Characterization of a SESAM Mode-locked Erbium Laser Frequency Comb with an Integrated Electro-optic Modulator

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In this paper the characteristics of a SESAM (semiconductor saturable absorber mirror) mode-locked frequency comb with an intra-cavity electro-optic modulator (EOM) are examined. To our knowledge this is the first time an intra-cavity EOM is used within a SESAM mode-locked erbium fiber frequency comb.

The frequency comb's precision depends on the short (phase noise) and long-time stability of the comb's repetition rate f_{rep} and offset frequency f_o. A reduction of the phase noise can be achieved using fast control loops for the stabilization of f_{rep} and f_o. In general the servo's bandwidth is whether limited due to the upper state life time of the laser's erbium, doped fiber ions or restricted due to the inertia of electro-mechanical components. An inline EOM overcomes these problems. Hereby the cavity's refractive index is changed by supplying a voltage to the EOM, which in consequence leads to a modulation in the frequency comb's f_o and f_{rep}. By using an EOM for stabilization, a significant enhancement in performance is obtained.

To locate promising operation points for locking the comb's offset frequency and repetition rate, a detailed characterization of the frequency comb was carried out. Hereby the sensitivity of f_o and f_{rep} is determined as a function of pump power setpoints and EOM voltages, considering the cavity's temperatures.

Furthermore the linewidth and phase noise of the free running offset beat, and EOM stabilized f_o is studied. In addition the impact of the pump laser's relative intensity noise (RIN), on the offset frequency's linewidth is analyzed, where a FBG pump diode and a hybrid external cavity laser (HECL) are used for comparison.

To prove the comb's function as a high stable and accurate interface between optical and HF standards, e.g. for atomic clocks, three different locking schemes for f_{rep} are investigated, using phase noise measurements as reference. These results underline the advantages of an intra-cavity EOM for f_{rep} stabilization.