A Configurable Wavelength Demultiplexer Using Periodic Filter Chains

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Summary

The ability to select an arbitrary wavelength out of a large set of wavelengths is important for future dense wavelength division multiple access (DWDM) systems. Current approaches use a spectrometer to demultiplex the wavelengths and use a switch at each wavelength to select or deselect that particular wavelength at the output [1]. In a DWDM system with N wavelengths, N number of switches at each receiver need to be employed in order to select an arbitrary wavelength using the conventional approach. Since switches are active components, this is undesirable when N is large.

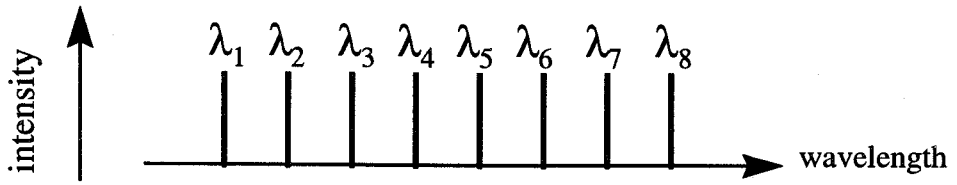
A better scaling can be achieved if we can arrange a series of configurable filters in a way that half of the spectral energy is filtered out when the input spectrum is passed through each successive stage of the filter. So the first stage filters out half of the spectrum. The second stage filters out another half of the spectrum that is left from the output of the first stage, etc. Figure 1(a) shows the spectrum of an eight-wavelength WDM signal. Figure 1(b) shows the filter function of each stage in a three-stage cascaded filter which is able to select any one wavelength in the signal spectrum shown in Figure 1(a). The solid lines represent the normal filter output transmission and the dotted lines represent the complimentary filter output. Optical filters are usually interferometric devices which generate periodic complementary outputs at the same time. An example is a Mach-Zehnder interferometer (MZI) [2]. A switch in series with each filter stage is used to select either one of the two complementary spectra as the input to the next stage (Figure 2). The period of the next filter is twice that of the previous filter. Any wavelength can be selected by properly setting the switches at each stage to select the appropriate normal transmission spectrum or complementary transmission spectrum. Scaling then becomes $\log_2 N$ instead of N which is much more favorable. To select one wavelength out of 1000, only ten switches are needed.

The filters used at different stages could be MZI's for which the periodicity is controlled by varying the optical path differences between the two arms of the MZI. To generate more square like transmission functions, a periodic cavity structure in the form similar to a one-dimensional photonic crystal [3] may be used. More detailed design considerations and analysis will be presented in the conference.

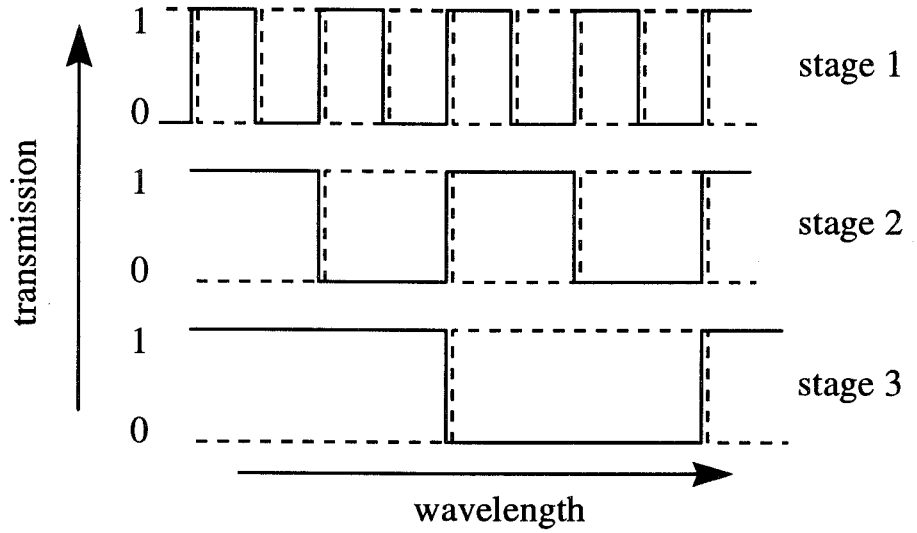
References

1. R.T. Hofmeister et. al, "Project LEARN - Light Exchangeable, Add/Drop Ring Network", OFC 97 post deadline paper, IEEE
2. P. E. Green, "Fiber Optics Networks", Prentice-Hall, 1993

3. E. Yablonovitch, J. Opt. Soc. Am. B, Vol. 10, No. 2, Feb. 1993



(a) Wavelength Multiplexed Signals



(b) Transmission Functions of Successive Stages

Figure 1. An example of a 3-stage WDM demultiplexer with the ability to isolate an arbitrary wavelength out of the eight multiplexed wavelengths.

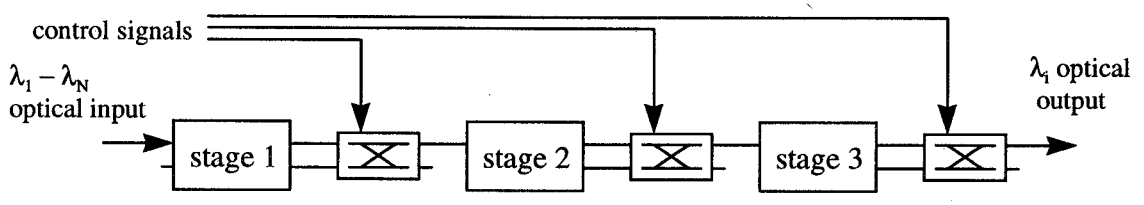


Figure 2. The schematic diagram of an eight-wavelength demultiplexer using three cascaded filter stages.