Parameters for forward/backward pumping validation

The test consists in calculating the signal longitudinal power evolution in the presence of forward and backward pumping as a function of the fraction of pump power in the forward direction

$$r = \frac{P_p^{(f)}}{P_p},$$

where $P_p^{(f)}$ is the forward pump power and P_p is the total pump power:

$$P_p = P_p^{(f)} + P_p^{(b)},$$

$P_p^{(b)}$ being the backward pump power.

The total pump power is chosen so that the signal (net) gain is equal to 1 (0 dB). In the undepleted pump approximation, it is easy to show that such pump power is equal to

$$P_p = \frac{\alpha_s L}{C_R L_{\text{eff},p}},$$

where α_s is the loss at the signal wavelength (in 1/m), L is the fibre length, C_R is the Raman efficiency at the signal wavelength, and $L_{\text{eff},p}$ is the effective length at the pump wavelength

$$L_{\text{eff},p} = \frac{1 - e^{-\alpha_p L}}{\alpha_p},$$

α_p being the loss at the pump wavelength (in 1/m).

The values of the relevant parameters are listed below.

Parameter	Symbol	Value	Unit	Comment
Fibre length	L	100	km	
Pump wavelength	λ_p	1450	nm	
Signal wavelength	λ_s	1550	nm	(1)
Fibre loss at λ_p	0.3	dB/km		
Fibre loss at λ_s	0.2	dB/km		
Raman efficiency	C_R	0.42×10^{-3}	1/W/m	(2)
Pump power	P_p	758.2	mW	
Signal power	P_s	0.1	mW	(3)

- (1) around maximum of Raman gain
- (2) OK for standard single mode fibre (SSMF) with 80 μm^2 effective area and unpolarized pump
- (3) undepleted pump approximation is OK at this signal power level

One obtains the following results: