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Dually-Mode-Locked Nd:YAG Laser

The problem:

Mode-locked Nd:YAG lasers have been contemplated for use as transmitters in pulse-code-modulated (PCM), optical communication systems. In such systems, a modulator external to the laser transmitter either passes or blanks each mode-locked pulse according to a binary coding scheme, thus producing a stream of ones and zeros at an optical receiver. The problem with mode-locking, however, is that the drive frequency which produces the internal time varying amplitude or phase perturbation of the laser must be matched exactly to the laser cavity length, in order to have good pulse amplitude, repetition rate, and width stability. Since the laser cavity varies continuously in length due to the thermal expansion and contraction and acoustical effects, stabilization is achieved only by continuously compensating for these effects. Different techniques have been used to stabilize mode-locking with limited effectiveness.

The solution:

Mode-locking is stabilized effectively by conventional loss-modulator and phase-modulator, mode-locking elements placed in the laser cavity in optical series with one another. The resulting dually-mode-locked system provides pulses with constant phase relative to the mode-lock drive signal without the presence of relaxation oscillation noise.

How it's done:

Figures 1(a) and (b) show schematics of two laser cavity configurations utilizing the dually-mode-locked concept. In Figure 1(a) the phase mode-locker is adjacent to the rear mirror and the loss modulator is adjacent to the front mirror. In Figure 1(b) the phase mode-locker is adjacent to the rear mirror and the loss mode-locker is just to the right of the phase mode-locker.

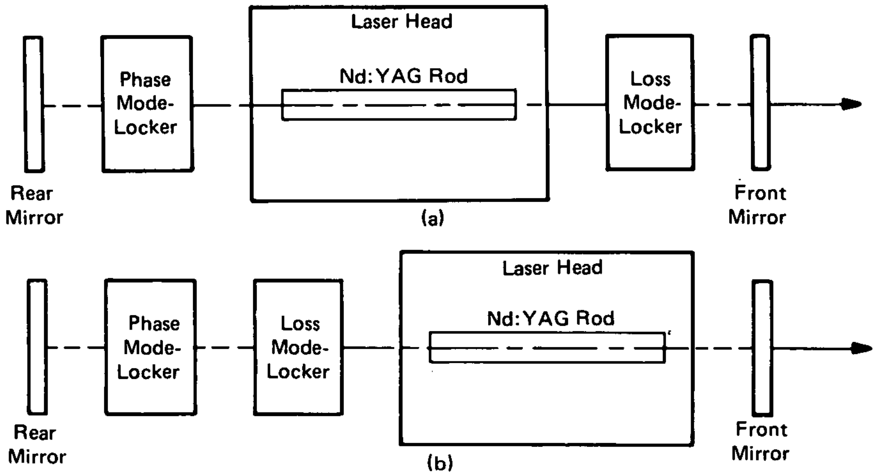

Figure 1. Laser Cavity Configurations: (a) Dually-Mode-Locked Laser With a Loss Mode-Locker Adjacent to the Front Mirror and a Phase Mode-Locker Adjacent to the Rear Mirror, (b) Dually-Mode-Locked Laser With a Loss Mode-Locker in a Different Position

(continued overleaf)

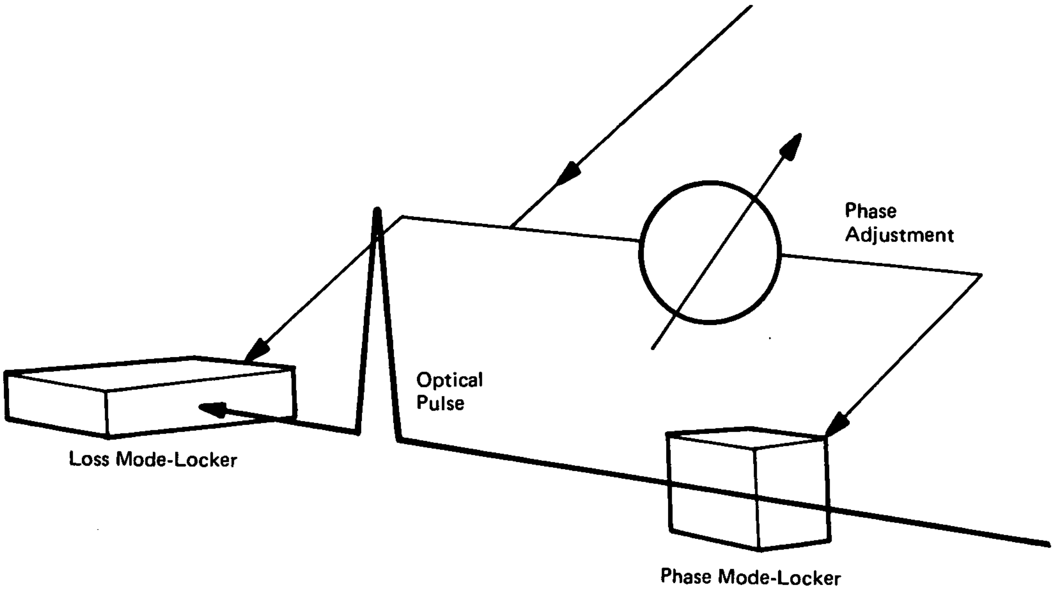

Figure 2. An Optical Pulse Propagating From the Phase Mode-Locker to the Loss Mode-Locker

There are two important considerations when implementing a dual loss and phase mode-locker system for optimum performance. First, the two mode-lockers must be driven at different modulation frequencies in order that each produce an output pulse train of the same repetition rate. The second consideration is that mode-locked pulses must be properly timed in order to pass through both mode-lockers without being extinguished.

Figure 2 shows a mode-locked pulse leaving the phase mode-locker and propagating toward the loss mode-locker. This pulse must arrive at the loss mode-locker when transmission through the loss modulator is at maximum. Timing can be accomplished by adjusting the phase of the modulation signal applied to one of the two mode-lockers; Figure 2 shows a simple case where both mode-lockers are driven by the same source, and the phase of the signal to the phase mode-locker is adjusted.

In this system, the loss mode-locker is driven at a very low level so that the mode-locked pulses are extremely wide and there is no relaxation oscillation noise. When operated in this condition, the loss mode-locker acts as a gate, forcing the phase mode-locker to remain always in phase with the mode-lock drive signal.

Note:

Requests for further information may be directed to:

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Patent status:

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning non-exclusive or exclusive license for its commercial development should be addressed to:

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