Carrier-envelope phase stabilization of a high-power regenerative amplifier

Fraser Turner*, Andrei Naumov*,[1], Chengquan Li†, and Alan Fry†

* National Research Council of Canada, 100 Sussex Dr., Ottawa, ON, K1A 0R6, Canada
† Coherent Inc., 5100 Patrick Henry Dr., Santa Clara, CA, 95054, USA

Synopsis: We present the results of the carrier-envelope phase stabilization of the commercially available high-power regenerative amplifier. We show the comparison between in-loop and out-of-loop phase noise measurements and discuss the effect of the Pockels cells on the carrier-envelope phase stability.

During the last several years significant progress has been made in carrier-envelope phase (CEP) stabilization of laser systems. Most of this work has focused on amplifiers with a multi-pass configuration, however as regenerative amplifiers are widely used as a primary amplification stage, stabilizing such systems is an important step in the realization of high power CEP stabilized lasers. It had previously been demonstrated that it is possible to maintain some degree of phase stability through a regenerative amplifier [1], subject to additional short-term noise sources and long-term drift in the stretcher, amplifier, and compressor. In the present work we show that a commercially available regenerative amplifier can be successfully CEP stabilized in the long term using a fast and slow feedback loop.

In our system, a Coherent Legend-HE regenerative amplifier was seeded by a temperature-stabilized Coherent Micra oscillator with an integrated Verdi V5 pump laser. About half of the oscillator output was re-compressed and sent into a Menlo Systems XPS800 f-to-2f interferometer, which was integrated into a thermalized baseplate together with the Micra oscillator. This produced a beatnote signal with more than 40dB signal-to-noise, and could stabilize the oscillator CEP to within 100mrad for several hours.

The Legend-HE Ti: Sapphire crystal was cooled to -5^{o}C using a thermo-electric cooler, and optically pumped with the Coherent Evolution 30 diode pump laser. The amplification process required about 15 passes through the laser cavity, including the crystal and two Pockels cells. The grating-based stretcher and compressor allowed for sub-40fs, 3mJ pulses at 1kHz.

The CEP stability of the amplified pulses was characterized with two Menlo APS800 f-to-2f self-referencing interferometer systems, one to control the slow feedback loop and the other for an out-of-loop phase noise measurement. The spectrometers were externally triggered to allow for precise and reproducible data acquisition.

In order to identify the sources of CEP noise, the entire system was placed on a floating optical table. While the oscillator was found to be susceptible to acoustic noise, the amplifier was instead sensitive to vibrations, the majority of which were suppressed by floating the table. Phase noise due to the electro-optic action of Pockels cells in the regenerative amplifier cavity was initially a concern. However, our analysis has shown that its' contributions to the phase noise are negligible.

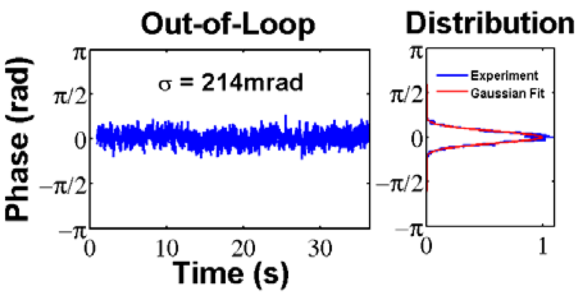

Fig. 1. Out-of-loop phase measurement of amplified laser pulse with a 5ms exposure time.

To date, we have achieved an out-of-loop phase stability of 214mrad for a spectrometer exposure time of 5ms (see Fig. 1). Phase-stable operation of the system could be maintained on the scale of hours.

References

[1] M. Kakehata et al., *Opt. Express* 12, 10 (2004)

1 E-mail: andrei.naumov@nrc.ca