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RESEARCH ARTICLE

Comparison of Previous Result with New Model for the Improvement of Gain in Raman Amplifier

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Abstract— Raman amplifiers are widely used for high capacity long haul communication systems. One of the main reason for which it can be used as its improved gain. In this paper gain of Raman amplifiers is studied and analyzed for counter pumping scheme. The methods to improve the gain is proposed and discussed. The previous result is being compared with the model proposed in this paper.

Keywords: - Distributed Raman amplifiers; Stimulated Raman scattering; Raman amplification and Discrete Raman amplifier; Amplified spontaneous emission

I. INTRODUCTION

Raman amplifier using the transmission fiber as the gain medium is a promising technology for the optical long haul DWDM communication systems. This is achieved by stimulated Raman scattering, stimulated Brillion scattering or stimulated four photon mixing by injecting a high power laser beam into undoped or doped optical fiber. Raman amplification exhibits advantage of self-phase matching between the pump and signal together with a broad gain bandwidth or high speed response in comparison with the other non-linear processes [1]. Raman amplifier is based on the phenomena of stimulated Raman scattering, a nonlinear optical process in which a pump photon is absorbed and immediately re-emitted in the form of a phonon and a signal photon, thus amplifying the signal [2]. Stimulated Raman scattering is a nonlinear optical process in which a photon, called the pump photon is absorbed by a material while simultaneously a photon of a different energy is emitted. The difference in photon energy is compensated by a change of the vibrational state of the material [3]. There are two types of Raman amplifiers: distributed and discrete Raman amplifiers. Gain of the Raman amplifier improves the overall performance of the system. As noise is inversely proportional to the gain, so, if gain is improved the noise is decreased in the system. Advantages of Raman amplifier are: improved noise figure, improved gain flatness.

The paper is planned as follows: section II is devoted to the description of distributed Raman amplifiers. The proposed model is discussed in section III. In section IV the previous result and new proposed model are compared.

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II. DISTRIBUTED RAMAN CONFIGURATION

The term distributed amplification refers to the method of cancellation of intrinsic fiber loss. A distributed raman amplifier is one in which the transmission fiber is utilized as the gain medium by multiplexing a pump wavelength with signal wavelength. The main reason to use raman amplification is the amplification bandwidth may be broadened simply by adding more pump wavelengths. Signal-to-noise ratio is improved in distributed Raman amplifier as compared to the discrete Raman amplifier.

The principal advantage of Raman amplification is its ability to provide distributed amplification within the transmission fiber, thereby increasing the length of spans between amplifier and regeneration sites.

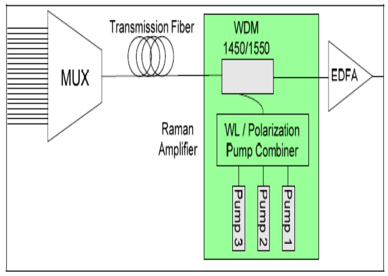

Fig 1: A simplified block diagram of a Raman amplifier deployed in counter pumping configuration.

III. PROPOSED MODEL

Under such conditions the saturated gain of the amplifier is given by:

$$G_s = \frac{G_A}{1+r_0 G_A}$$

Where r_0 is related to the signal to pump power ratio at the fiber input as and G_A is unsaturated gain or we can say that G_A is the total amplifier gain or on-off Raman gain.

If we use the typical values [3] as g_R= $3W^{-1}$/km for a DCF, L_{eff}=1km, P_0~1.5W then the signal can be amplified by 20 db. Once the gain fiber and pump power are given, the net gain G(z) can be written explicitly as a function of the fiber length z.

$$G(z)=\exp(g_R P_0 L_{eff} - a_s z) \quad (1)$$

The first term indicates the on off Raman gain and other is the fiber attenuation. After taking the derivative of (1) with respect to z, seeking the condition for z in which the derivative becomes zero. The net gain is maximal when

$$z = -\frac{1}{\alpha_p} \ln\left(\frac{\alpha_s}{g_R P_0}\right).$$

Where P_0 is the input pump power at z=0, ap is the attenuation constant for pump and g_R is Raman gain coefficient.

Now, the final proposed model is as follows:

$$\text{Gain} = \frac{w_s P_p(0) G_s / w_s P_p(0) - w_p P_s(0) G_s}{\exp[-a_s/a_p(\ln(a_s/g_r P_0))]}$$

From my work, we can see the improved gain of Raman amplifier. According to the equations given above we can obtain better results of gain.

Where w_s = angular frequency of signal
P_p = pump power
w_p = angular frequency of pump
P_s = signal power

Equations are taken from [3].

IV. COMPARISON AND RESULTS

Appropriate model is used to improve the gain in Raman amplifier. In this model fiber loss, spontaneous Raman scattering and its temperature dependency and pump depletion due to Raman energy transferred are included. After entering the required parameters for a desired amplifier in main program, gain can be obtained as a function of pump power and wavelength. As can be seen from fig 2 for a given pump power the amplifier gain increases up to 35 db. This increase is because of noise figure tilt. Noise figure is dependent on the amount of generated Amplified Spontaneous Emission (ASE) on the frequency difference between the pump and the signal. As this difference decreases, more ASE is generated.

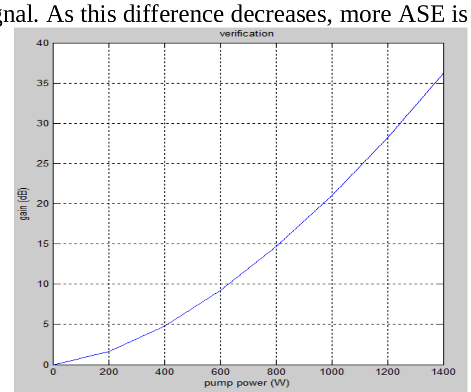

Fig 2: Proposed model results

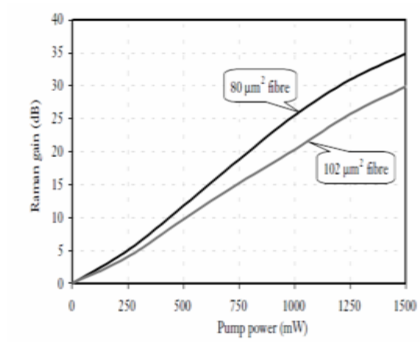

Fig 3: Previous result [4]

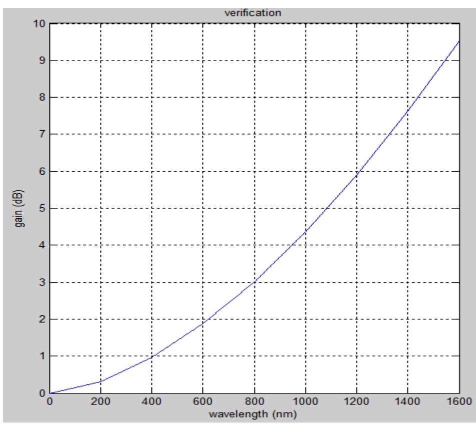

Fig 4: Proposed model results

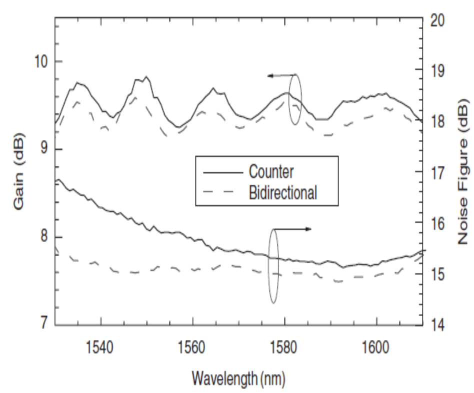

Fig 5: Previous result [3]

From fig 4, we can conclude that gain of the amplifier is approximately 9.5 db, which is very close to the result given in [3]. From the above figures 2-5 we can conclude that the proposed model in this paper has better result than the previous.

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