FUTURE TIMING AND SYNCHRONIZATION SCHEME AT ELBE

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Abstract

In 2011 the superconducting electron accelerator ELBE at Helmholtz-Zentrum Dresden-Rossendorf is extended to generate nC bunches at a repetition rate of 125 kHz in continuous wave operation. These bunches will be generated by a superconducting photo-electron gun (SRF-Gun) [1]. These bunches will be compressed in a chicane to 150 fs duration and will be used to generate narrowband and broadband THz radiation. Therefor a new beamline is designed including a THz undulator and an optical beamline to the Laboratory located on the roof. The other applications are electron bunch – high power laser experiments with the TW-laser DRACO [2] like Compton backscattering where preliminary experiments have already started [3].

All planned experiments and radiation sources call for a synchronization system at femtosecond level to achieve stable experimental conditions. In upcoming years there will be an optical synchronization system based on a commercial femtosecond laser oscillator which is locked to the accelerators RF. The laser pulses will be distributed over stabilized fiber links to all remote stations.

CURRENT SYNCHRONIZATION SYSTEM

The current synchronization system is based on commercial optical cw transmitters and singlemode optical fibers to distribute the 13 MHz Master Oscillator Signal to client stations like experimental lasers. The links have a noise floor at -142 dBc which results in a jitter of 3 ps [1 Hz; 5 MHz] after the transmission (see Figure 1). Due to that fact a RF oscillator locked by a PLL is always used as flywheel filter to lower the fast jitter before locking an external laser.

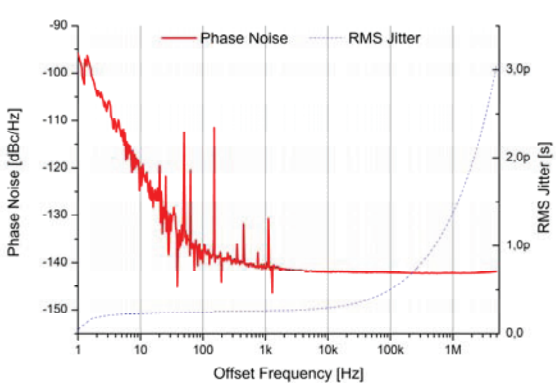

Figure 1: Phase Noise (solid line) and RMS-Jitter (dashed line) of 13 MHz after cw distribution.

The current system was improved in some details to enable first experiments between DRACO and ELBE. The reference signal for the Ti:Sa Oscillator is now shifted by a IQ-Modulator based electronic phase shifter instead of coaxial phase shifters and discrete cable delays. Now the phase between electron bunch and laser pulse can be adjusted continuously and via remote control.

In addition a commercial trigger generator was set up to trigger the ELBE single shot and the DRACO pulse picker for 10 Hz operation.

SYNCHRONIZATION SYSTEM

Layout

The future synchronization system will use a femtosecond laser as an optical reference. This will be locked to the accelerator RF master oscillator and feed all remote stations that need femtosecond stability. The laser signal will be split in a fiber coupler and distributed to the clients using stabilized single mode fibers [4]. The performance of active and passive stabilization concepts has to be validated within the next months.

Figure 2 shows the layout of the extended ELBE facility including all existing and future sources that have to be synchronized.

As a first application the Ti:Sa Oscillator of the TW Laser DRACO will be locked to the new reference signal. Afterwards all Lasers in the new THz-Laboratory will use that system.

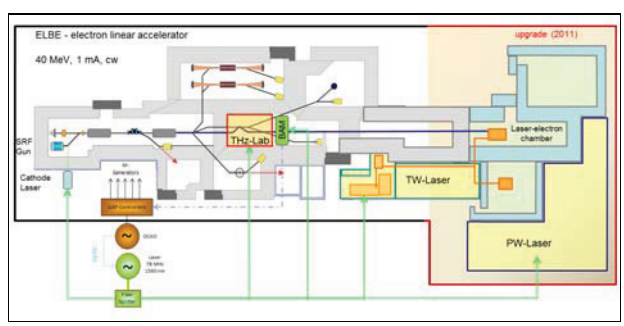

Figure 2: Future Synchronization Layout.

One of the main advantages of the optical distribution is the galvanic insulation to avoid ground loops. Since the laser laboratory have all a separate power supply including separate grounding such insulation is mandatory. Also the EMI in the accelerator hall has no effect to the singlemode fibers and the optical signals.

Master Laser Oscillator

A significant increase of stability of commercial laser systems has been achieved in recent years [5][1]. Femtosecond Lasers show excellent short term stability compared to RF oscillators but a weak long term performance. Thus the long term stability is always given by an electrical reference.

We are using an Onefive Origami 15 femtosecond laser which is locked to the accelerators RF. In preliminary test it showed excellent phase stability. It is a real turnkey system in a sealed housing and needs no maintenance.

It has a RMS-jitter of less than 7 fs [1 kHz; 10 MHz] what makes it a very good reference source (see Figure 3). The lower frequency behavior is mainly determined by the frequency stability of the RF reference and the quality of the locking.

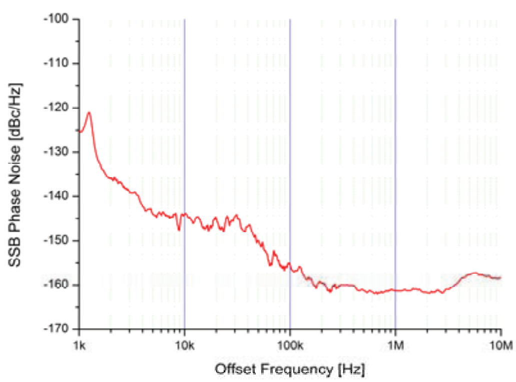

Figure 3: SSB Phase Noise measured at 1326 MHz (17th Harmonic of fundamental signal).

The repetition rate is matched to most of the used laser sources what makes it easier to find a common lock frequency. The output power is specified to feed up to 8 links without using an additional optical amplifier before the splitter.

Table 1: Origami 15 Specifications

central wavelength	1571 nm
spectral bandwidth	35,6 nm
pulse length	76 fs
output power	89 mW
repetition rate	78 MHz
RMS Jitter (1 kHz; 10 MHz)	< 7 fs

TIMING SYSTEM

Current Layout

The current ELBE Timing system shown in Figure 4 is a combination of 5 different Trigger generators used to drive different functions of the accelerator. All are referenced to the 13 MHz RF Master clock in a direct or indirect way but have no locked phase. That means it is not possible to find a reproducible setting for all trigger sources. Up to now the Macro Pulse generator was the master trigger source but after extending the accelerator by a second electron source and connecting the Pulse generator of DRACO to the system which needs an interruption free signal, a new timing system has to be designed.

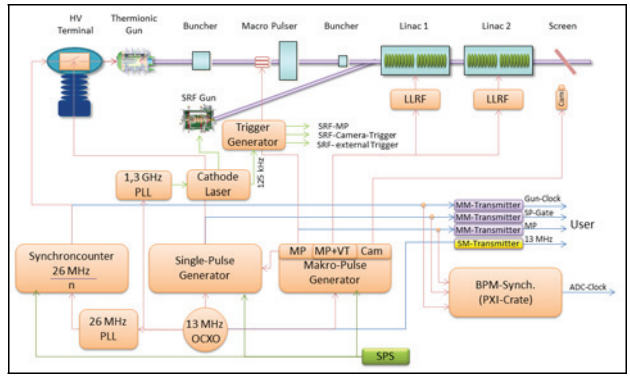

Figure 4: Current Timing Structure.

Future Layout

Figure 5 is showing a possible scheme based on a central trigger generator where all signals are created and then delivered to the stations relevant for the accelerator operation and a distribution terminal for the experimental timing. All frequencies, duty-cycles, delays and dependencies will be managed by that central device.

Based on the accelerators trigger signals a terminal in every laboratory will generate user defined patterns to trigger their experimental setup.

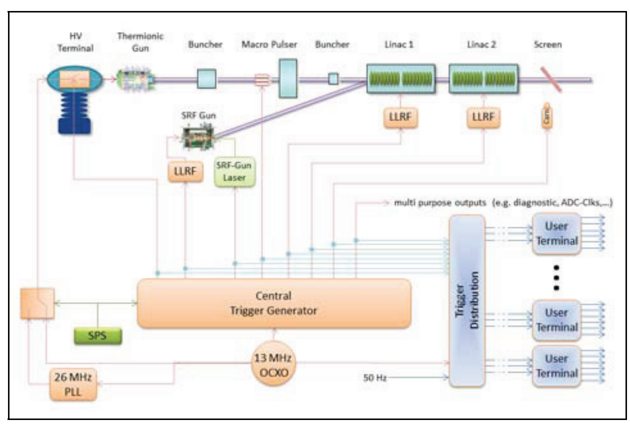

Figure 5: Future Timing System.

Currently the needed specifications are prepared before we enter the design state.

CONCLUSION AND OUTLOOK

The current ELBE synchronization system was evaluated and improved to enable first proof of principle experiments. A new synchronization scheme has been designed which is based on an optical femtosecond master laser oscillator. Onefive Origami was tested as future reference and showed high potential.

For triggering new experiments a new timing system based on a central trigger generator is in the design phase.

In the next months the experiments with the master laser oscillator will continue and it is planned to install a first stabilized link by the end of 2011.

REFERENCES

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