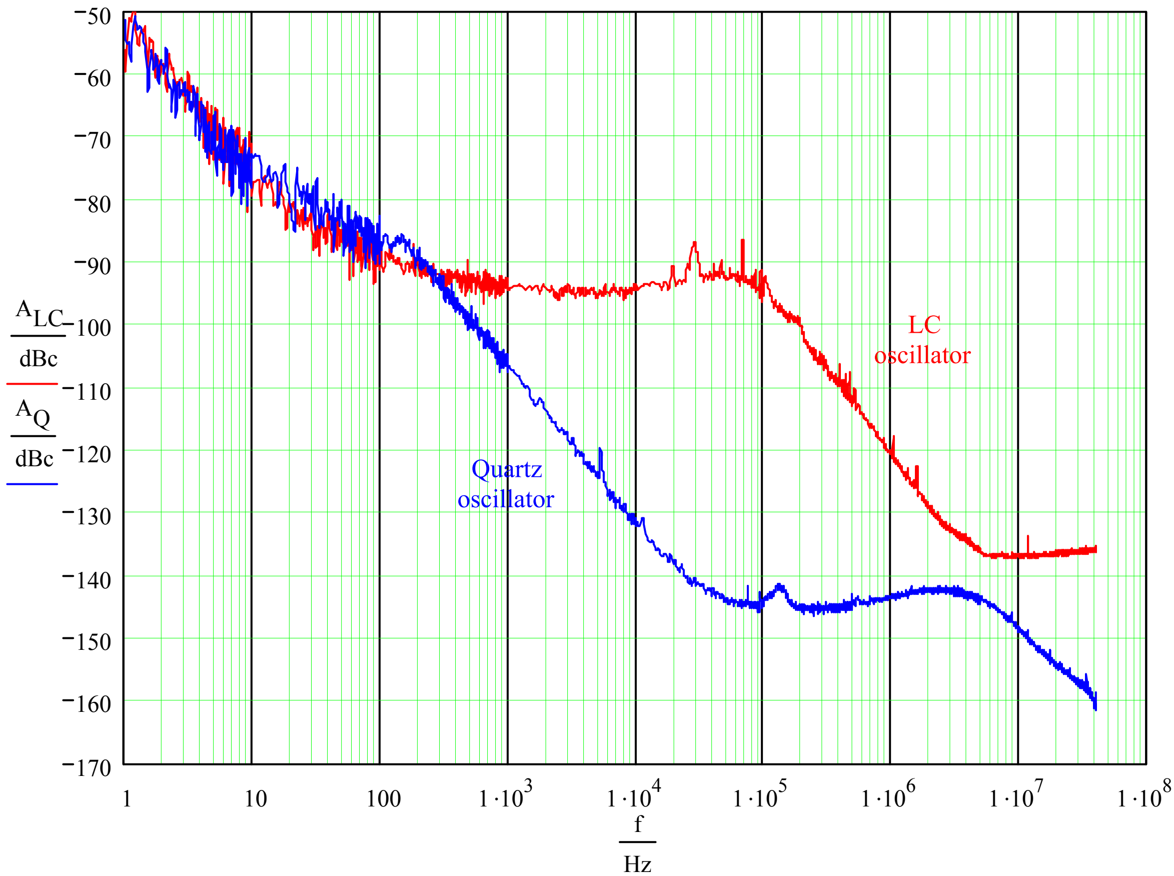

Figure 2: 1.3 GHz PLL single-sideband phase noise spectra with LC and quartz oscillator

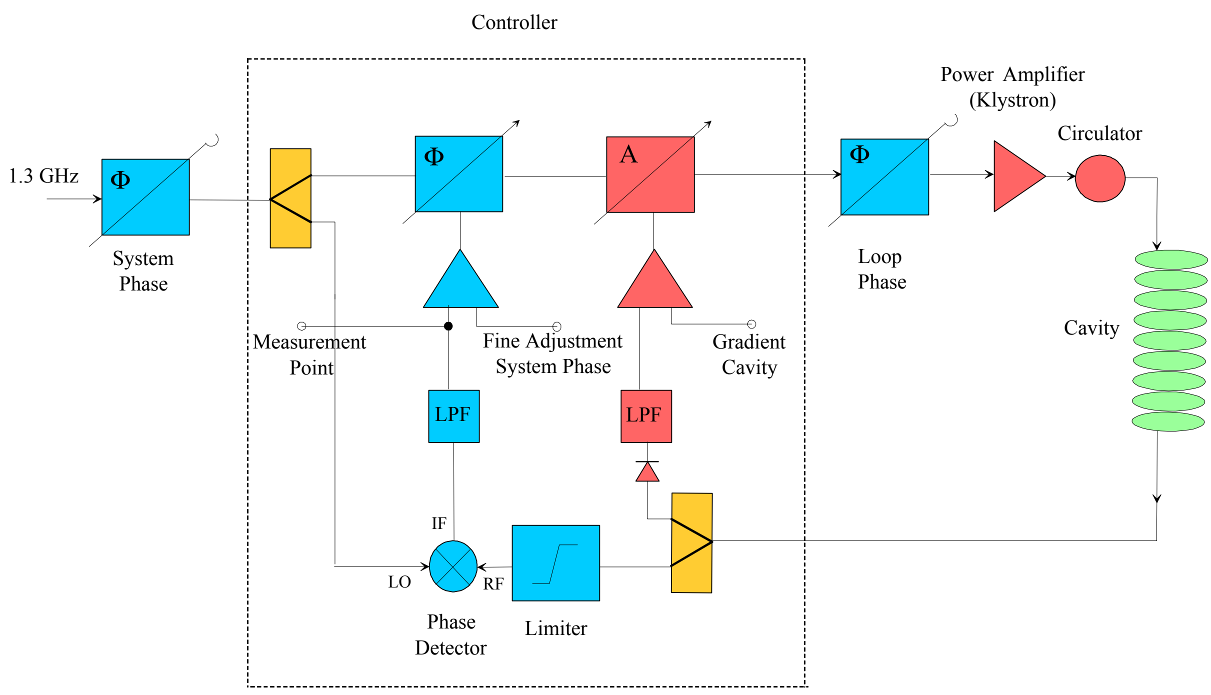

Figure 3: 1.3 GHz control loop block diagram

2 CONTROL LOOP MEASUREMENTS

The block diagram for the amplitude and phase control loops for the 1.3 GHz cavities are shown in Figure 3. 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 in Figure 3. The measurements were done at the shown 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.

Figure 4 compares the results for the open loop measurements and Figure 5 compares the results for the closed loop. Table 1 summarizes the results. From spectral analysis it could be concluded that the open loop phase noise with the quartz oscillator is the microphonics of the ELBE accelerator.

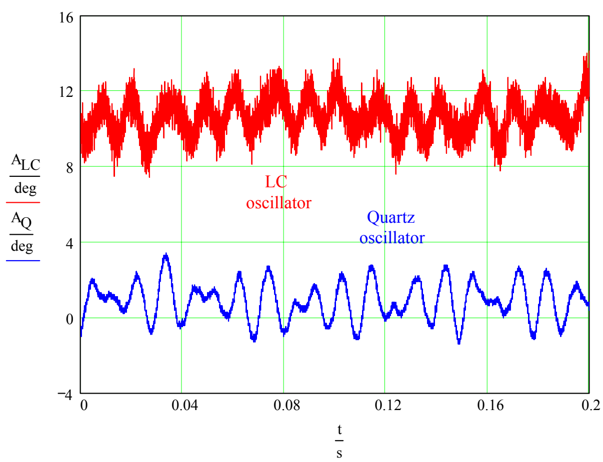

Figure 4: Open loop phase noise

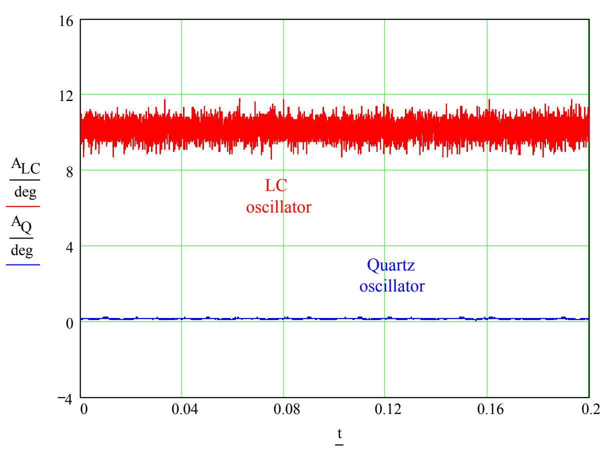

Figure 5: Closed loop phase noise

Table 1: Phase noise values

	LC oscillator	Quartz oscillator
Open loop	0.942 deg rms	0.974 deg rms
	6.7 deg pp	4.8 deg pp
Closed loop	0.417 deg rms	0.022 deg rms
	3.2 deg pp	0.156 deg pp

Figure 6 shows the measured step response of the closed phase loop for the quartz oscillator. From the step response the closed loop corner frequency could be estimated to 9 kHz.

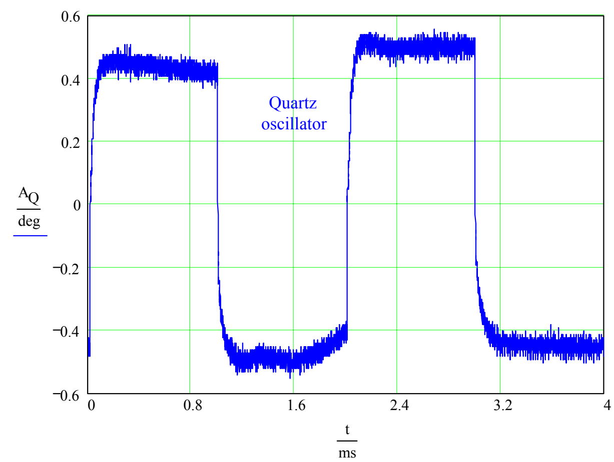

Figure 6: Phase loop step response

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’t be accepted.

3 REFERENCES

[1] A. Büchner, F. Gabriel, E. Grosse, P. Michel, W. Seidel, J. Voigtländer, “The ELBE-Project at Dresden-Rossendorf” EPAC’2000, Vienna, June 2000.

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[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