A Comprehensive Experimental Investigation on Power Consumption of Multi-mode Pumped Super L-band EDFAs

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Introduction

- **Super L-band erbium doped fiber amplifiers (EDFAs)** are the building block of the future super C/L-band optical links that enable larger data transmission capacity [1].
- Designing such amplifiers based on Er³⁺/Yb³⁺ co-doped fiber (EYDF), pumped by multi-mode (MM) laser, has the potential to significantly lower the fabrication costs, as using the MM pump diode is a cheaper option compared to SM pump diode lasers.
- We perform a comprehensive investigation on power consumption of the MM pump and SM pumping in identical EYDFs (excluding any impact of the glass matrix) under various operation conditions, to find out whether MM cladding pumping can be more power efficient than the SM core pumping.

Experiment & Results

Three parameters are swept in the experiment setup (Fig. 1):
1. Input signal power (-4 to 14 dBm)
2. Target gain tilt
3. Length of the EYDF (20 to 55 cm)

Each time

**First:** Tune the power for the SM (1480 nm) pump to reach the target gain tilt.

**Second:** Shift the pump to the MM (915 nm) and measure the power that is required by MM laser to achieve the same minimum gain level, as shown on Fig. 2.

**Third:** Calculate the ratio $\frac{MM}{SM}$ of power consumption in four ways, as shown on Fig. 3 and 4.

Almost for all input signal powers:

- **MM electrical power consumption** < **SM electrical power consumption**, as long as the gain is larger than 8 dB.

### Experimental Setup

**Fig. 1:** Experimental setup: WDM: wavelength-division multiplexer, VOA: variable optical attenuator; CMB: signal/MM-pump combiner.

### Data Analysis

**Fig. 3:** MM/SM power consumption ratios at fixed minimum gain ripple (which results in shallowest gain flattening filters).

The general trend shows the power ratios (electrical or optical) decrease with the increase in minimum gain or the higher the target gain, the more efficient using MM pump is!

**Interesting Observation:**

- **MM minimum gain ripple (~69%) is better**
- **SM minimum gain ripple (~75%).**

**Fig. 5:** Exemplary MM & SM gain shapes for input signal power of 6 dB and target minimum gain of 8 dB.

### Conclusion

- We compared the optical and electrical power consumptions using SM and MM pumping within the same super L-band EYDF. Two methods of comparison have been used:
  1. fixed gain tilt
  2. fixed target minimum gain.
- The conservative conclusion from this work is: **the electrical power saving of using MM pump can be up to ~ 30%**.

References: