

Hybrid Raman EDFA

1. INTRODUCTION

In the ultra-high bit rate optical transmission systems such as 100 Gbps systems, which will be introduced in the future, the combination of a Raman amplifier with superior noise characteristics and an erbium-doped optical fiber amplifier (EDFA) with higher gain is expected to be a promising application.

To realize space-saving and low price in such applications, Furukawa Electric has commercialized a module integrating both a Raman optical light source and an EDFA, and has started selling it as ErFA40000 Series. This product was exhibited at OFC/NFOEC 2010 that was held in San Diego, California, U.S.A. in March 2010, and has earned a good review.

2. BACKGROUND OF THE DEVELOPMENT

Furukawa Electric has many basic patents of Raman amplifiers (i.e., a number of patents registered in Japan and U.S. related to a Raman optical light source and the control methods of its system) and has been strong in the manufacture of a complete and full range of key devices such as erbium-doped fiber (EDF) and laser diode modules. Based on such advantages, Furukawa Electric has been recognized as a leader in the market of the Raman amplifiers and the EDFAs.

Today, Raman amplifiers are used to compensate adequately the output of EDFAs in the optical systems requiring repeaters for long distances. Future amplifiers, to be used in the ultra-high bit rate optical transmission systems such as 100 Gbps systems require superior signal-to-noise characteristics and also need higher gain and output power because of the increase of the transmission loss with the increased number of optical devices.

Therefore, it is expected that, the combination of Raman amplifiers with superior signal-to-noise characteristics and the higher power output EDFAs, will improve the optical signal noise ratio (OSNR) in the ultra-high bit rate optical transmissions and will compensate for the losses through optical transmission path and optical devices. For such application, Furukawa Electric, has taken advantage of the technologies developed on the EDFAs with high speed control circuit and high power 1480 nm pumping laser diode modules has commercialized the compact and high performance Raman EDFA which integrates Raman light sources and EDFAs and started selling it as ErFA40000 Series. A picture is shown in Figure 1.

3. FEATURES

The configuration of the product is shown in Figure 2 and the mechanical dimensions are shown in Figure 3. The Raman light sources consist of two pumping light sources at the wavelength of 1425 nm and 1452 nm. Each light power is backward launched into the signal line in the opposite direction of the signal path. The total output power is 500 mW and the Raman gain of 9 dB is provided at the C-band. The automatic gain constant controlled amplifier of the EDFA is optimized as 15 dB for the gain and 18 dBm for the output power. To stabilize the output change during the transient event, it has a high speed control circuit. Since the filter can be applied to level the total gain of the Raman gain and the EDFA gain, the favorable wavelength characteristics are achieved as shown in Figure 4. Gain ripple represents flatness of the total gain of the Raman gain and the EDFA gain. Gain ripple in Figure 4 shows an example of the product (Raman EDFA) application to single mode fiber (SMF).

4. IN CONCLUSION

To meet the demand for optical amplifiers for the ultra-high bit rate transmissions systems, Furukawa Electric has commercialized a space-saving and a low price Raman EDFA by combining Raman light sources and an EDFA in one package. The detailed specifications of the product for usage environmental condition, the Raman pump module and EDFA are shown in Table 1.



Figure 1 ErFA40000 series.

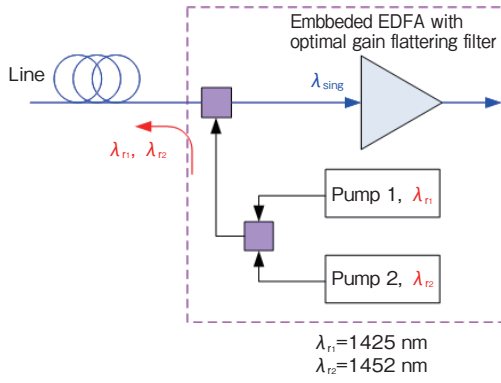


Figure 2 Configuration drawing.

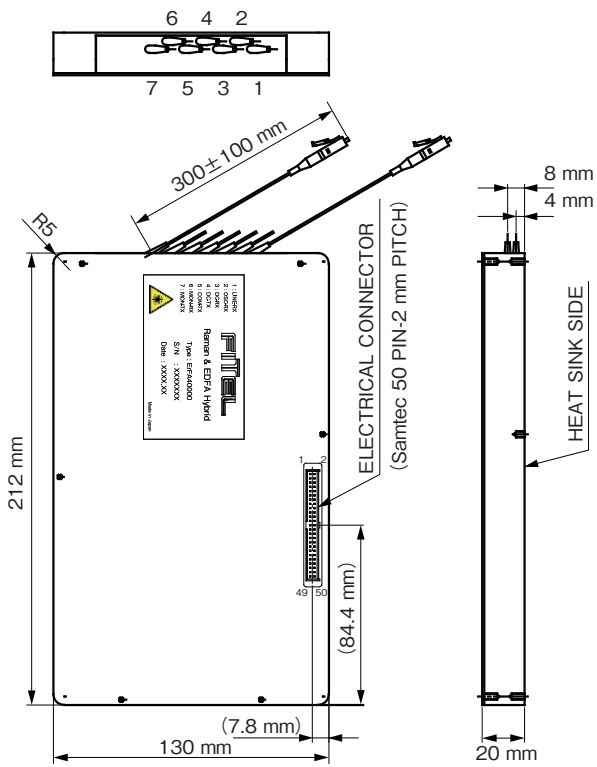


Figure 3 Mechanical dimensions.

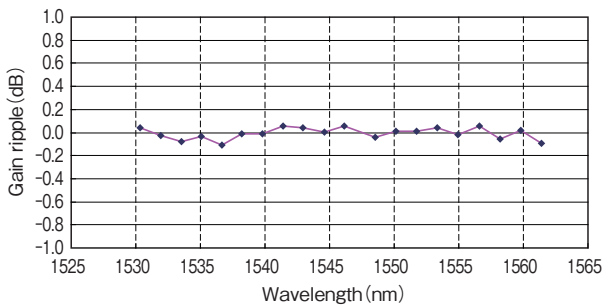


Figure 4 An example of wavelength characteristics.

Table 1 Specifications.

Environmental conditions.

Items	Specifications			Unit
	Min.	Typ.	Max.	
Operating case temperature	5		70	°C
Operating humidity	5		85	%RH
Storage temperature	-40		70	°C
Storage humidity			85	%RH
Power supply voltage	4.75	5.0	5.25	DCV

Specifications of Raman pump module.

Items	Specifications		Unit
	Min.	Max.	
Pump 1 wavelength	1425		nm
Pump 2 wavelength	1452		nm
Total Raman pump power		500	mW
Average Raman gain	9.0		dB

Specifications of EDFA.

Items	Specifications		Unit
	Min.	Max.	
Signal wavelength range	1529	1562.5	nm
Input power range	-40	8	dBm
Gain (Nominal)		15	dB
Maximum output power		18	dBm
Gain flatness		1.0	dB
NF		7.0	dB

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