Problems for exercise 6 (Oscillators and phase noise)

X-band microwave oscillators are to be designed. The usual 130-nm CMOS process is to be used with a supply of 1.2V. The frequency is 10GHz and the phase noise at 1MHz offset is to be below -115dBc/Hz.

We assume that on-chip inductors can be realized with a quality factor of 15 at 10GHz for the inductance values needed. Furthermore we assume the noise factor to be equal to 3 for our oscillators. To ensure startup, the startup loop-gain must be at least equal to 2.5. The amplitude of the outputs is chosen to 0.8V, to achieve high performance but still leave some margin with a 1.2V supply.

1. A Colpitts oscillator is to be designed. How this can be done is shown by the teacher.
2. A differential oscillator is then to be designed.
   How large is the current consumption, and what efficiency is achieved?
   How large are the transistors compared to the Colpitts oscillator?

Hints and useful equations:
Remember that P_{sig} is the total power loss in the tank, that is in both inductors

$$V_o = \frac{2}{\pi} I_{bias} R_p$$

where V_o is the amplitude at one side, and R_p is the resistance of one side of the tank

The loop-gain is $g_m R_p$ at startup