Relaxation oscillation noise suppression in fibre DFB lasers using a semiconductor optical amplifier

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Abstract: We report the experimental results of a simple, all optical technique to reduce the relative intensity noise peak of a fibre distributed feedback laser. A noise reduction of 30 dB is achieved.

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The fibre distributed feedback (DFB) laser is an attractive alternative to semiconductor diode lasers, due to its fibre compatibility, narrow linewidth, and low intensity noise. However, the characteristic relaxation oscillation peak in the laser noise spectrum can limit sensitivity in low frequency applications such as sensing and metrology. Previously, optoelectronic feedback methods have been used to reduce this noise peak [1]. In this paper, we present a simple, all optical technique that uses the gain dynamics of a saturated semiconductor optical amplifier (SOA) to reduce the relative intensity noise (RIN) peak of a fibre DFB laser.

We used a single polarisation Er-Yb codoped fibre DFB laser with a cavity length of 5 cm. The laser was counter-pumped at 980 nm and had an operating wavelength of 1552.1 nm [2]. The output power of the laser was set to 10 dBm, yielding a relaxation oscillation frequency of 930 kHz. The output of the laser was then attenuated to ~4.5 dBm before being launched into the SOA (Figure 1), while the SOA drive current was set to 200 mA. This combination of drive current and optical input power ensured that the SOA was operated in the gain-saturated regime.

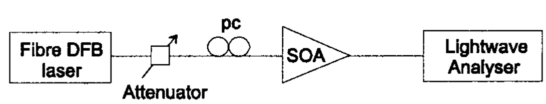

Fig. 1. Experimental setup

The noise spectrum was measured before and after the SOA using an Agilent lightwave analyser (Figure 2a).

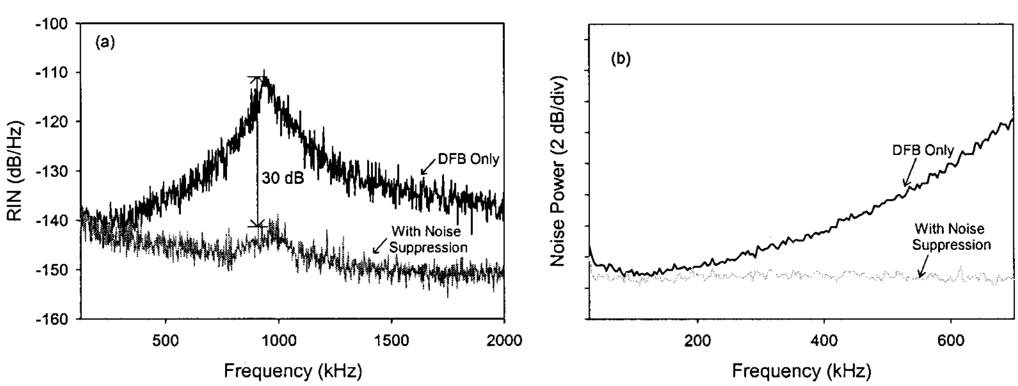

Fig. 2. (a) RIN measurements before and after noise suppression using a lightwave analyser. The apparent increase in RIN visible at frequencies lower than ~600 kHz is caused by the noise floor of the analyser. (b) Low frequency noise power spectrum (30-700 kHz) using an electrical spectrum analyser and a 125 MHz high sensitivity photodetector

By using the SOA we are able to reduce the relaxation oscillation noise peak from -110 dB/Hz to less than -140 dB/Hz, thereby achieving a RIN improvement of 30 dB. Our results clearly show intensity noise suppression at frequencies as low as 30 kHz (Figure 2b) and noise suppression down to DC has been demonstrated using numerical simulations [3]. At frequencies greater than the noise suppression bandwidth of the SOA (~3 GHz), a slow increase is observed in the RIN spectrum, which is caused by the unsuppressed spontaneous emission beat noise introduced by the amplifier. At 10 GHz the RIN value with the DFB alone is -163 dB/Hz, while the SOA increases this to -150 dB/Hz. The frequency range over which the noise suppression occurs is determined by the carrier lifetime of the SOA and is of the order of a few GHz [3].

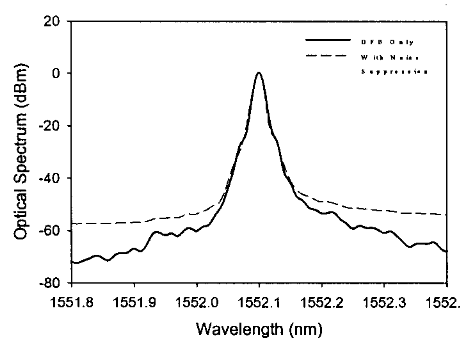

Fig. 3. Optical Spectra before and after noise suppression

The optical signal-to-noise ratio of the SOA output signal was measured to be greater than 55 dB (Figure 3). Additionally, linewidth measurements performed using the delayed self-heterodyne technique showed no noticeable difference in the laser linewidth before and after noise suppression.

In conclusion, the gain saturated SOA provides a simple and effective method for reducing the relaxation oscillation peak in a fibre DFB laser. Using this technique, the RIN peak of the laser was reduced to less than -140 dB/Hz, achieving a noise suppression of 30 dB. The SOA provides suppression at frequencies below ~3 GHz, thereby enhancing the potential of using fibre DFB technology for low frequency sensor and metrology applications.

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