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An Analysis on Apodization Factor with Length in Optical and Drop Multiplexer

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ABSTRACT

This Paper explores the design of new optical add drop multiplexers (OADMs), which are critical devices enabling the realization of metropolitan WDM ring networks. Three types of OADMs are investigated corresponding to different network requirements, namely fixed, reconfigurable and bidirectional OADMs. The devices use a multi-port optical circulator (OC) and one fibrebragg grating (FBGs). The simulation of the reflectance of the uniform and apodized fiber bragg grating (FBG) are presented. Various apodization technique is useful to reduce side lobes of reflection spectrum of fibrebragg grating. We design a Matlab Graphical User Interface (GUI) window to check apodization effect on crosstalk performance of OADM. From this window we can select various input waveform (from 1548 nm to 1552 nm) of different amplitude, can change FBG wave-length for drop channel also can add new information from add channel.

Keywords:- Fibrebragg grating, Multiplexers, Wavelength-division multiplexing, Optical add–drop electronic device.

INTRODUCTON

The first observation of permanent periodic modification of the index of refraction in an optical fiber in 1978 [1] marked the start of a major breakthrough in optical telecommunication equipment development.

These activities inspire the FBG fabrication technology, which over time has advanced to the purpose wherever complicated grating structures are currently possible [2]. The flexibleness offered within the style and fabrication of FBGs lays down broad and necessary roles in numerous applications that concern optical systems. FBGs would perform identical functions because the existing various devices or become the enabling devices of various once impractical technologies. Evidently, FBGs are recognized as key elements in new age optical telecommunication systems [3].

Fiber brag gratings are spectral filters supported the principle of Bragg reflection. They typically reflect light over a narrow wavelength vary and transmit all different wavelengths. Once light propagates by sporadically alternating regions of upper and lower refractive index, it's partly reflected at every interface between those regions. If the pitch of the rating is correctly designed, then all partial reflections add up in phase and might grow to just about 100 pc, for a selected wavelength even if the individual reflections are terribly little. The condition for top reflection is thought as brag condition. For all alternative wavelengths the out of phase reflections end up cancelling one another, leading to high transmission.

The Optical add–drop electronic device (OADM) is a key element for wavelength-division multiplexing (WDM). An important technical issue for OADM style is that the disturbance, which may severely degrade system performance. Many sorts of OADMs are incontestable supported different optical devices. These devices embody arrayed-waveguide grating multiplexers, Mach–Zander interferometers with fiber full general gratings (FBGs), and optical circulators with FBGs. Among them the structures that use fiber gratings combined with circulators are attractive because of their low insertion loss, low disturbance, and temperature and polarization unfitness [1].

In this paper, we demonstrate and analysis the OADM structures that exhibit low disturbance even with multiple wavelengths. The OADM use an easy configuration of a 3 port Optical Circulator with FBGs, betting on the necessity of ADD or DROP channel. It is used in Optical Cross Connects.

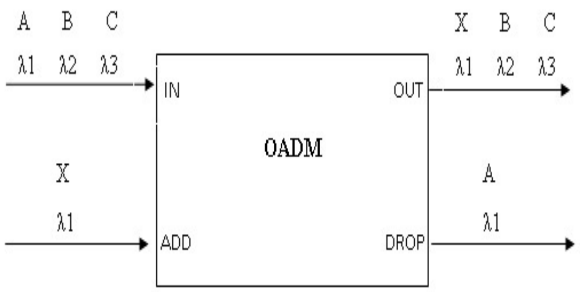

Figure 1.1: Basic OADM Block Diagram.

Figure 1.1 shows a diagram of unofficial fixed OADM, in which signals travel in one direction through the device. Thee IN and OUT ports of the OADM are connected to the network, whereas the ADD and DROP ports are connected to the local transmitter and receiver, severally. During this example three channels A, B and C at wavelength λ1, λ2 and λ3 severally, enter the IN port of the OADM. Channel A is born from the DROP port. Channel X at wavelength λ1 enters the device via the ADD port. ADD channel X together with through channels B and C are routed to the OUT port of the OADM and continue through the network.

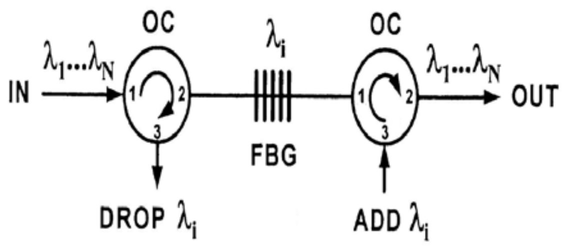

Figure 1.2: Basic OADM Structure.

If the OADM shown in figure 1.1 can be dynamically reconfigured to add/drop different channel(s), the device becomes an ROADM. An ROADM has either a strictly non-blocking, a rearrangeability non-blocking, or a block shift function. If the OADM is strictly non-blocking, a channel can be born and/or accessorial while not troubling any other channels.

II OPTICAL CIRCULATOR

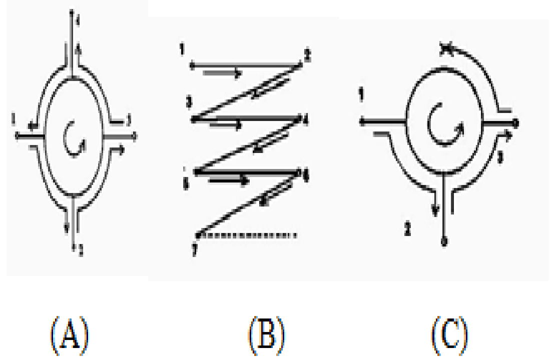

Figure 2.1: (A) - Strict Sense Circulator with 4 ports,
(B) Non Strict sense circulator with ladder topology,
(C) Non strict sense circulator with 3 port.

An optical circulator is a generalized isolator having three or more ports. Whereas an isolator causes loss in the isolation direction, a circulator collects the light and directs it to a non-reciprocal output port. The figure drawn above shows the

many possible circulator configurations. Figure (a) illustrates the port mapping for a four-port circulator. The ports cyclically map 1-&g t; 2 -&g t; 3 -&g t; 4 -&g t; 1. This is known as a strict-sense circulator because each input port has a specific non-reciprocal output port. Construction of a strict-sense circulator with more ports becomes homely but ones with three ports become easy. Figure (b) illustrates a non-strict-sense circulator having any number of ports bigger than two. In this case every input port has a specific non-reciprocal output port apart from the last port; the light input to the last port is lost. The ladder diagram reflects the optical path among the part and indicates the no connection between the first and the last ports. Figure (c) illustrates the three-port non-strict-sense circulator. This circulator has significance in telecommunication applications because come of light from port 3 to port one isn't often required. for example, the reflected light from a fiber bragg grating want only be separated from the input light while not loss, however as optical links aren't usually operated in reverse there is no would like for strict-sense behavior.
When one port of a three-port circulator is terminated in a matched load, it are often used as an isolator, since a symptom will travel in just one direction between the remaining ports. .

2.1 Design of Optical Circulator
Cost and stability are the most limiting factors in increasing the applications of optical circulators. Recently, many styles are developed in a shot to reduce the value and notice high responsibility. in the style shown in the second figure on top of, the circulator is employed in a very collimated beam and every port is collimated employing a lens; so, comparatively massive size parts need to be used in order to construct the look because of the beam size. In recent styles, efforts are targeting reducing the employment of materials and size.

2.2 Circulator Design Using Diverging Beam
A compact affordable circulator design has been projected, inserting optical parts in a branching beam rather than in a collimating beam to cut back the use of costly materials.

As shown within the figure below, in this design, all optical parts are placed in a branching beam between the input/output ports and lenses. Two identical teams of parts are placed close to the put concentration of the lens, leading to reduced size and producing quality. every group of parts consists of two refraction crystals, one chemist rotator with 45° rotation angle, and two half-wave plates with their optic axes bound in opposite directions (22.5° and -22.5°).

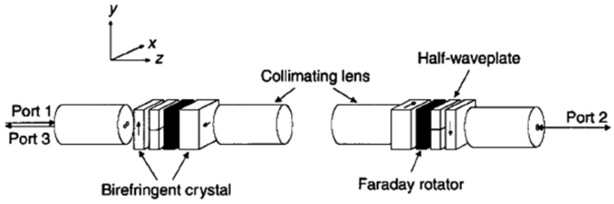

Figure 2.2: Compact Circulator Based on Diverging Beam Shifting.

In operation, a light beam from port 1 is split into two orthogonally polarized beams in the coordinate axis by the first refraction crystal. the two half-wave plates and the chemist rotator are organized such after passing through the rotators the polarization directions of the two beams are a similar and match the normal ray direction of the second refraction crystal. Therefore, the two beams have the second refraction crystal with none displacement. Two lenses are used for providing a matched imaging system. Because the second group of the part is the same as the first one, the two} beams are recombined and began port 2.Similarly, a light beam launched into port 2 is split and older to the rotators. Because of the unrequited rotation of the chemist rotator, the polarization directions of the two beams are turned matching the extraordinary ray direction of the second refraction crystal. Therefore, the two beams are shifted a particular quantity along the x-axis and shifted again constant amount by the second refraction crystal in the different group. If the ad of beam shifting by the two refraction crystals is meant such it's a similar as the distance between the first and third ports, the two beams are recombined and paired into port 3.

Because port 1 and port 3 share one lens and the beam shifting is completed at the branching beam, the desired beam shifting in this case is very little and generally up to the fiber diameter of 125 am. On the other hand, the required beam shifting in the design shown antecedently is set by the diameter of a lens thanks to the employment of collimated beams and is often within the order of millimeters.

III Optical Add-Drop Multiplexer Architectures

There are two main styles of OADM that may be employed in WDM optical networks; fixed OADMs that are wont to drop or add knowledge signals on dedicated WDM channels, and reconfigurable OADMs that have the power to electronically alter the selected channel routing through the optical network. the most options of the second style of OADM is to supply flexibility in rerouting optical streams, bypassing faulty connections, permitting lowest service disruption and the ability to adapt or upgrade the optical network to totally different WDM technologies.

An important characteristic of OADMs is disturbance. Disturbance is mostly divided into in-band and out-of-band noise. In-band (or homodyne or interchannel) disturbance happens once the disturbance and desired signals are at constant nominal wavelength and out-of-band (or heterodyne or interchannel) disturbance happens once the disturbance signal is at a special wavelength to desired signal. The result of in-band disturbance on the required signal bit-error-rate (BER) is way more severe than for out-of-band disturbance. Therefore, a good in-band disturbance characteristic for an OADM is very important in order to make sure an honest BER performance.

Configurations given within the literature to perform the required add or drop functions use both planate and fiber technology. Planate devices offer compact solutions with the chance of adding or dropping many channels using just one integrated optical circuit using arrayed-waveguide-grating (AWG) or waveguide -grating-router (WGR) technology. The most drawbacks of planate devices are their high insertion loss, which may be as high as 7dB, and their polarization dependence. or else, all-fiber devices are attractive solutions because of their low insertion losses, polarization unfitness (depending on the fiber and configuration) and ease of coupling between device output and inputs of the optical network using easy splices and pigtails. Typically, because of their larger dimensions these devices are sensitive to environmental variations, dependent upon the configuration. Devices based mostly in free area optics (micro mirrors and gratings) have also been used with success to perform add-drop operations with smart performance. Fiber and planate add- drop configurations and their several performances are discussed within the following section.

3.1 Add-Drop Configurations

Excellent performance and compactness offered by four-port planar-waveguide-based devices will be rivaled by the simple all-fiber add-drop configuration, as shown in Figure 3.1. It consists of a 3dB splitter and a grating in one of the output arms; light began port1 is split in two; λB is mirrored by the grating then born at Port 4. the other coupling output port is immersed in an index matching fluid so the light isn't reflected. the selected signal emerges at each the input and drop port. Associate in Nursing optical isolator at port one protects the input network from the back-reflected sign al. The born signal is 6dB weaker than the first signal. In transmission, a second 3dB coupling splits the signal that wasn't reflected by the grating. The add perform is performed by launching a proof into port 3 that is mirrored by the grating and so extra to the signal at port 2, as illustrated in Figure 3.1. An isolator is also required to isolate the Add port from the sign al transmitted from the input. Once using the two isolators, at the input and Add ports, this non-interferometric Configuration provides wonderful add-drop performance. In this configuration there are no limitations on the length, position, or apodization of the written grating. Ideal grating filters is also designed using an inverse scattering methodology. The first downside of this configuration is the insertion loss to all the channels that's a minimum of 6dB. However, once comparison with planar-waveguide-based devices, it's similar insertion losses but has multiplied flexibility in writing and standardization ideal gratings. even so, planate devices have the advantage of compactness and are easier to stabilize with relation to environmental changes.

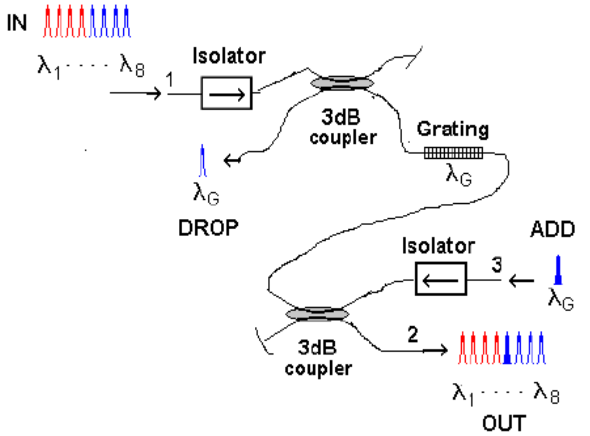

Figure 3.1: Add Drop Multiplexer Configuration Based on a Grating and Two 3 dB Coupler.

One methodology to beat the high insertion loss of the above configuration needs an extra grating, just like the first, written in the unused coupling ports, so forming a Mach-Zehnder measuring device. Both planate and devices using this configuration are according. On paper this device is even and might yield wonderful performance in terms of insertion loss, back-reflection and cross-talk.

Figure 3.2 illustrates the principle of operation for this configuration: A 3dB coupling splits light began port 1 and a particular wavelength λG, is mirrored by the two identical gratings. These mirrored signals interfere within the 3dB coupling in such the way that the signal is born and the back-reflected candlepower incoming at port1 is zero, providing the coupling is compatible (50% splitter). The transmitted wavelengths are created to interfere within the second 3dB coupling such they make the output port with no residual light at the Add port, once more for a well- matched coupling. This configuration is based on the rending and interference of light and is so quite sensitive to changes within the signals path length, the characteristics of the identical gratings, and the matching of the 3dB couplers. so environmental stabilisation, UV trimming of the individual ways and identical couplers and gratings are essential for good device performance. the soundness and tolerances for achieving practical WDM performance using this configuration were analysed by Erdogan. This configuration in planate technology has shorter path lengths and so is simpler to Stabilise. Also, identical gratings will be written with one exposure simply by using a little separation between the measuring system arms. different configurations supported the dual-core fibers that present shorter measuring system arms and avoid the need for UV trimming are incontestable as practical devices using the MZ measuring device configuration stabilise. Also, identical gratings will be written with one exposure simply by using a little separation between the measuring system arms. Different configurations based on the dual-core fibers that present shorter measuring device arms and avoid the requirement for UV trimming are demonstrated as practical devices using the MZ measuring device configuration.

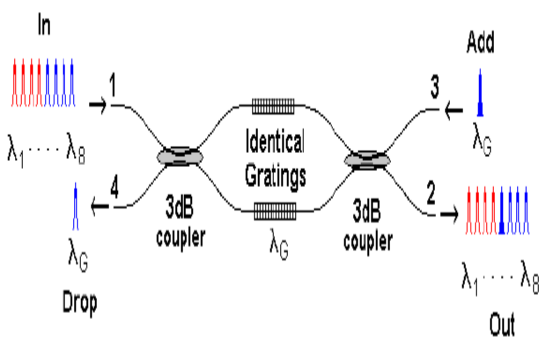

Figure 3.2: Add Drop Multiplexer Configuration. **Based on a Mach-Zehnder Interferometer**.

Another example of a regular four-port add-drop electronic device is comparable to configuration 1 shown in Figure 4.3, with the 3dB couplers replaced by optical circulators. in theory the operation of this non-interferometric device is ideal: The spectral properties rely in the main on the performance of the grating which will be designed as a perfect square filter using inverse scattering techniques; the insertion loss and cross-talk are chiefly keen about the performance of the optical circulators. Figure 3.4 illustrates this configuration. light began port 1 is directed into a fibrebragg gratin g with resonant wavelength λG, reflected back to the circulator and born to port 4 with the remaining optical channels being transmitted to make port 2. Another signal of wavelength λG, is launched in port 3, reflected by the grating and more to the optical stream at port 2.

The main downside of this configuration is that circulators are dear and hulking devices. However, with the arrival of cheaper circulators and with low insertion losses, it'll be a really engaging add-drop electronic device solution, thanks to its inherent stability and performance.

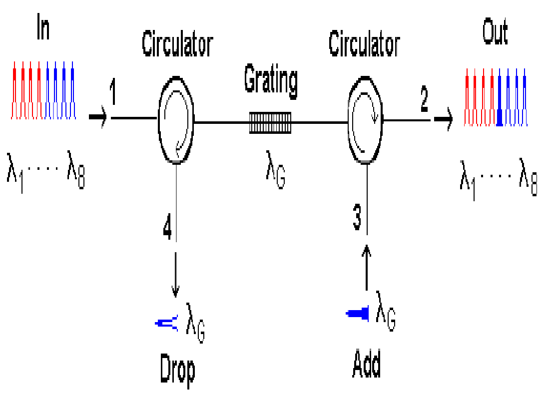

Figure 3.3: Add Drops Multiplexer Configuration Based on a Grating and Two Circulators.

The stability of the interferometric add-drop electronic device shown in Figure 4.3, configuration 2, can even be improved by using the interference between the Eigen modes of a fiber mechanical device. Writing a grating within the waist of a half-cycle (100%) mechanical device has been demon strated in each fiber and planate configurations as a means of achieving add-drop performance. The device is compact, but in theory only has an ideal even performance once the grating is a point-like reflector. This is only possible by using very short and powerful gratings or very long couplers. Figure 4.4 shows schematically this configuration. Light began port 1 is transferred to the even and odd eigenmodes of the machine. A grating is placed at the middle of the machine where the half distinction between the eigenmodes is p/4 i.e., where light is equally split between the two coupled waveguides (see chapter 4 for the eignemode description of a united coupler). The channel at the grating resonance wavelength λG is reflected and also the remaining signals propagate through the coupling incoming at the output port. In reflection, the eigenmodes reach the beginning of the coupling with a p/2 total section distinction then; the channel is born to port 4. in theory, the stabilisation of this interferometric device is improved with regard to the Mach-Zehnder (configuration 2) because of the purpose-like reflection point and conjointly the interference achieved through the beating between the propagating machine eigenmodes. However, limitations inside the grating strength and invented couplers compromise the expected performance.

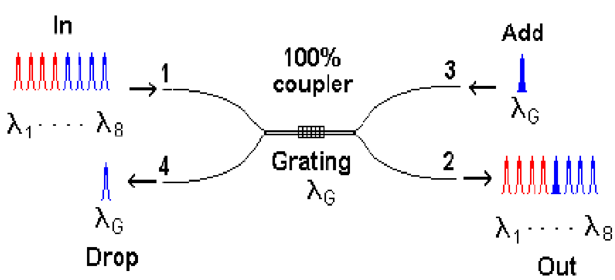

Figure 3.4: Add Drop Multiplexer Configuration Based on Grating Inscribed in The Waist of a Coupler.

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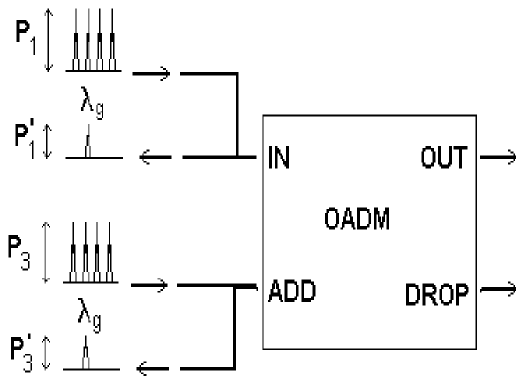

Figure 3.5: Schematic Representation of the S11 and S33 Back-Reflection Parameters of an Add Drop Multiplexer.

IV SIMULATION AND RESULT

The output and the result of proposed method is show in the MATLAB. MATLAB is a multi-language simulation environment by Matrix laboratory, for simulation of proposed method using gaussian pulse. With the help of editor window write a MATLAB codes for optical add drop multiplexer. In this project work apply different length (L = 5,10 and 20) for different wave length. The wave length in between 1548 to 1552. All wave length are taking in nano meter (nm). After apply these condition and calculate the reflectivity of FBG.

4.1 Graphical User Interface

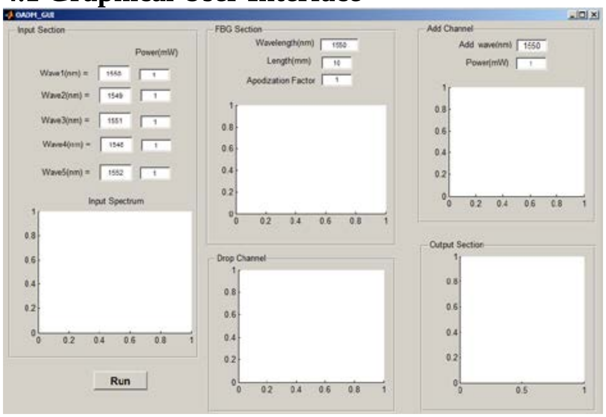

Figure 4.1: Initial View of Graphical User Interface.

To simulate various combinations of input waves, FBG length and different apodation factor, we create a MATLAB graphical user interface (GUI). In this GUI, we can modify and simulate the effect of power at a different input wavelength, a FBG apodization factor and a FBG length. From this program, we can see the input waveform, add channel waveform, channel waveform and OADM output waveform. This program also gives a numerical value of different waves.

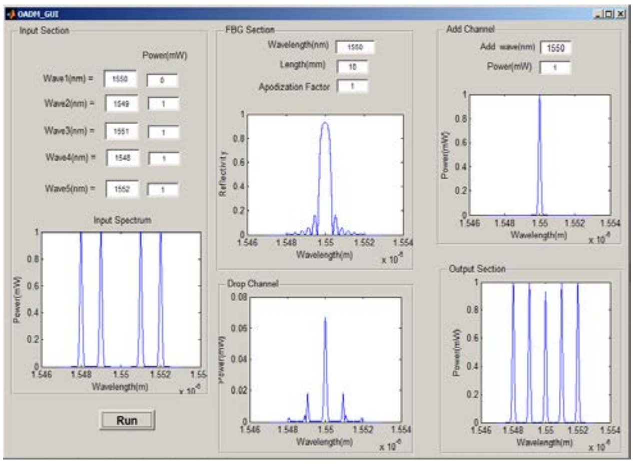

Figure 4.2: Graphical User Interface (Add to Drop Channel Effect).

Shows the how to perform the add drop multiplexer in OADM. The above figure is the summarized output of the proposed add drop multiplexer. The above figure contain four different windows. In this windows first window shows the input waveform. In this window shows the input wavelength at axis and y axis shows the power of wavelength of input signal. In the second window shows the drop wavelength and third figure shows the add wavelength or channel. At last part of the figure shows the final output of waveforms. So the proposed OADM is worked on add drop phenomena that is discuss in the above section.

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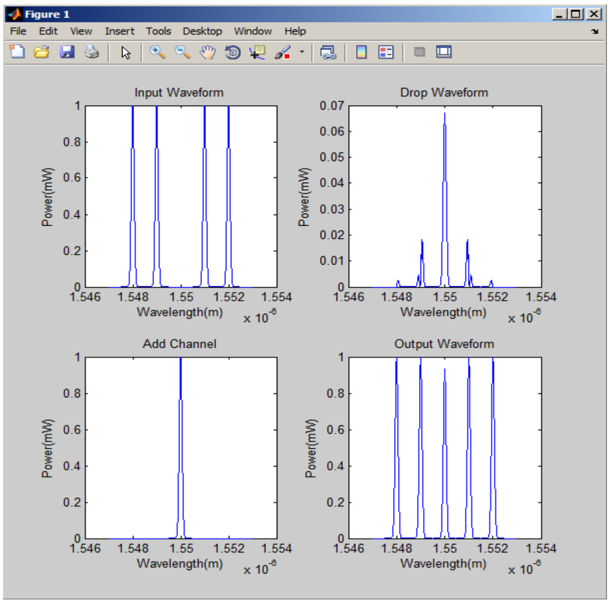

Figure 4.3: Output Waveform (Add to Drop Channel Effect).

	1548	1549	1550	1551	1552
Input	28.9441	28.9441	2.5181e-16	28.9441	28.9441
Add	0	4.5450e-17	28.9441	2.0636e-16	0
Drop	0.0387	0.3714	2.0765	0.3723	0.0397
Output	28.9053	28.5727	26.8676	28.5717	28.9044

Figure 4.4: Screen Shot of Power Calculation Table (Add to Drop Channel Effect).

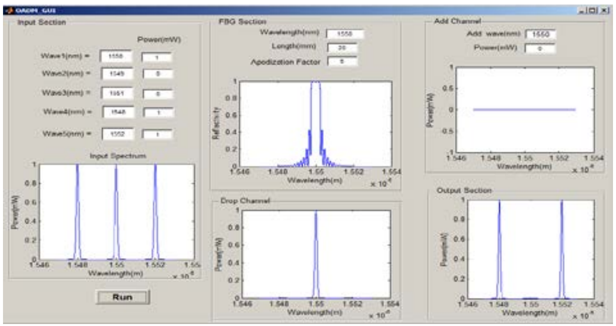

Figure 4.5: Graphical User Interface (Add Channel Power = 0).

	1548	1549	1550	1551	1552
Input	28.9441	2.5181e-16	28.9441	2.5181e-16	28.9441
Add	0	0	0	0	0
Drop	0.0200	3.9921e-18	28.8978	2.6796e-17	0.0204
Output	28.9240	1.3866e-16	0.0462	1.3383e-16	28.9237

Figure 4.6: Screen Shot of Power Calculation Table (Add Channel Power = 0).

4.2. Basic Reflection Characteristic of Fiber Bragg Grating

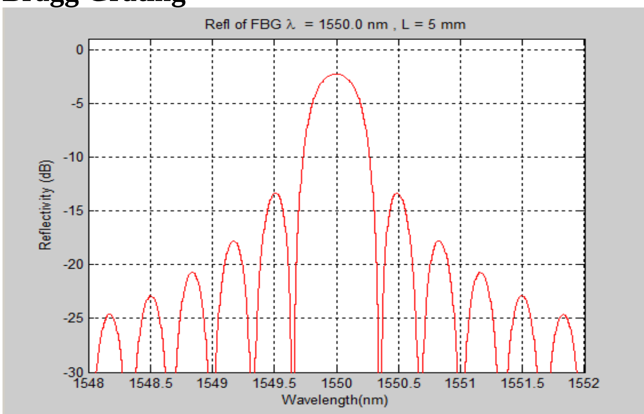

Figure 4.7: Reflection Spectra of Uniform FBG of Wavelength 1550nm and Length 5mm.

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4.2.1 Effect of FBG Length on FBG Reflection Spectra

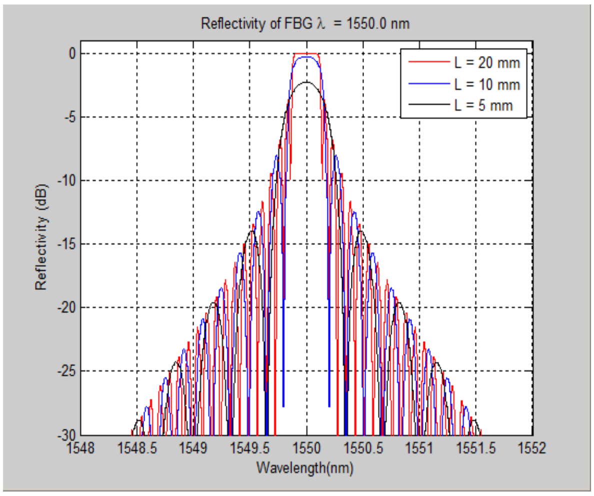

Figure 4.8: Effects of FBG Lengths on Reflection Spectra of FBG.

4.3Simulation Result of OADM

4.3.1 Length = 5mm, Apodization Factor = 0 (Uniform FBG)

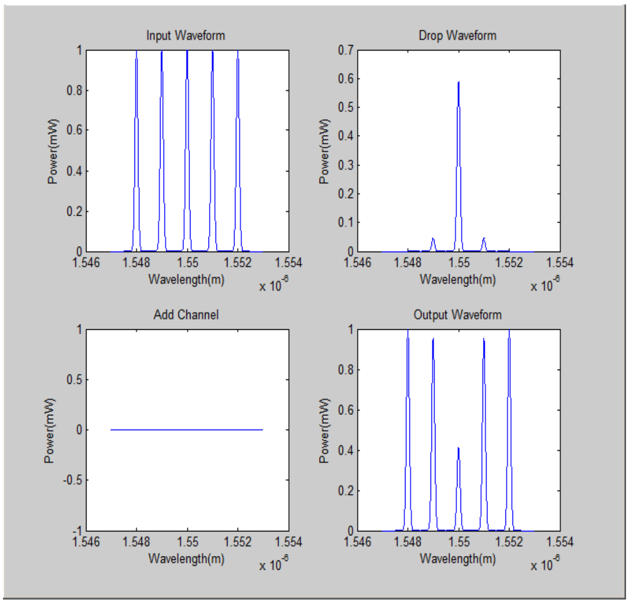

Figure 4.9: Simulation Result for Length =5mm and Apodization Factor = 0 Power (mW).

	1548	1549	1550	1551	1552
Input	28.9441	28.9441	28.9441	28.9441	28.9441
Add	0	0	0	0	0
Drop	0.0178	1.2386	16.9002	1.2381	0.0182
Output	28.9263	27.7055	12.0438	27.7059	28.9258

Table 4.1: Power Calculation for Length =5mm and Apodization Factor = 0.

4.3.2 Length = 20mm , Apodization Factor = 0 (Uniform FBG)

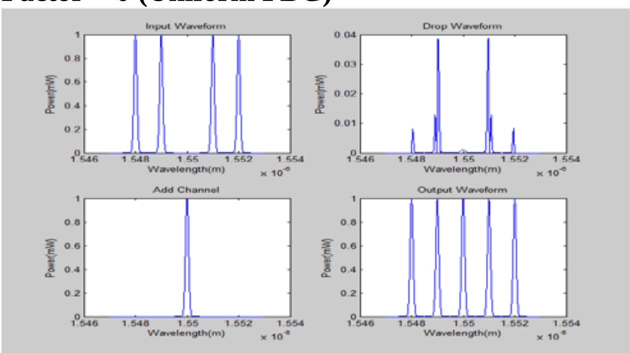

Figure 4.10: Simulation Result for Length =20mm and Apodization Factor = 0.

Power (mW)

Power (mW)	1548	1549	1550	1551	1552
Input	28.9441	28.9441	2.5181e-16	28.9441	28.9441
Add	0	4.5450e-17	28.9441	2.0636e-16	0
Drop	0.0964	0.6772	0.0457	0.6777	0.09777
Output	28.8476	28.2669	28.8983	28.2663	28.8463

Table 4.2: Power calculation for Length =20 mm and Apodization Factor = 0.

4.3.3 Length = 20mm , Apodization Factor = 5

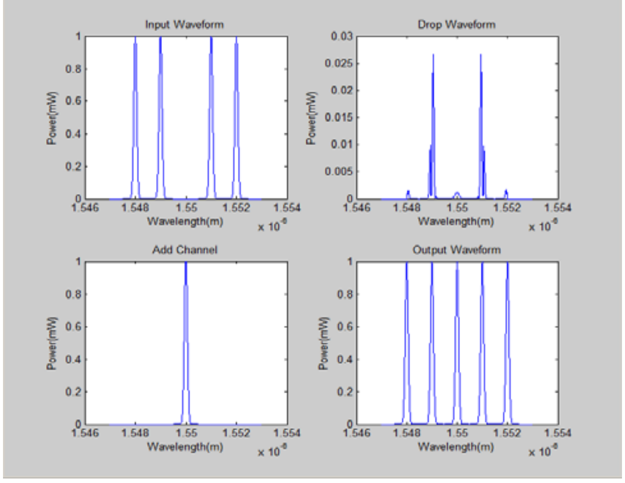

Figure 4.11: Simulation Result for Length =20mm and Apodization Factor = 5.

Power (mW)

	1548	1549	1550	1551	1552
Input	28.9441	28.9441	2.5181e-16	28.9441	28.9441
Add	0	4.5450e-17	28.9441	2.0636e-16	0
Drop	0.0200	0.4553	0.0462	0.4556	0.0204
Output	28.9240	28.4887	28.8978	28.4884	28.9237

Table 4.3: Power calculation for Length =20 mm and Apodization Factor = 5.

V CONCLUSION AND FUTURE WORK

It is clear from Table 4.1 that, when the length of the FBG is small (5 mm), the maximum reflectivity of the FBG is about 60% due to the fact that there is more leakage from the inlet to The through channel as shown in Figure 3.4. To increase the maximum reflectivity, we must increase the length of FBG. It is clear from Table 4.2 that for a length of FBG of 20 mm, the maximum reflectivity is about 99.841%. But as we increase the length of FBG, the lateral lobe power also increases, resulting in out-of-band crosstalk. Using an apodization technique, we can reduce these lateral lobes and thus cross-talk. The Length of FBG is small (5mm),the maximum reflectivity of FBG is about 60% due to that there are more leakage from Input to through channel. With increase in FBG length the side lobe power also increase which produce out of band crosstalk. By using apodization technique we can reduce these side lobes and hence reduction of out of band crosses talk. FBG is work like band reject filter so if higher values of FBG contain error in terms of Side lobe and main. To improve this problem use gaussian pulse and enhance the A.F. up to 5 to 10.Optimization of the preconditioning technique to manufacture DC-based networks should allow better suppression of lateral lobes. Reducing the increments of UV beam translation can eliminate "seam" errors.

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