

Cladding-Pumped Optical Fiber Amplifier

1. INTRODUCTION

In optical fiber systems for analog signal distribution including CATV systems, increasing the individual output power of distribution optical amplifiers is one of the efficient measures to effecting cost reduction.

The output signal power of erbium-doped fiber amplifiers (EDFAs) most commonly used for distributed amplification is limited by the output power of pumping laser diodes, and it is around +22 dBm ordinarily. If it is desired to have higher output powers, a number of pumping laser diodes must be used, probably raising problems of higher cost and bulky equipment.

Here will be presented a compact optical fiber amplifier that has achieved, by cladding-pumping an Er/Yb co-doped fiber of double-clad structure using multimode laser diodes, an optical output power of +31 dBm maximum.

2. FEATURES

The optical fiber amplifier developed here by Furukawa Electric is, as shown in Figure 1, of two-stage configuration. In the first stage, an EDFA with an ordinary erbium-doped fiber is used for pre-amplification realizing low noise, whereas in the second stage, a cladding-pumped amplifier is employed to achieve an optical output power of +31 dBm maximum, whereby backward pumping is effected using 980-nm multi-mode laser diodes of Furukawa's in-house product.

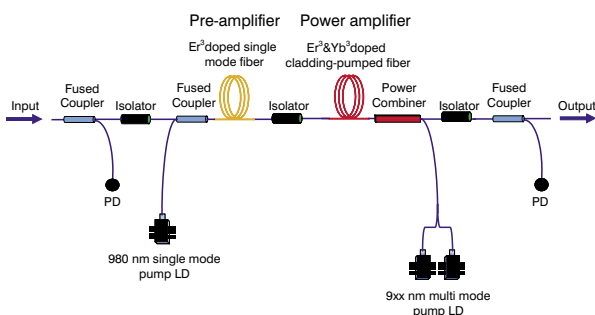


Figure 1 Configuration of cladding-pumped optical fiber amplifier.

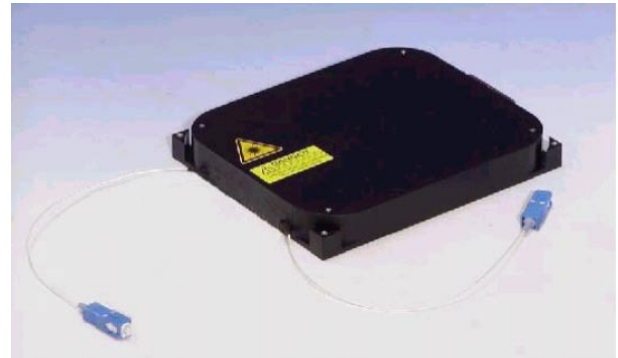


Photo 1 Appearance of cladding-pumped optical amplifier for CATV.

Photo 1 shows the appearance of a cladding-pumped optical fiber amplifier for CATV.

Figure 2 shows the cross-section of a double-clad optical fiber for cladding pumping --one of the products of OFS Fitel-- that features this amplifier. Its silica cladding where the launched pumping light of multimode propagates is not circular but star-shaped, with the aim of guiding efficiently, by eliminating skew propagation that does not contribute to pumping, the pumping light over the rare earth-doped core. The tapered fiber bundle shown in Figure 3 --an OFS Fitel product-- is used for coupling the multimode pumping light into the cladding-pumping optical fiber.

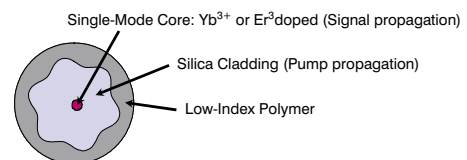


Figure 2 Cross-section of double-clad optical fiber for cladding pumping.

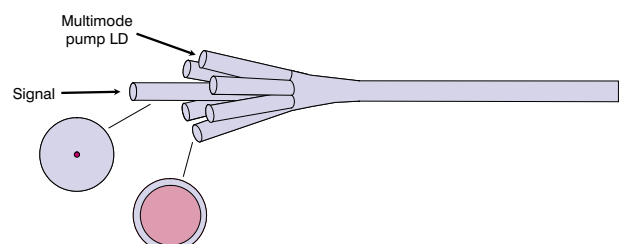


Figure 3 Schematic of tapered fiber bundle.

All these devices including a control circuit capable of mounting up to three pumping laser diodes are accommodated in a package measuring 150(L) mm x 125(W) mm x 20(H) mm, thus realizing downsizing. The amplifier module has adopted D-SuB25pin for interface connector --an industry-wide standard, in addition to a single driving power supply of +5 V DC, and is provided with an RS232C serial communication port enabling external control of amplifier operation and alarm monitoring. With respect to control method for LDs, automatic gain control (AGC), automatic level control (ALC), and automatic current control (ACC) are available, so that the operation mode can be selected depending on user applications.

3. CHARACTERISTICS

Table 1 shows the basic characteristics of the cladding-pumped optical fiber amplifier developed here, and Figure 4 its characteristics. The amplifier uses two multimode laser diodes with 2.5 W output power in its cladding amplifier stage, achieving an optical output power of +31 dBm at an optical pumping power of 5 W. The noise figure of signal is not more than 5.5 dB, comparable to ordinary EDFAs. Transmission characteristics including signal distortion, the essential performance for analogue transmission, have also been evaluated, and it has been confirmed that composite second-order distortion (CTB) is -67 dB or less and composite triple beat distortion (CTB) is -70 dB or less.

Table 1 Specifications of cladding-pumped optical fiber amplifier.

Item	Unit	Specification	
		Minimum	Maximum
Wavelength	nm	1545	1560
Input optical signal	dBm	-3	3
Output optical signal	dBm		31
Noise figure	dB		5.5
CSO	dB		-67
CTB	dB		-70
Dimensions	mm	150 x 125 x 20 (without heatsink)	
Number of LDs		3	
Interface connector		D-SuB25pin	
Power supply		+5V DC	
Power consumption		typ. 60 W (Case temperature: 50°C)	
Communication		RS232C serial communication	
LD control		Automatic gain control (AGC) Automatic level control (ALC) Automatic current control (ACC)	
Monitor function		Optical input- and output-power, Amplifier gain, Reflected power, LD information (Current, Output power, Temperature)	
Alarm		Optical input power, Optical output power, LD, Case temperature, LD drive current	

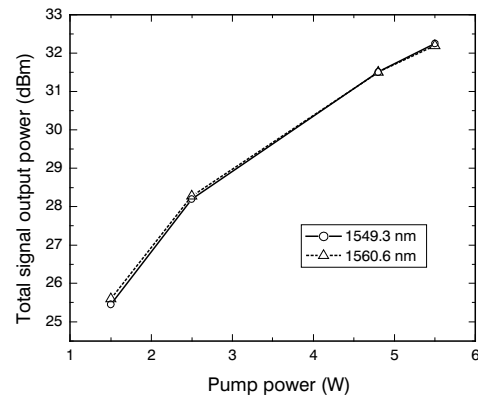


Figure 4 Relationship between pumping power and signal output power.

4. CONCLUSION

An optical fiber amplifier based on the cladding-pumping technology has been integrated with a platform with control functions to develop a compact, high output power optical amplifier for CATV, achieving a signal output power of +31 dBm at a pumping power of 5 W from multimode laser diodes.

It is hoped that the amplifier will be used in various analog transmissions.

For more information, please contact:

Technological information:

Optical Components Dept., Information and Communications Co.

TEL: +81-436-42-1703 FAX: +81-436-42-1789

Others:

Fitel Planning and Coordination Dept., Information and Communications Co.

TEL: +81-3-3286-3432 FAX: +81-3-3286-3708

Email: fitel@ho.furukawa.co.jp