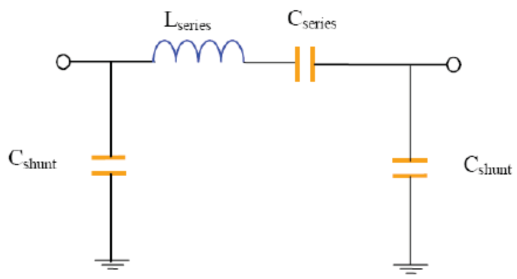

Fig 1. 4-Element lumped resonator. The L-C series elements determine the resonant frequency of the oscillator and hence the oscillating frequency.

The shunt capacitors are required to set the loaded Q of the resonator to at least 15 to ensure a compliant phase noise response.

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Effective capacitance which resonates with the series inductor L_{series} is : -

$$C_e = \frac{1}{\frac{1}{C_{series}} + \frac{2C_{shunt}(\omega_o R_o)^2}{(\omega_o R_o C_{shunt})^2 + 1}}$$

R_o = input/output load resistance

Required inductance to resonate at f_o is given by : -

$$L_{series} = \frac{1}{\omega_o^2 C_e}$$

If we assume an unloaded Q of 120 for the inductor, therefore the effective Q,
Qe is given by : =

$$Q_e = \frac{1}{\frac{1}{Q_L} - \frac{1}{Q_U}} = \frac{1}{\frac{1}{15} - \frac{1}{120}} = 17$$

The required shunt reactance assuming an inductor value of 10nH gives $X_L = 2\pi f * 10^{-8} = 63\Omega$

$$X_{shunt} = R_o\left(\frac{2R_o Q_e}{X_L} - 1\right)^{-1/2}$$

$$= 50\left(\frac{2 * 50 * 17}{63} - 1\right)^{-1/2} = 9.8\Omega$$

$$C_{shunt} = \frac{1}{2\pi f X_{shunt}} = \frac{1}{2\pi * 1E^9 * 9.8} = 16.2\text{pF}$$

Required inductance to resonate at f_o is given by : -

$$L_{series} = \frac{1}{\omega_o^2 C_e} \text{ therefore assuming}$$

$$L = 10nH \ C_e = \frac{1}{\omega_o^2 L} = 2.53pF$$

$$C_e = \frac{1}{\frac{1}{C_{series}} + \frac{2C_{shunt}(\omega_o R_o)^2}{(\omega_o R_o C_{shunt})^2 + 1}} \quad \text{Re - arrange to get } C_{series} \text{ ie}$$

$$C_{series} = \frac{1}{\frac{1}{C_e} - \frac{2C_{shunt}(\omega_o R_o)^2}{(\omega_o R_o C_{shunt})^2 + 1}}$$

$$= \frac{1}{\frac{1}{2.53E^{-12}} - \frac{2 * 16.2E^{-12}(2\pi * 1E^9 * 50)^2}{(2\pi * 1E^9 * 50 * 16.2E^{-12})^2 + 1}} = 3.6pF$$

The calculated circuit element values for a 1GHz resonator Q ~ 16 are shown in the diagram Figure 4.

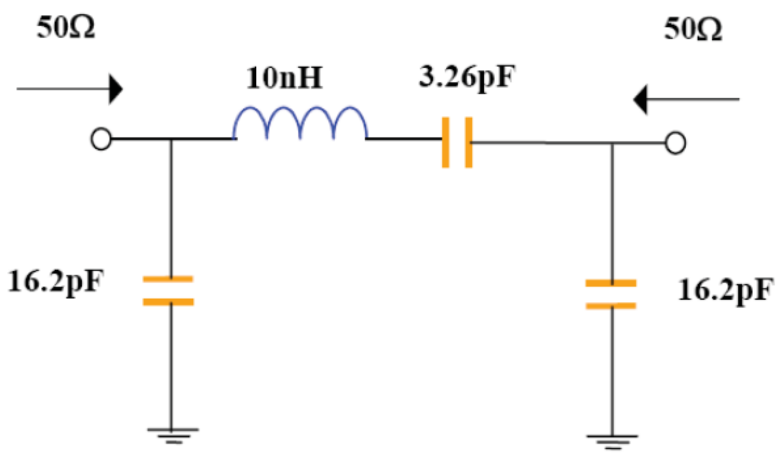

Fig 4. Final component values for the 4-element resonator designed to have a resonant frequency if 1GHz with a loaded Q of > 15 in a 50 ohm system.

[2] Oscillator Design & Computer Simulation, Randell W Rhea, Noble Publishing, 1995, ISBN 1-884932-30-4, p36, p191 – p211.