Erbium Doped Fiber Amplifiers
(Keith Matthews)

Erbium Doped Fiber Amplifier’s (EDFA’s) have revolutionized the optical communications world by expanding the applications for which optical fiber is a solution. Today it is possible to have links greater than 10,000 km with EDFA’s cascaded with 50 km spacings as opposed to repeaters being used every few kilometers. EDFA’s allow for a complete optical link whereas repeaters required for electro-optic conversions and more components. Soliton systems and wavelength division multiplexing (WDM) have become very popular with the development of EDFA’s.

An EDFA consists of a semiconductor pump laser at 980 nm or 1480 nm, a coupler for the pump wavelength and the signal wavelength, the erbium fiber itself, a pump filter, and optical isolators at both ends of the amplifier. Erbium is excited by the 980/1480 nm pump wavelength and then the 1.55 \( \mu \text{m} \) input signal stimulates emission, providing amplification. The pump power usually ranges from 10 mW to 50 mW. As pump power increases the gain increases up to about 30 mW. After this point, a large increase in pump power is needed to gain more than a few dB.

The pump wavelengths of 980 nm and 1480 nm are widely used because they are commercially available with high power and they give the best noise figure and gain numbers. As for the wavelength vs. noise figure, wavelengths above 1.52 \( \mu \text{m} \) give a noise figure close to 3 dB which is the theoretical limit. Wavelengths in the range of 1520 to 1560 nm are typically used for EDFA’s.

Another important concept for EDFA’s is that they have a carrier lifetime on the order of milliseconds. This means that for any data rate greater than kilobits per second, there will be very low crosstalk. Other advantages of the EDFA are its low noise, polarization insensitivity, high saturation power, and its cost effectiveness compared to repeaters. The only real disadvantage is that the optical signal can not be cleaned up meaning that the optical nonlinear effects build up over the course of the optical link. Some of the applications that EDFA’s are used for include preamplification, post amplification, offsetting component losses, and in-line amplification for systems such as CATV.

EDFA’s have been a vital component in optical communications for the past decade and should continue to evolve. The many advantages and few disadvantages of the EDFA, make it the best technology has to offer today. There is still room for improvement, especially in expanding the usable bandwidth of the EDFA. Research in development of EDFA’s should continue well into the future.