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«Investigation of DWDM System Based on Cascaded Four-Wave Mixing»

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1. FWM description

- Four wave mixing is the Kerr nonlinear interaction among four different optical waves

ωi, ωj, ωk

- The interaction produce new optical waves with frequencies

ωi ± ωj ± ωk

2. Description of problem

- Four-wave mixing is harmful effect for DWDM systems
- This effect is useful for fiber optic parametrical amplifiers
- Another new application of FWM is the generation of equally-spaced products for the use in DWDM or WDM-PON

3. System design

In the basic configuration, two pump lasers interfere in a low-dispersion fiber to induce a nonlinear phase modulation at the beat frequency, generating a few sidebands on both sides of the pump laser lines

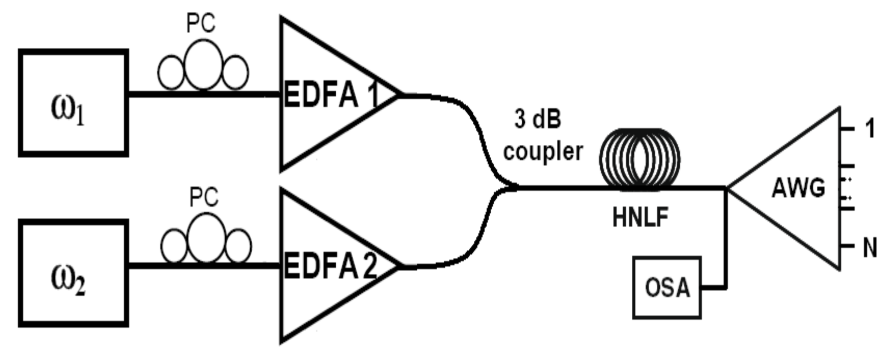

Fig.1 Cascaded four-wave mixing system for DWDM carriers' generation

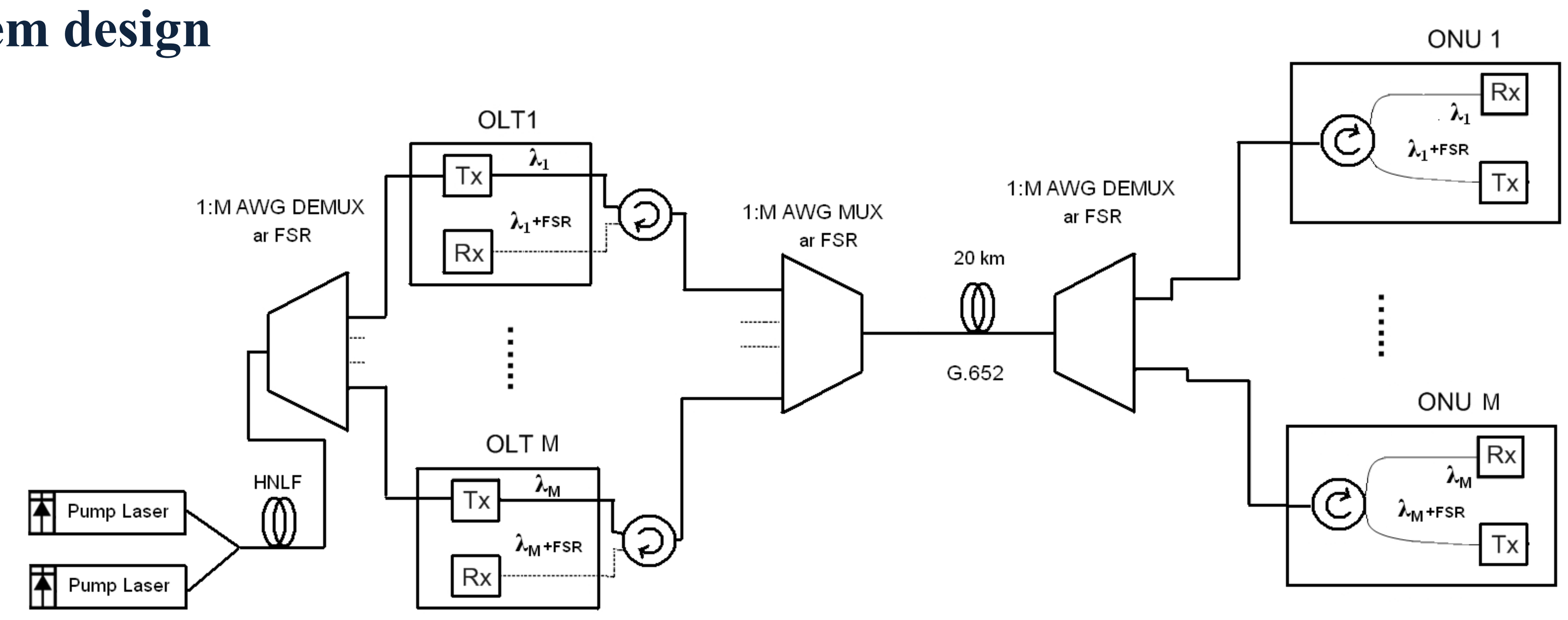

Fig. 2 FWM WDM-PON model

4. Fiber parameters

The dispersion slope of the HNLF in the zero-dispersion wavelength region is very flat satisfying the phase matching condition necessary for four-wave mixing phenomenon

TABLE I.
HNLF FIBER PARAMETERS

Nonlinear coefficient $(W \times km)^{-1}$	11.5
Effective area (μm^2)	11.7
Attenuation at 1550 nm (dB/km)	0.9
Zero dispersion wavelength (nm)	1548

5. Slicing procedure

- This technique of getting DWDM carriers for modulation is similar to spectral slicing. Each of demultiplexed channels is intensity-modulated at 10 Gb/s by a Mach-Zander modulator

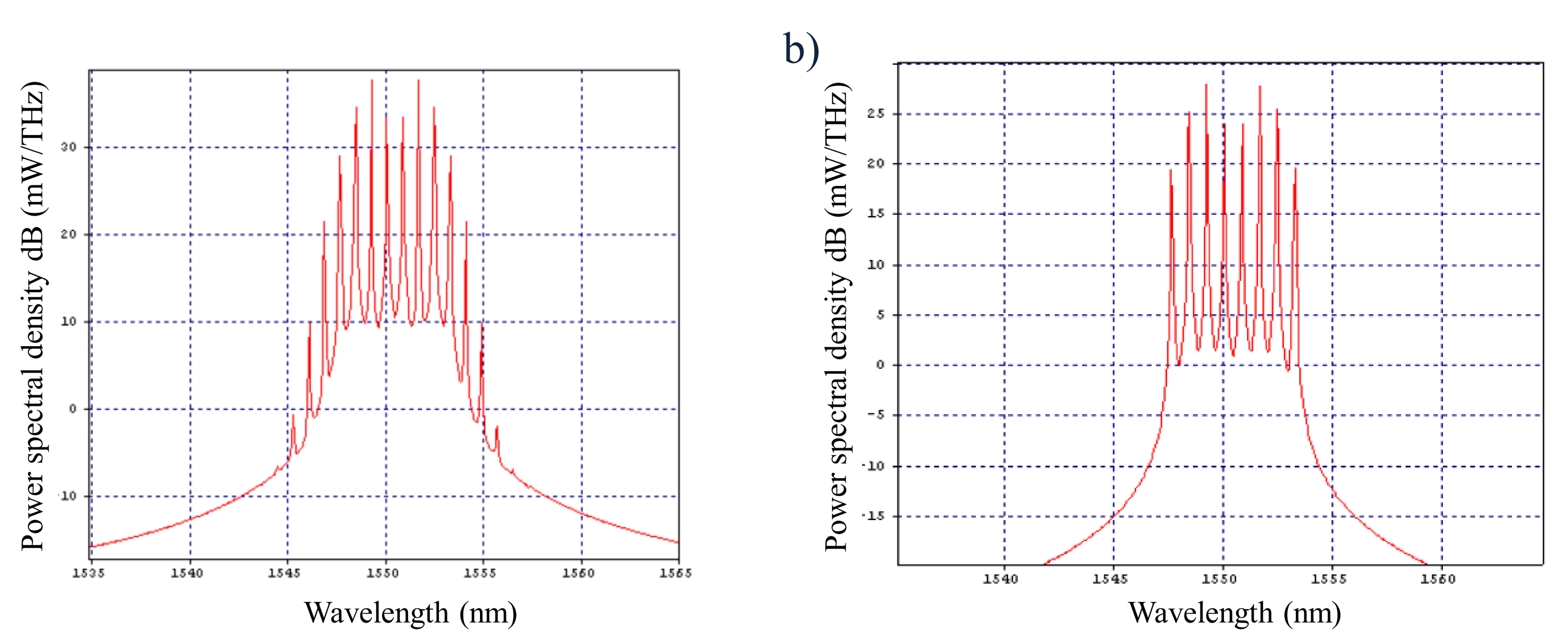

Fig. 3 Channel slicing; a) Spectrum before slicing, b) Spectrum after slicing using arrayed waveguide grating (AWG)

6. Optimal pump power

The first experiment is finding the optimal pump power for minimal DWDM optical carriers' power nonuniformity and maximal power level

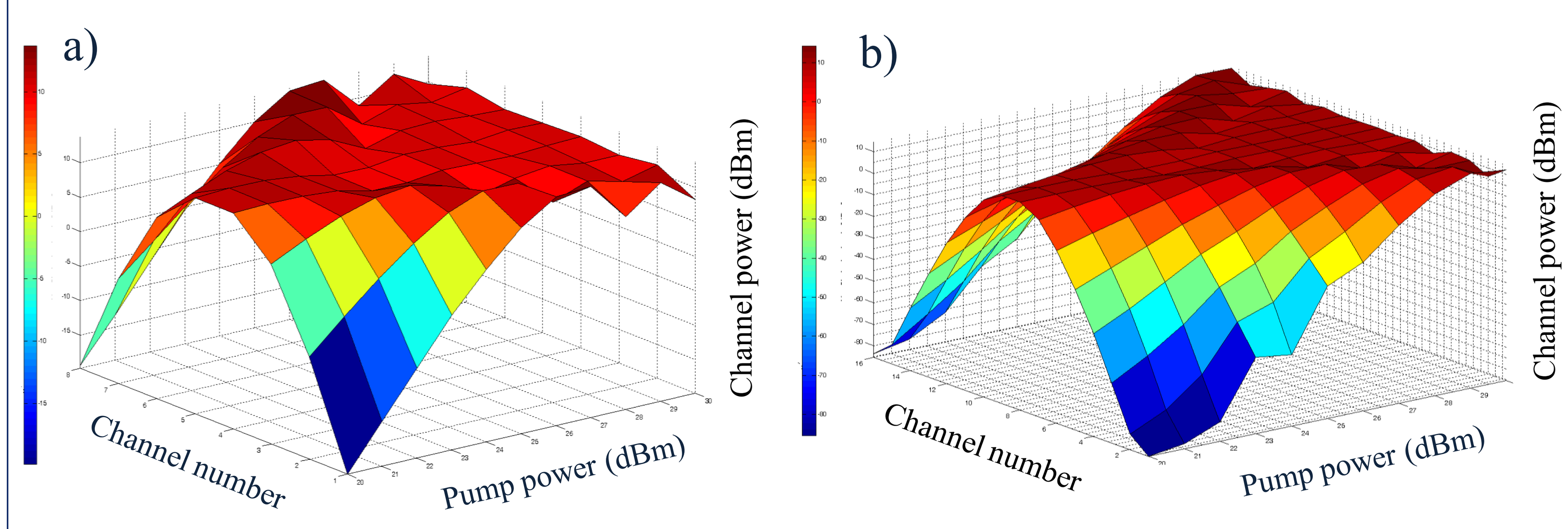

Fig. 4 Channel power distribution profiles a) 8-channel system, b) 16-channel system

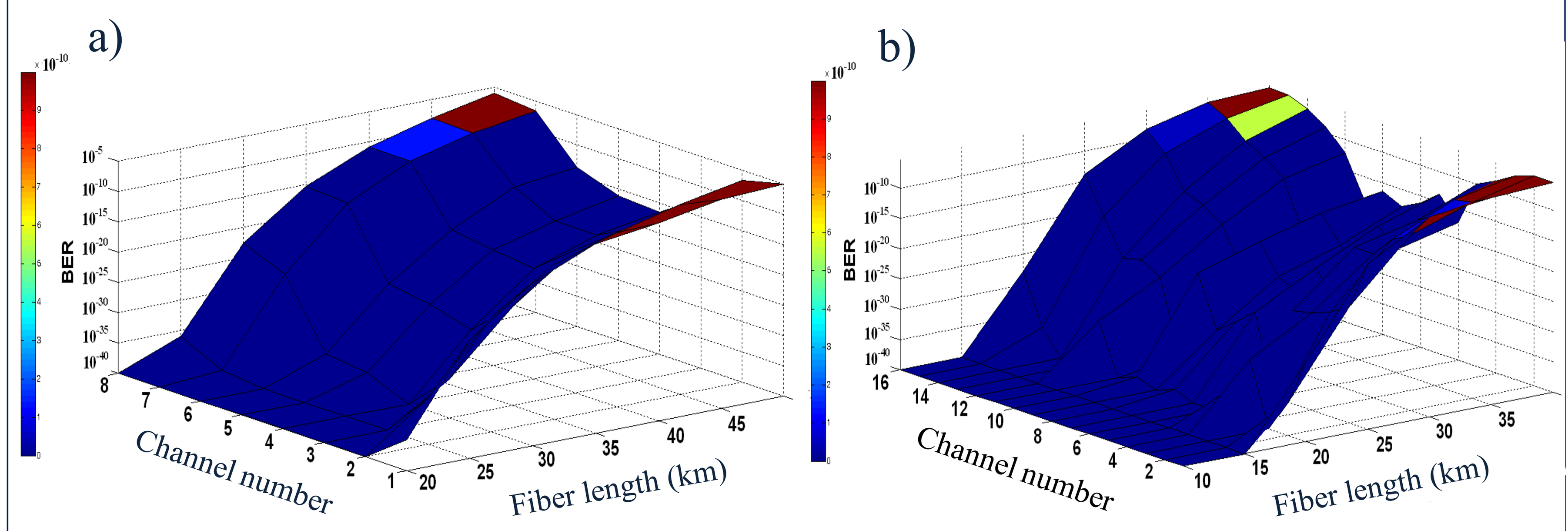

Fig. 5 BER profiles a) 8-channel system, b) 16-channel system

7. Optimal pump power

In real life scenario all the pump laser parameters must be precisely controlled due to possible power nonuniformity fluctuations, which can achieve extra 2 dB changing the pump power by at least by 0.5 dB

TABLE II.
OPTIMAL PARAMETERS FOR DWDM CARRIERS' GENERATION

Channel number	8	16
HNLF length (km)	1.1	1.25
Pump power (dBm)	25	28
Power nonuniformity(dB)	3.25	6.76

8. Fiber length scenario

- SBS suppression using phase modulation of pump lasers (580 and 1000 MHz)
- The simulation scenario includes step-by-step fiber length increasing to find maximal fiber length where BER $< 1 \cdot 10^{-9}$

9. Conclusion

- A two-pump CFWM solution for DWDM optical carriers' generation has been proposed and demonstrated for efficient 8 and 16-channel DWDM system realization
- Optimizing the HNLF length (1.1 km and 1.25 km) and pump power of lasers (25 dBm and 28 dBm) minimal power nonuniformity of 3.25 dB and 6.76 dB has been achieved.
- Pump lasers' phase modulation limits the system performance due to jitter and frequency chirp; however SBS threshold must be taken into account
- The calculated maximal distances 40 and 30 km for 8 and 16-channel systems are quite enough for metropolitan area and access networks

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