Problem 9 solution

1. An APD operates in the 850nm wavelength has a quantum efficiency $\eta = 0.85$, an APD gain of $M_{APD} = 100$ and a noise figure of $F(M) = M_{APD}^{0.3}$. The operating temperature is $T = 300K$, and load resistance is $R_L = 50\,\Omega$. Dark current is neglected for simplicity.

(a) If the input optical power is -30dBm and the receiver bandwidth is 1GHz, what is the SNR?
(b) At which signal optical power that shot noise is equal to thermal noise?

2. The material gain of an optical amplifier has a parabolic shape with the FWHM bandwidth of $\Delta f = 30\,\text{nm}$. Neglect gain saturation effect for simplicity, please find the optical bandwidths when the peak optical gains of the amplifier are 10dB, 20dB and 30dB, respectively.

3. For an optical amplifier with the small-signal optical gain $G_0 = 30\,\text{dB}$ at the peak gain wavelength, and the saturation optical power is $P_{sat} = 10\,\text{mW}$. Find optical gain of this amplifier for the input signal optical power of -30dBm, -20dBm and 0dBm at the peak gain wavelength. (note: numerical method has to be used).

4. An optical amplifier operates in the 1550nm wavelength window with a spontaneous emission factor of $n_{sp} = 2.5$ and an optical gain of 30dB. What is the optical noise power within 0.1nm optical bandwidth?

5. Consider an optical amplifier in the 1550nm wavelength window with 6dB noise figure and optical gain $G >> 1$. The optical signal at the out of this amplifier is detected by a photodiode as shown in the following figure. If there is a bandpass optical filter (BPF) with the bandwidth $B_o = 1\,\text{nm}$ before the photodiode, what is the signal optical power at which the signal-ASE beat noise is equal to the ASE-ASE beat noise? (assume that electric bandwidth is much less than the optical bandwidth)