FEMTOSECOND FIBER LINK STABLIZATION TO TIMING SYNCHRONIZATION SYSTEM FOR SHINE PROJECT

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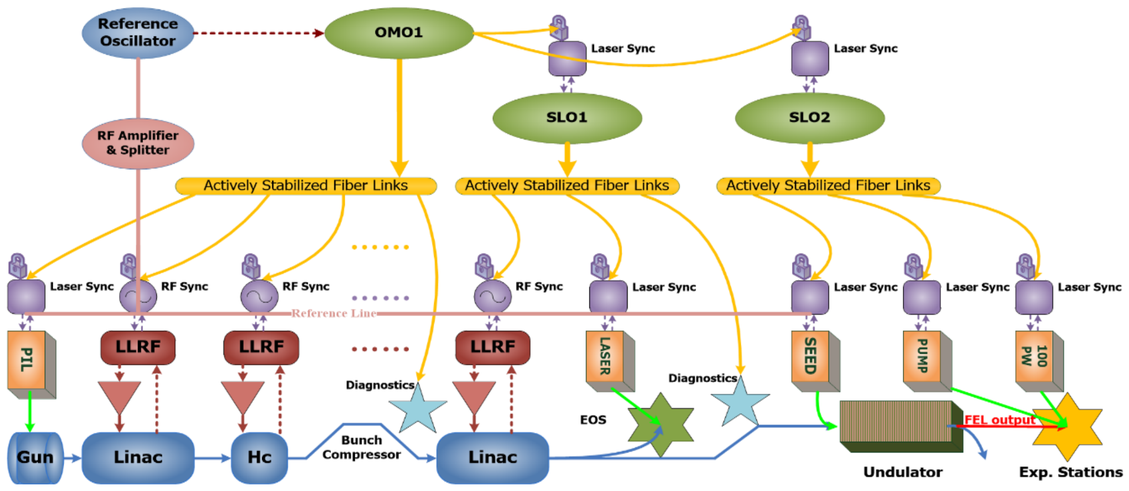
Abstract

The under-construction Shanghai high repetition rate XFEL and Extreme light facility (SHINE) project has a high precision requirement for the timing synchronization system on femtosecond timescale over more than 3-km long optical fiber links, therefor, an ultra –low noise reference signals from the optical master oscillator (OMO) transmission is play an important role. For this purpose, we setup a fiber link stabilization units based on balanced optical cross-correlators to stable the long-distance fiber link. In this paper, the current progress and measurement results will be reported.

Introduction

We have conducted research for fiber link stabilization units based on a mode-locked fiber laser which locked on a RF master oscillator to provide the low noise reference signals to multiple terminals, including photo-injector laser, seed laser, RF system, user experiment stations, bunch arrival time monitors and so on. The following finger shows a typical femtosecond synchronization system



Schematic of a typical femtosecond synchronization system

Principle of fiber link stabilization

Stabilized the long-distance fibers depends on a balanced optical cross-correlators (BOC) locking methods, using a periodically-poled KTiOPO4 (PPKTP) crystal. This is a highly sensitive method to measure timing fluctuations between optical pulses and it can be also employed to detect time of flight fluctuations of pulses circulating in a fiber link. The following figure shows the operation principle of fiber link stabilization using BOC.

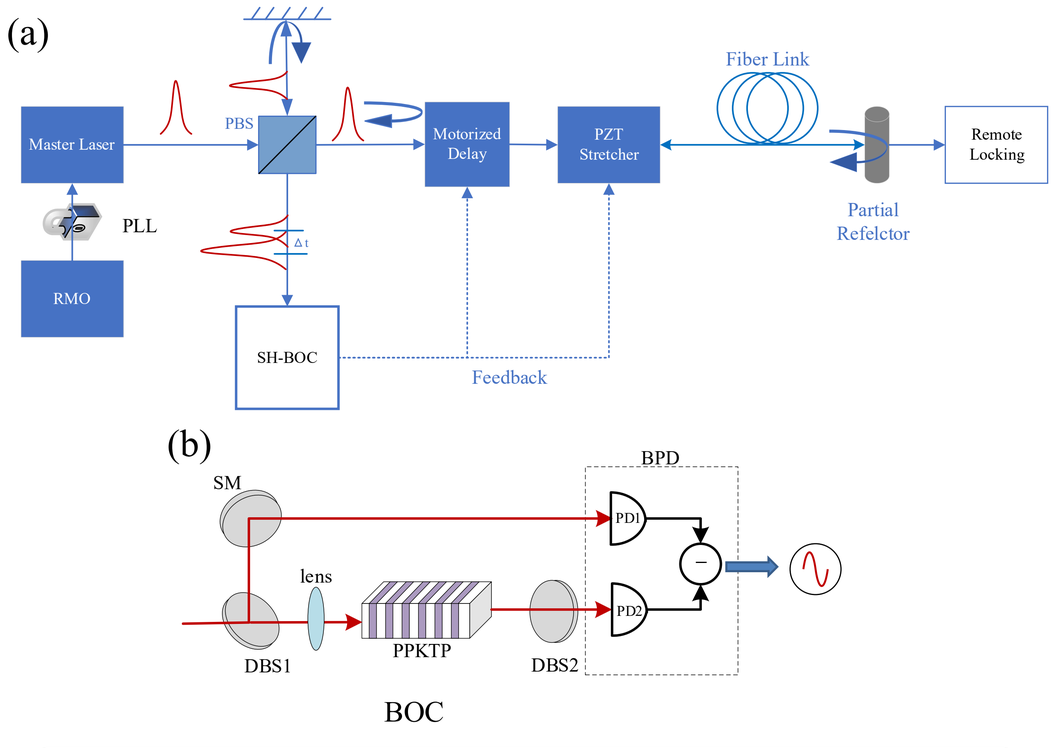
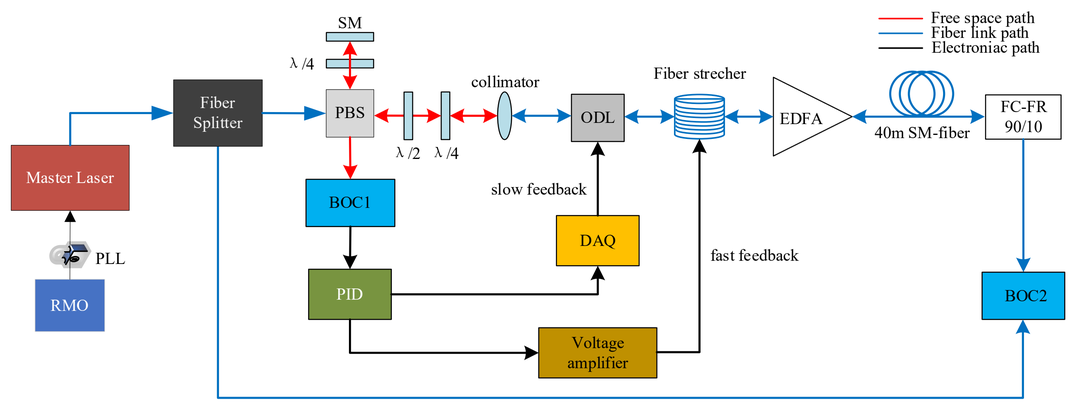


Figure (a) Operation principle of fiber link stabilization using BOC
Figure (b) Principle and main parts of BOC

Experimental setup and results

The fiber link stabilization unit mainly consist of three parts: free space optical path, fiber link and electronic part:

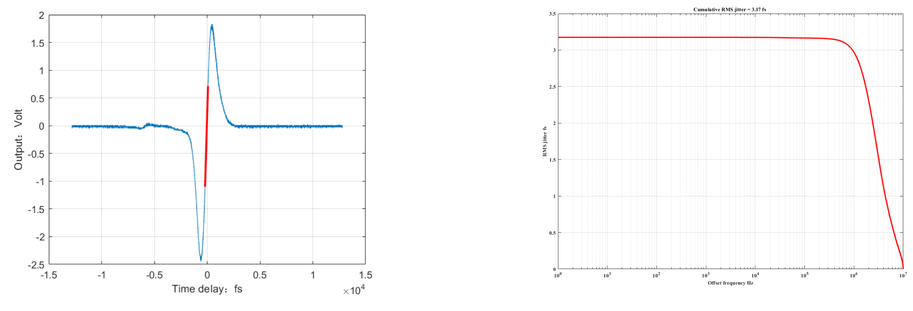
- The pulse trains from the master laser divided by PBS the reference path and the fiber link path, and both two combined into the BOC.
- BOC mainly consists of a dichroic mirror, a single periodically-poled KTiOPO4 (PPKTP) crystal (1mm×2mm×4mm), and a balanced photodetector
- Fiber link include a motorized optical delay line (ODL), a fiber stretcher, a erbium-doped fiber amplifier (EDFA), a 40-m fiber link, and a 90/10 transmission/reflection fiber-coupled Faraday rotator (FC-FR).
- The electronic signal from the BOC is processed by a PID controller and divided into fast feedback and slow feedback
- Two BOCs have been setup in laboratory, as is shown in the following figure. BOC1 is the in-loop section, and BOC2 is the out-of-loop part.



Schematic diagram of experimental setup

The latest experimental results:

- Sensitivity of in-loop BOC is 6.4mV/fs;
- RMS timing jitter from 1Hz to 1MHz is 3.17fs.



Experimental results of sensitivity and timing jitter

Summarize

We have setup a fiber link stabilization unit to femtosecond timing synchronization system for SHINE project, and the timing jitter in laboratory is less than 5fs. We will update the single-mode fiber to polarization maintaining fiber (PMF) for kilometers-long fiber link stabilization to meet the high accuracy requirement on SHINE project.