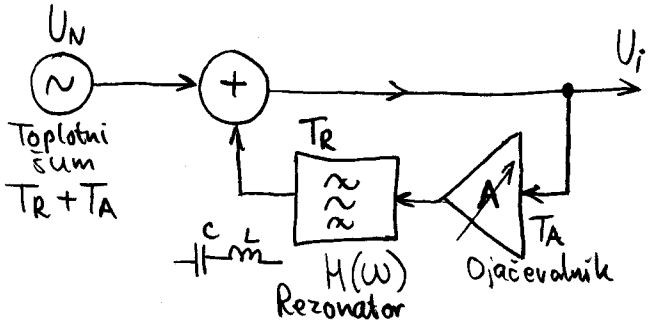
Fazni šum visokofrekvenčnega oscilatorja



$$U_i = U_N + U_i A H(\omega)$$

$$U_i = \frac{U_N}{1 - A H(\omega)}$$

Ustaljeno nihanje oscilatorja @ $\omega_0 \longrightarrow$ A nastavljen za $A H(\omega_0) = 1$

$$A H(\omega) = \frac{\Sigma R}{\Sigma R + j\omega L + \frac{1}{j\omega C}}$$

$\omega = \omega_0 + \Delta\omega$ (majhen odmik $\Delta\omega \ll \omega_0$)

$j\omega L = j\omega_0 L + j\Delta\omega L$

$$\frac{1}{j\omega C} = \frac{1}{j\omega_0 (1 + \frac{\Delta\omega}{\omega_0}) C} \approx \frac{1}{j\omega_0 C}\left(1 - \frac{\Delta\omega}{\omega_0}\right)$$

$$A H(\omega) \approx \frac{1}{1 + \frac{2j\Delta\omega L}{\Sigma R}}$$

$$j\omega L + \frac{1}{j\omega C} \approx j\Delta\omega L - \frac{1}{j\omega_0 C}\frac{\Delta\omega}{\omega_0} = 2j\Delta\omega L$$

$$A H(\omega) \approx \frac{1}{1 + 2j Q_L \frac{\Delta\omega}{\omega_0}}$$

$$\frac{2j\Delta\omega L}{\Sigma R} = 2j \frac{\omega_0 L}{\Sigma R}\frac{\Delta\omega}{\omega_0} = 2j Q_L \frac{\Delta\omega}{\omega_0}$$

Q_L ← obremenjeni Q

$$U_i = \frac{U_N}{1 - \frac{1}{1 + 2jQ_L\frac{\Delta\omega}{\omega_0}}} = U_N\left(1 + \frac{1}{2jQ_L}\frac{\omega_0}{\Delta\omega}\right) \qquad P = \propto |U|^2$$

$$P_i = P_N\left[1 + \left(\frac{1}{2Q_L}\cdot\frac{\omega_0}{\Delta\omega}\right)^2\right] = P_N\left[1 + \left(\frac{1}{2Q_L}\cdot\frac{f_0}{\Delta f}\right)^2\right]$$

$$P_N = B k_B (T_R + T_A) = B k_B T_0 F \left(1 + \frac{f_c}{\Delta f}\right)$$

Šum 1/f:
BJT, HBT → f_c = 1kHz – 10kHz
GaAsFET, HEMT → f_c = 1MHz – 10MHz

$$L(\Delta f) = \frac{1}{2}\frac{P_i}{P_0 B} = \frac{1}{2}\left[1 + \left(\frac{f_0}{2Q_L\Delta f}\right)^2\right]\frac{k_B T_0 F}{P_0}\left(1 + \frac{f_c}{\Delta f}\right) \quad [/Hz]$$

SPEKTRALNA GOSTOTA FAZNEGA ŠUMA

$\frac{1}{2}$ ← brez amplitudnega šuma

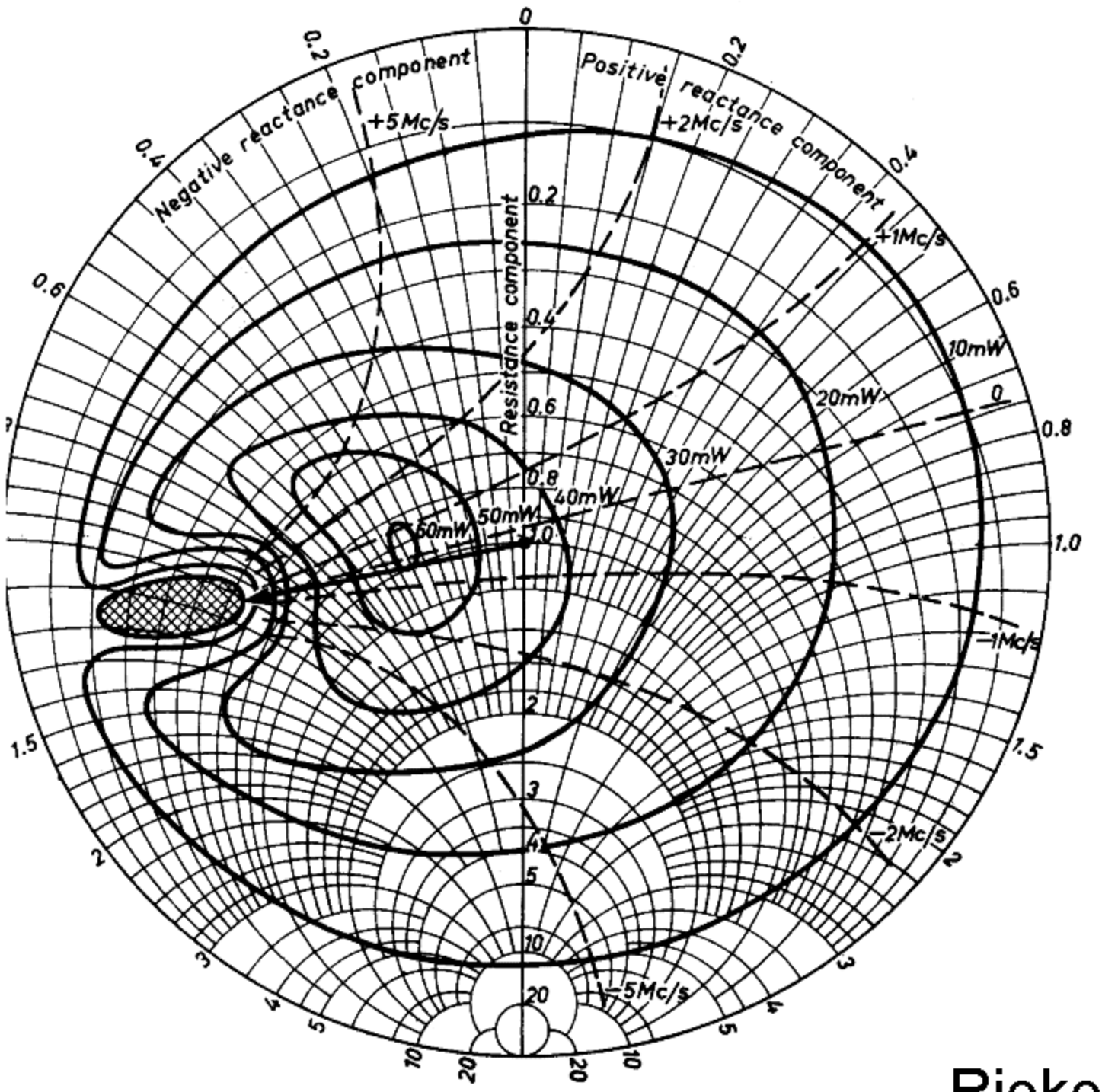
Leeson-ova enačba (David B. Leeson 1966)

$$L(\Delta f)_{dBc} = 10\log_{10}\frac{1}{2}\left[1 + \left(\frac{f_0}{2Q_L\Delta f}\right)^2\right]\frac{k_B T_0 F}{P_0}\left(1 + \frac{f_c}{\Delta f}\right)\cdot 1Hz \quad [dBc/Hz]$$

Fazni šum: $\sigma_\varphi(f_a, f_b) = \sqrt{2\int_{f_a}^{f_b} L(\Delta f)\, d\Delta f}$ [rd] Residual PM noise

Frekvenčni šum: $\sigma_f(f_a, f_b) = \sqrt{2\int_{f_a}^{f_b} \Delta f^2 L(\Delta f)\, d\Delta f}$ [Hz] Residual FM noise

Refleksni klistron 2K25



Rieke-jev diagram

Magnetron 2M214