New optical filter employing multireflection mirror to provide design flexibility for WDMA

S. Vargas, C. Vázquez

Dpto. Ingeniería Eléctrica, Electrónica y Automática, Area Tecnología Electrónica, Universidad Carlos III,
Av. Universidad 30, Leganés 28911, Madrid, Spain • *Fax*: 3416249430 • *E-mail*: cvazquez@ing.uc3m.es

Abstract: An optical filter employing multireflection mirror within an amplified ring resonator is presented. The multireflection mirror allows bandpass frequency response tuning by changing the coupling factor of a coupler. The device can achieve higher crosstalk with lower gain values in comparison with previous optical filters with similar architecture. Easy to use expressions to simplify design process are derived.

Introduction

Single-hop architectures in multiwavelength networks use control channels to inform the destination node that a packet has been transmitted and to which channel to tune its receiver [1]. One optimum way is using subcarrier multiple access (SCMA) for the control channels. Key components to extract those headers are tuneable filters and routers, which can also be used in a self-routing Frequency Division Multiple Access (FDMA) topology [2]. Some optical filters previously reported are cascaded Mach-Zehnder (MZ) demultiplexors [3], Amplified Ring Resonators (ARR) with a FSR limited by ring length [4]. Other devices are based on ARR and Bragg Gratings (BG) to overcome FSR constraint [5]. In any of them tuning process is done by means of changing ring length.

In this paper an optical filter is presented. It is based on an AAR and BG but it has an extra flexibility in the tuning process, which can be done in the conventional way or by changing the coupling factor of a coupler. This coupling factor controls the multireflection mirror and allows low gain levels for optimum performance. Basic architecture along with analytical expressions to make easy the design and the tuning process are reported.

Principle and Design Equations

Optical filter reported here comprises an amplified ring resonator (ARR) and a non-periodic bandpass filter, which consist on a coupler and two equals BG, see Fig.1, which behaves as a multireflector mirror. The architecture is similar to the device described in [5-6] but a general coupler replaces the 3dB coupler of the non-periodic band pass filter. The selection of the coupling factor controls the separation between selected channels. Output power at port 3 and port 4 is obtained from the following equations:

$$P_3 = (1-\gamma)^{1/2}\left[\sqrt{1-K}\cdot P_1 + j\cdot\sqrt{K}\cdot P_{2f}\right] \tag{1}$$

$$P_{4f} = (1-\gamma)^{1/2}\left[j\sqrt{K}\cdot P_1 + \sqrt{1-K}\cdot P_{2f}\right] \tag{2}$$

$$P_{2f} = \sqrt{G}\cdot z^{-1}\left[Ft_1\cdot P_{4f} + \sqrt{G}\cdot Fr_1\cdot P_{2b}\right] \tag{3}$$

$$P_{2b} = (1-\gamma)^{1/2}\cdot\sqrt{1-K}\cdot P_{4b} \tag{4}$$

$$P_{4b} = z^{-1}\left[\sqrt{G}\cdot Ft_1\cdot P_{2b} + Fr_1\cdot P_{4f}\right] \tag{5}$$

Ft_1 and Fr_1 are transmission and reflection transfer function of the multireflector mirror respectively.

From previous equations it can be derived that output power at port 3 is given by:

$$\frac{P_3}{P_1}(z) = (1-\gamma)^{1/2}\left[\frac{A+Bz^{-1}+Cz^{-2}}{1+Dz^{-1}+Ez^{-2}}\right] \tag{6}$$

Poles and zeros locations are obtained from (6) and operating with them we obtain that the separation in frequency of the two maxima that now appear is controlled by Kb through the following expression:

$$\Delta f = \left(0.5-\frac{\phi}{\pi}\right)\left[\frac{n+cT\left(\alpha_p+\sqrt{{k_p}^2+{\alpha_p}^2}\right)}{c\left(\alpha_p+\sqrt{{k_p}^2+{\alpha_p}^2}\right)}\right] \tag{7}$$

with ϕ for the poles equal to:

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$$\phi = atan\left[\frac{2\sqrt{K_b} - K_b^{\,2}}{1 - 2K_b}\right] \qquad (8)$$

where n is the refractive index, c is light velocity, α_p and k_p are loss and coupling coefficient of Bragg grating respectively [7].

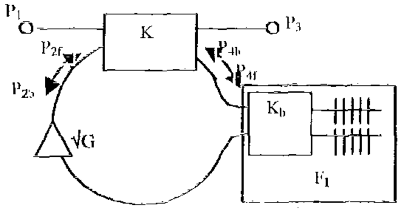

Figure. Filter schematic

At Fig. 2.a and 2.b it can be seen output power at port 3, P_3, and port 4 forward, P_{4f}, with and without multireflection mirror. In the first case, no multireflection mirror is considered, that can be accomplished using Kb=0.5 or using an isolator. The transfer function is equivalent to that reported in [6] with a maximum at BG central wavelength. For K=0.1, G=1.3, Kb=0.55 and BG with a 99% reflectivity and a FWHM of 0.14nm a crosstalk of 20 dB is obtained. Using the novel device, with no isolator, so F_1 behaves as a multireflection mirror, with the same values of G, Kb and K, and the same BG and using Eq. (6), we can see that two maxima separated by 320 MHz appear. A crosstalk of 35dB in port 3, P_3, is obtained, so we can have 20dB crostalk with a lower gain value.

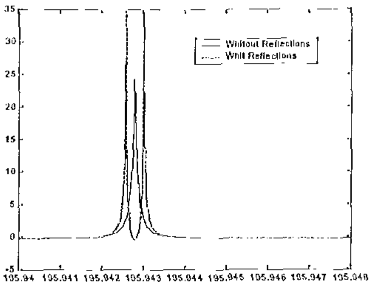

Figure 2a: Output power at port 3, with and without multireflection mirror.

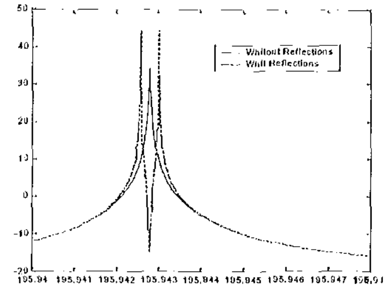

Figure 2b: Output power at port 4 forward, with and without multireflection mirror.

Conclusions

A novel optical device employing an amplified ring resonator and a multireflecting mirror inside, is presented. Is founded its transfer function. Also simple expressions for the separation of the two maximums of this novel transfer function are developed. We have obtain separations of 320 MHz for $\Delta K_b = 0.05$.

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