Design of Distributed and Discrete Broadband Amplifier Systems with Accurate Gain Profile and Optimal Fiber Combination

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Abstract---We point out the limitation of using an approximate gain profile in designing distributed fiber Raman amplifier (FRA) and design a broadband FRA based on the measured gain profile. A design of discrete amplifiers for ultra-long-haul transmission is also reported by optimizing the combination of DCF and SMF fibers.

Based on the approximate Raman gain profile, we designed a pumping scheme for a distributed FRA system to have flat bandwidth of 100nm wide, as shown in Fig.1. However, when we replace the approximate Raman gain with the measured gain profile, the gain spectrum becomes quite different and the flatness disappears, as shown in Fig.1. In fact, the measured Raman gain curve degrades abruptly when the frequency shift is beyond the maximum Stoke shift, 13.2THz, but the approximate Raman gain curve doesn't. In designing a broadband FRA system, in order for considering the practical interactions among the pumps and signals, the simulated range of the Raman gain spectrum must be wide enough (e.g., at least 23.2THz for a 100-channel system of 100GHz channel spacing). In such a case, the approximate gain profile results in a considerable error. To simplify the design procedure of a broadband FRA system, the simple method proposed here includes three steps: (1) Setting pumping frequency with equal interval, (2) Setting initial pumping power as a geometric series, and (3) adjusting the power of each pumping source. Then, flat gain is achieved easily, as shown in Fig.2.

In ultra-long-haul systems, we report a systematic design of a 100km-span long haul system without using FRAs by carefully inserting a segment of DCF into each span. We first evaluate different types of fiber combination for a single span. Thirty channels of 100GHz spacing in the C-band are simulated and each carry a PRBS signal with a data rate of 10Gbps. The configuration of [SMF₁+DCF+SMF₂] has the best performance. We then analyze the system performance for different output signal levels for a cascaded link. Under the condition of a BER less than 10^{-9} , the maximal achievable transmission distances for the amplifier output power of +7dBm, +10dBm, and +13dBm, are about 300km, 700km, and 1300km, respectively, as shown in Fig.3.

Fig. 1: Comparison of a 4-pump FRA gain with different gain profile.

Fig. 2: Gain of the broadband FRA system.

Fig. 3: Maximal attainable distance against the output power.

Reference:

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