All-Optical Tunable Microwave Filters with Negative Multi-Taps based on Uniform Fiber Bragg Gratings

J. Mora, M. V. Andrés, J.L. Cruz, , Universidad de Valencia, Burjassot (Valencia), Spain;
B. Ortega, J. Capmany, D. Pastor, S. Sales, Universidad Politécnica de Valencia, Valencia, Spain.
e-mail: Jose.Mora-Almerich@uv.es

We have demonstrated a novel transversal filter with negative coefficients under incoherent operation. Our proposal is based on filtering a broadband optical source with fibre Bragg gratings (FBG's) to generate the taps with negative coefficients, while a laser array generates the positive taps. Previous proposals require active elements[1], while our scheme uses passive components, i.e., FBG's, and, in addition, the negative taps are fully independent on the positive taps.

In our previous work, we have analysed other transversal filters based on broadband optical sources sliced by FBG's [2]. After that work, one can conclude that the use of a broadband source permits to obtain the correct response of the negative transversal filters above a frequency f_C. Such a sort of cut-off frequency is given by $f_C \approx 1/(\beta \cdot L \cdot \delta\omega)$, where β is the linear fiber dispersion (15.5 ps/nm×km at 1530 nm), L is the fiber length and $\delta\omega$ is the bandwidth of the optical source. Therefore, using a high dispersion value and a broadband source, f_C becomes an electric low frequency. The residual contribution in the frequency band $[0,f_c]$, can be filtered by using an electrical filter in the receiver. The free spectral range (FSR) of the filter will be $FSR=1/(\beta \cdot L \cdot \Delta\omega)$, where $\Delta\omega$ is the optical frequency separation between taps.

In our present experiment (figure 1), the implemented filter is formed by three tunable lasers (TL) and the signal transmitted by two FBG's, which are illuminated with the ASE of an Erbium Doped Fiber Amplifier (EDFA). The broadband optical source has a 3dB-bandwith of 5 nm around 1530 nm, when injected current is 150 mA. The FBG's are 1 cm-long and are written on photosensitive fiber, having a maximum reflectivity of 8 dB**.** The output light from the FBG's and the TL's is driven to a 90/10 optical coupler. The combined signal can be monitorised by an optical spectrum analyser (OSA) by using the 10% arm. The 90% arm signal is amplitude modulated in an external modulator (EOM), whit a RF-signal of frequency f, generated by a lightwave component analyser (LCA). A fiber length of 23 km will be the dispersive element in the filter, and finally, the transfer function of the filter is measured in the LCA.

In order to show the performance of this filter when various taps are added, figure 2 plots the transfer function of a 5-taps RF filter with a wavelength separation between taps of 1.16 nm. The FSR is 2.40 GHz and the 3dB-bandwith is 0.437 GHz, corresponding to the theoretical predictions. Above a frequency f_C =0.58 GHz, we can observe a perfect agreement between experimental results (solid lines) and theoretical calculation (dotted line). Moreover, the system allows a wide tuning range, being possible to tune the FSR range from 1GHz to 6 GHz (see inset fig. 2).

In conclusion, our proposal is an all-optical and passive configuration, which exhibits a good performance and higher tunability and lower cost than previous configurations. Current work is focused on reducing the frequency f_C to hundreds of kHz without increasing the noise to signal ratio.

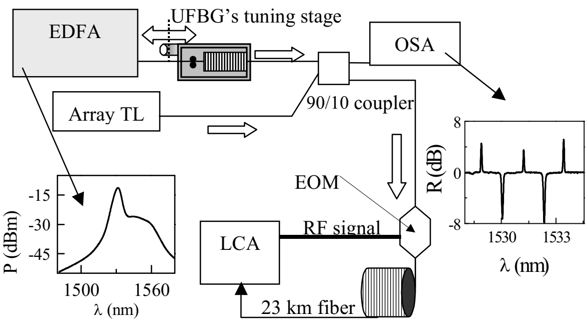

Figure 1. Setup of the RF negative-taps filter. Insets: (right) Input signal launched into EOM relative to EDFA power level (left).

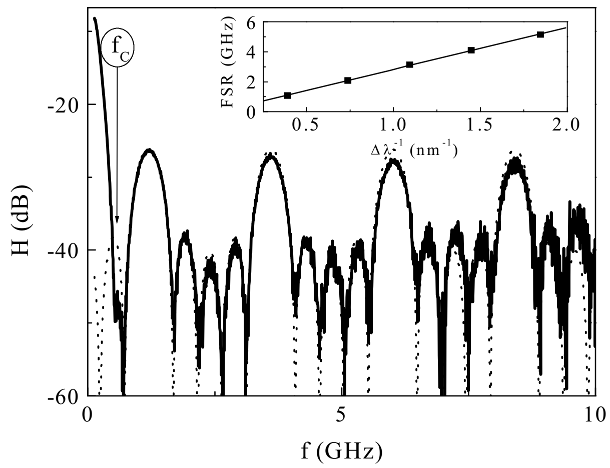

Figure 2. Filter response versus RF signal frequency. Theoretical calculation (dotted line) and experimental results (solid line). Inset: FSR as a function of wavelength separation between taps.

References

[1] Yi Xiaoke, Fang Wei, Ng Jun Hong and Lu Chao, IEEE Photon. Tech. Lett., **13**, 857 (2001).
[2] J. Mora, B. Ortega, J. Capmany, J. L. Cruz, M. V. Andres, D. Pastor, S. Sales, Opt. Express, **22**, 1291 (2002).