การขยายและกรองสัญญาณทางแสงหลายย่านความยาวคลื่นด้วยเส้นใยแก้วนำแสงที่เจือด้วยเออร์เบียม โดยการมอดูเลตสัญญาณพัลส์ให้กับเลเซอร์ปั้ม

Multi-wavelength Tunable Optical Amplifier and Filter by Electrical Pulse Signal Modulation into Laser Pumping of EDFA

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บทคัดย่อ

งานวิจัยนี้เป็นการศึกษาและพัฒนาการขยายและกรองความยาวคลื่นแสงแบบหลายย่านความยาวคลื่นด้วยเส้นใยแก้วนำแสงที่เจือด้วยเออร์เบียม โดยการศึกษานี้ใช้อุปกรณ์เพียงน้อยชิ้นเพื่อทำการสืบสาวถึงผลกระทบของการนำสัญญาณพัลซ์มาทำการมอดูเลตให้กับเลเซอร์ที่ใช้ปั๊มให้กับเส้นใยแก้วนำแสงที่เจือด้วยเออร์เบียม จากการทดลองพบว่าสัญญาณแสงที่ผ่านเข้ามาในเส้นใยแก้วนำแสงนี้สามารถจะเลือกให้มีการส่งผ่านสัญญาณหรือลดทอนช่วงสัญญาณทางแสงได้ด้วยการควบคุมความถี่ที่มอดูเลตให้กับเลเซอร์ปั๊ม ผลที่ได้จากการศึกษานี้จะมีค่าที่สามารถปรับจูนได้อยู่ในช่วง 1-5 นาโนเมตร โดยการมอดูเลตความถี่ในช่วง 0-100 เฮิร์ตซ์ มีค่ากำลังขยายสัญญาณทางแสงสูงสุดที่ 0.63 มิลลิวัตต์ ที่กำลังเลเซอร์ที่ใช้ปั๊ม 50 มิลลิวัตต์ และสามารถลดกำลังแสงลงได้ถึง -43 เดซิเบล

คำสำคัญ: เส้นใยที่เจือด้วยเออร์เบียม การแบ่งคลื่นเป็นช่วงๆ เลเซอร์หลายความยาวคลื่น

Abstract

We set up an experiment by using minimal equipment to investigate the properties of optical amplifier and filter by using an Erbium Doped Fiber Amplifier (EDFA) to modulate a pulse signal into laser pumping. The channels of light can be chosen to transmit or distort the optical signal by using a frequency modulated light source to pump the EDF. The wavelength spacing could be tuned to achieve about 1-5 nm by adjusting the range of frequencies between 0-100 Hz. The maximum optical output power including amplifier is 0.63 mW at the pumping power of 50 mW while the distortion of light after passing through the EDF is -43 dB.

Keywords: Erbium-Doped Fiber Amplifier (EDFA), WDM, Multi Wavelength Laser.

Introduction

The Erbium Doped Fiber Amplifier (EDFA) has been actively used in a variety of applications including communications, optical fiber lasers and components in the measurement systems[1-5]. Its advantages are because of its low noise, high gain bandwidth and, many amplification of multi-channels at different wavelengths[6]. EDFA wavelengths have the ranged in the C-Band and L-Band. Some research projects require the amplification of specific wavelengths, so when creating a tunable fiber laser source, the wavelength can be adjusted accordingly[7-8]. This is a crucial part of the present experiment.

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In this paper, the requirement is to filter and amplify a wavelength signal. As such, it become necessary to select a filter such as the Mach-Zehnder Interferometer (MZI) optical grating filter or a fiber optic ring resonator[9-10]. We designated the EDFA as an important component to be used in the design of the optical signal amplifier and filter. The function of selecting a wavelength for the desired amplifier or filter, by means of a modulation pulse signal is applied to the laser pumping source which provide the signal for the EDFA. This approach is to show that by using a few optical devices can produce the results shown in [Figure 4 and 5], making a lighting system cheaper and easier to prepare and manipulate [Figure 1].

Experimental setup and Results

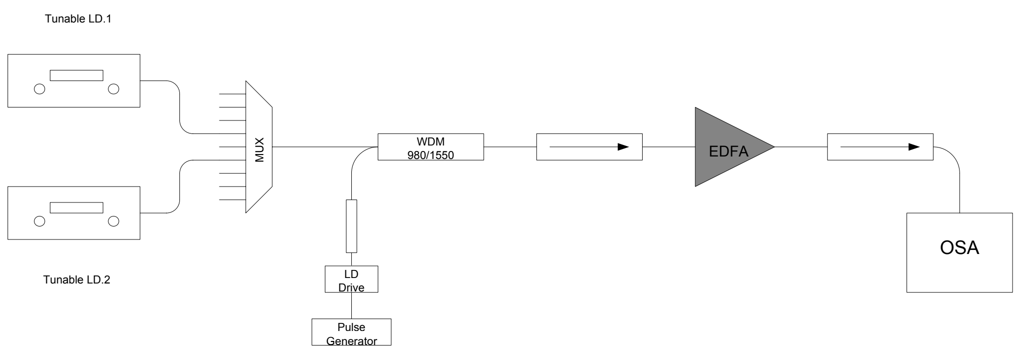


Figure 1 The Experimental setup of tunable amplifier and filter by modulation pulse signal into the laser pumping.

The experimental setup of the multi-wavelength tunable optical amplifier is illustrated in Figure 1. The output of tunable laser diodes1 and 2 (Tunable LD.1, LD.2) are launched into the wavelength division multiplexer (MUX) using a Fiber-optic connector (FC). The output power is 0.16 mW and the wavelengths are 1,546 and 1,547.6 nm respectively. The output of the MUX is fusion spliced to an end arm of 1,550 nm at WDM 980/1550. The 980 input port of WDM 980/1550 is spliced to a fiber pigtailed 980 nm laser diode to serve as a pumping source for the EDFA. The output port of this WDM is spliced to an optical isolator to improve the noise figure return to the laser diode (LD.1, LD.2 and LD. pump). The output port of the optical isolator is also spliced to the EDFA. The other end of the EDFA is spliced to the optical isolator, again for protection against noise return-ing to the EDFA. The output port of the second optical isolator is connected to the Optical Spectrum Analyzer (OSA.) with a FC connector to allow analysis of the optical output. The pumping laser (LD.pump) is controlled by the laser diode drive and modulation circuit (LD. Drive). In the modulation circuit, we use an electrical pulse generator to generate the modulation pulse signal into the laser pump.

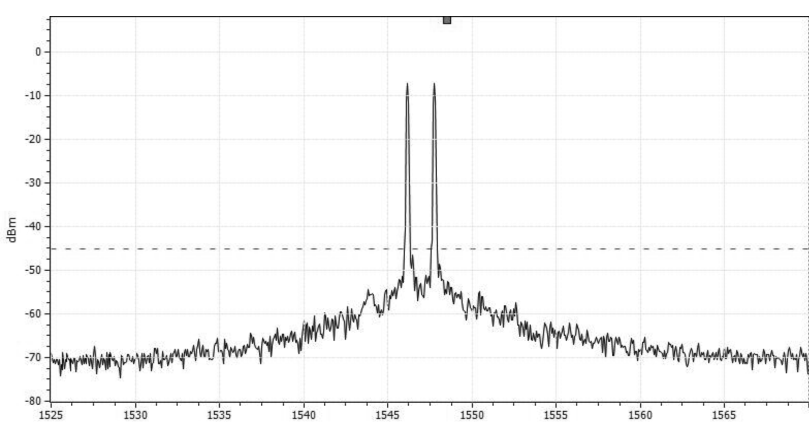


Figure 2 Spectrum of tunable laser (LD1 and LD2) with multiplexing by MUX

The modulator (Mod.) is used to modulate the pulse signal by using a pulse generator to control the current in the laser diode with a frequency pulse varying from 10 Hz to 100 Hz in steps of 5 Hz.

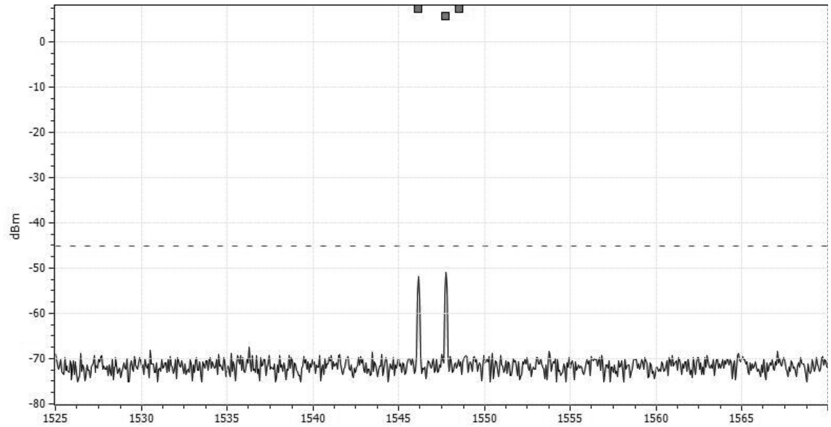


Figure 3 Spectrum after passing EDF without laser pumping.

The operational principle of the tunable optical amplifier and filter by EDFA relies on the result of applying a low frequency modulation pulse signal into laser pumping at 0 to 100 Hz. We measured the spectrum after LD.1 and LD.2 multiplexing by the MUX and then measured at the output port of the MUX by using the OSA. The result of multiplexing is illustrated in Figure 2. The wavelength spacing of our experiment is 1.6 nm, and the maximum output power is -7 dBm. After measuring the optical multiplexing, we splice the output port of MUX into the EDFA system and then measured the output spectrum and its power at the output port of the optical isolator. The result is shown in Figure 3. The results show that an optical fiber can filter with attenuation of the optical signal at -43 dB.

For the next experiment, we modulate an electrical pulse signal into the laser pumping from 0 to 100 Hz by increasing the frequency in steps of 5 Hz. The laser output power is set at 50 mW. Figure 4 shows the output spectrum of the unmodulated signal (0 Hz), the output power from LD.1 and LD.2 is about -5 dBm.

The results of applying a modulated signal into the laser pumping are shown in Figure 5. Figure 5 (a) illustrates the spectrum of the light source with a modulation pulse signal at 30 Hz, from LD.1. The light source is distorted -33 dB and LD.2 is amplified to 5.98 dB.The optical power with modulation at 45 Hz., with the amplifier at channel 1 (LD.1) and filter at channel 2 (LD.2) is shown in Figure5 (b) where the amplifier is 6.90 dB and loss is -26 dB. Figure 5(c) shows the spectrum with the frequency set at 80 Hz. At this frequency, the EDFA is filtering the wavelength from LD.1 and LD.2 with distortion at -19.00 dB and -13.00 dB respectively. The modulation pulse signal at 95 Hz gives an output power of 4.98 dB as shown in Figure 5 (d).

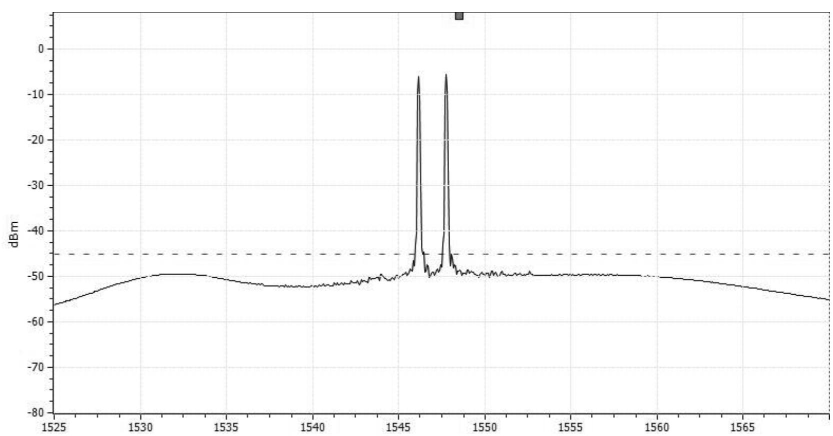
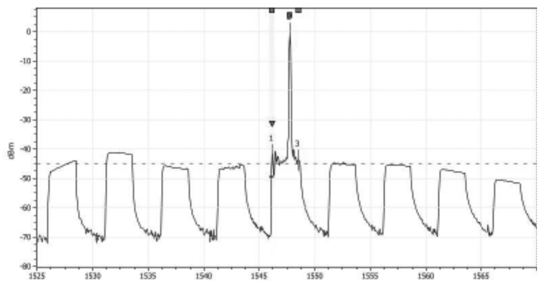
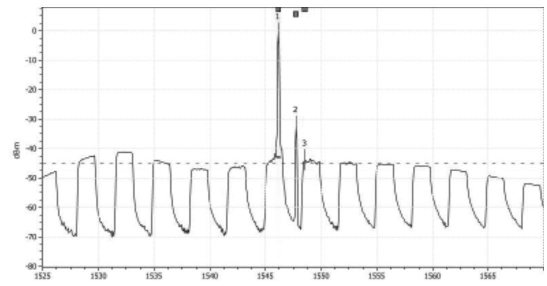


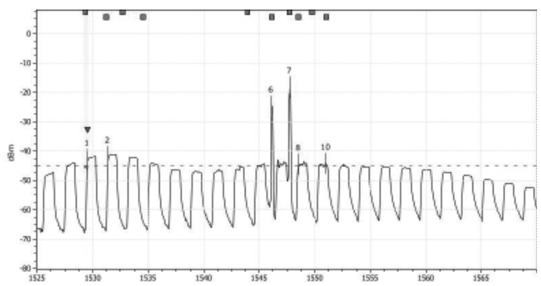
Figure 4 Spectrum of light signal with laser pumping at 50 mW with non-modulation pulse signal (0 Hz)



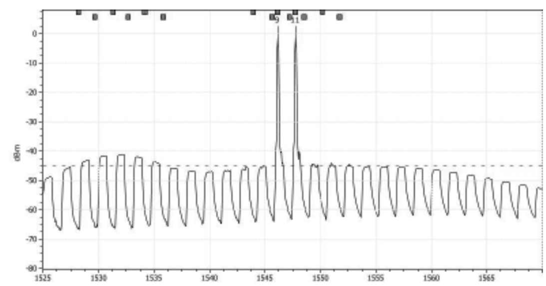
(a)



(b)



(c)



(d)

Figure 5 Spectral response of EDF with modulation pulse signal at frequencies (a) 30 Hz,(b) 45 Hz,(c) 80 Hz and (d) 95 Hz respectively.

The wavelength spacing of the EDFA with modulation pulse signal is shown in Figure 6. This result shows the frequencies which are modulated and compared to the spectral range for being choices for the selective range of the amplifier and filter.

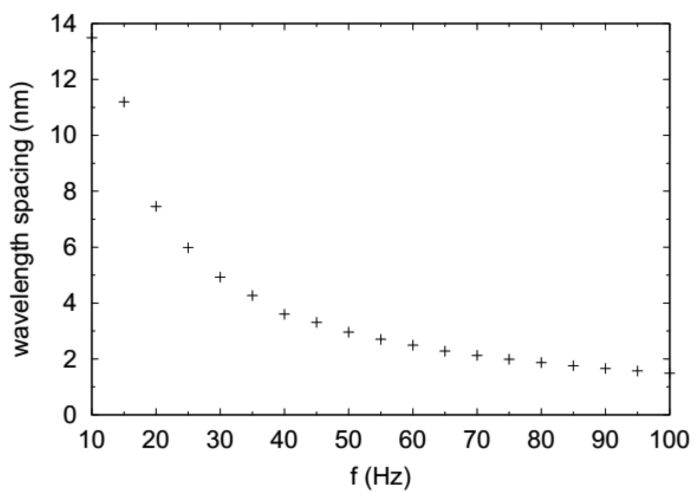


Figure 6 The wavelength spacing versus pulse signal with modulation in the laser pumping

Discussion and Conclusion

Devising a multi-wavelength tunable optical amplifier and filter by modulating a pulse signal into laser pumping is reported. The spectrum for the amplifier and filter is tuned by adjusting the frequency modulation. The tuning range of 1 nm is obtained in this experiment. In the future investigations, improvement in the tuning range may be obtained by using a high frequency laser diode driving and modulation circuits. The demonstration devices used in this research are selected for their simplicity, moreover, they made it easy to select from the entire Erbium window (C-band), the group of wavelengths for filtering and amplifying.

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