

GHz Harmonic Mode-Locking from a Yb-Doped Fiber Laser with Consistently High SMSR

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Methods for generating GHz repetition rate laser oscillators can be generally categorized into harmonic mode-locking, semiconductor saturable absorber mirrors, and Kerr-lens mode-locking. Among these, harmonic mode-locking is achieved through soliton splitting. When the pulse energy exceeds a certain threshold, it undergoes a process of splitting to form higher-order solitons¹. In a mode-locked laser, the repetition rate of these higher-order solitons becomes a multiple of the fundamental frequency. Consequently, the repetition rate of the oscillator is not constrained by the length of the resonator.

Here, we present a laser oscillator with a fundamental repetition rate of 150 MHz and a pump power of 3 Watts. By adjusting the angle of the polarizer within the resonator, we can observe harmonic mode-locking. Remarkably, a super mode suppression ratio (SMSR) of over 70 dB can be consistently maintained from a fundamental mode-locking to the 6th harmonic mode-locking.

The radio frequency spectrum depicting various orders of mode-locked harmonics is presented in Fig. 1, revealing distinct and progressively increasing repetition rates. We can observe an excellent SMSR up to the 6th mode locking. The inset shows RF spectrum of the 6th harmonic mode-locking, where the SMSR is greater than 70 dB.

As we can see, the seventh harmonic mode-locking faces challenges in achieving a sufficient SMSR due to limited pump power. We believe that this constraint may similarly impede the realization of higher-order mode-locking. The pulse width also remains approximately 980 fs, showing a slight increase with higher orders. The repetition rate is expected to be further promoted to several GHz level by increasing pump power, and a shorter pulse width can be obtained by optimizing the intracavity net dispersion.

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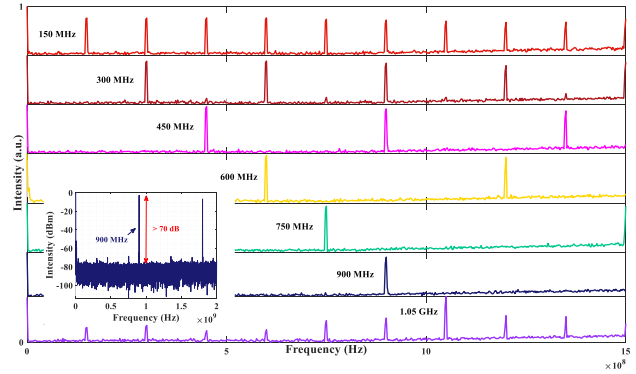


Fig. 1: Radio frequency spectrum of the harmonic mode-locking laser. Inset: RF spectrum ranging from 0 to 2 GHz with a resolution bandwidth of 300 kHz.

¹ Xueming Liu, Pang Meng. "Revealing the buildup dynamics of harmonic mode-locking states in ultrafast lasers." *Laser & Photonics Reviews* 13.9 (2019): 1800333.