RF Tasarım

Vize çalışması: Doğrusal olmama ve gürültü (özet)

Orijinal not: Notes.pdf

UYARI Bu belge, el yazısı ders notlarından Claude (Anthropic) yardımıyla dijitale aktarılmıştır. Yardımcı kaynak olarak hazırlanmıştır; hata veya eksik içerebilir. Lütfen orijinal notları ve ders kaynaklarını esas alın.

NOTICE *This document was transcribed from handwritten lecture notes with the help of Claude (Anthropic). It is meant as a supplementary resource and may contain errors or omissions. Always check against the original notes and official course material.*

orj. s. 1

$$P_{ave} = \underbrace{V_{rms}}_{\frac{|V|}{\sqrt{2}}} \underbrace{I_{rms}}_{\frac{|I|}{\sqrt{2}}} \cos(\phi) \qquad \phi = \theta_V - \theta_I$$

$$S = \frac{1}{2}(V \cdot I^*) = (V_{rms} \cdot I^*_{rms})$$

$$P_L = \frac{1}{8}\frac{|V_s|^2}{R_s}$$

Drawbacks of Nonlinearity

① Harmonic distortion

$$y = a_1x + a_2x^2 + a_3x^3$$

$$(\cos \omega t)^2 = \frac{1}{2}(1 + \cos 2\omega t)$$

$$(\cos \omega t)^3 = \frac{1}{4}(3\cos \omega t + \cos 3\omega t)$$

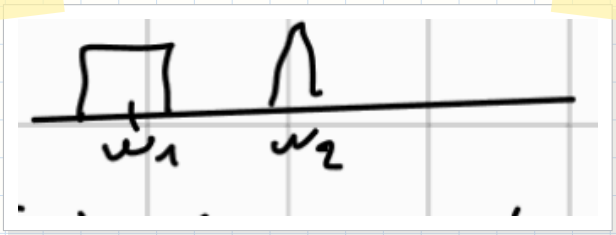
② Gain compression

$$\text{Gain} = \frac{V_{out}(\text{fundamental})}{V_{in}} = \frac{a_1A + \frac{3a_3A^3}{4}}{A}$$

$$\text{Gain} = a_1 + \frac{3}{4}a_3A^2$$

1) $a_1 > 0,\ a_3 < 0 \rightarrow \text{Gain} = a_1 - \frac{3}{4}|a_3|A^2 \rightarrow v_{in}$

③ Desensitization



orijinal çizim, s. 1

$$x(t) = A_1 \cos \omega_1 t + A_2 \cos \omega_2 t$$

$$y = a_1 x + a_2 x^2 + a_3 x^3$$

$$\cos a \cdot \cos b = \frac{\cos(a+b) + \cos(a-b)}{2}$$

$$\frac{3}{4} a_3 A_1^3 \cos \omega_1 t + \frac{3 A_1 A_2^2}{2} a_3 \cos \omega_1 t$$

$$y(t)_{BPF} = \frac{3}{4} a_3 A_1^3 \cos \omega_1 t + \frac{3 A_1 A_2^2}{2} a_3 \cos \omega_1 t + a_1 A_1 \cos \omega_1 t$$

if A_2 small

ignore $\frac{3}{4} a_3 A_1^3$

$$\text{Gain} = \frac{a_1 A_1 - \frac{3}{2} |a_3| A_1 A_2^2}{A_1} \Big\} A_2 \uparrow\uparrow$$

No signal appears at output

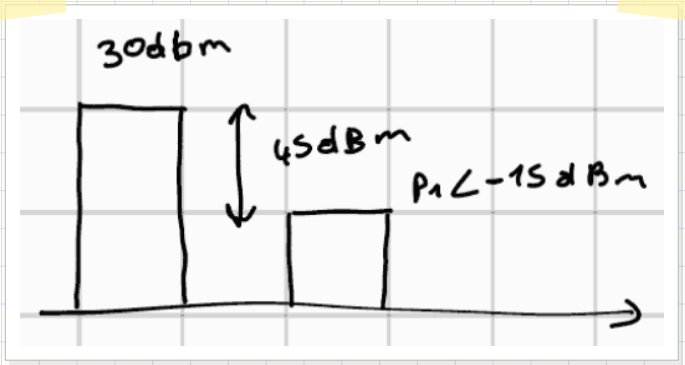
Ex:

$$P_{Tx} = 1\,W = 30\,dBm$$

$$P_1 - 10 < -25$$

$$P_1 < -15$$

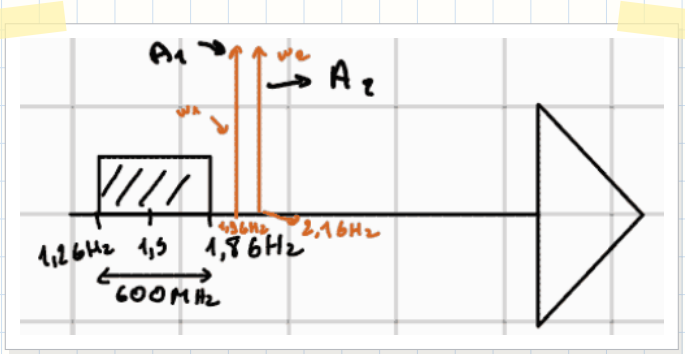
orj. s. 2



orijinal çizim, s. 2

2. harmonik 45 dBm bastırılmalıdır

④ Intermodulation



orijinal çizim, s. 2

$$A_{IM3} = \frac{3}{4} a_3 A_1^2 A_2 \ (\cos(2\omega_1 - \omega_2)t)$$

$$A_1 = A_2 = A \Rightarrow A_{IM3} = \frac{3}{4} a_3 A^3$$

system linear $\rightarrow a_1 A$

Intermodulation products $\rightarrow \frac{3}{4} a_3 A^3$

$$IM3 = \frac{\frac{3}{4} a_3 A^3}{a_1 A} = \frac{3}{4} \left| \frac{a_3}{a_1} \right| A^2$$

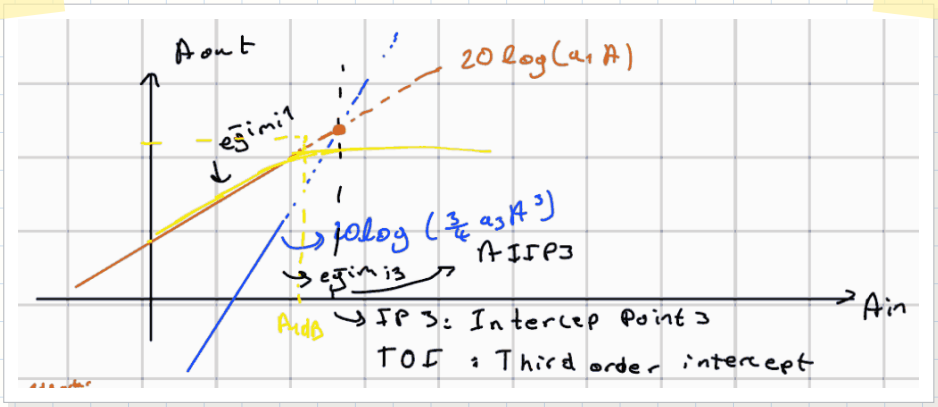
$$A_{IIP3} = 20 \log(|a_1| A_{IIP3}) = 20 \log \left(\frac{3}{4} |a_3| A_{IIP3}^3 \right)$$

$$A_{IIP3} = \sqrt{\frac{4}{3} \left| \frac{a_1}{a_3} \right|}$$

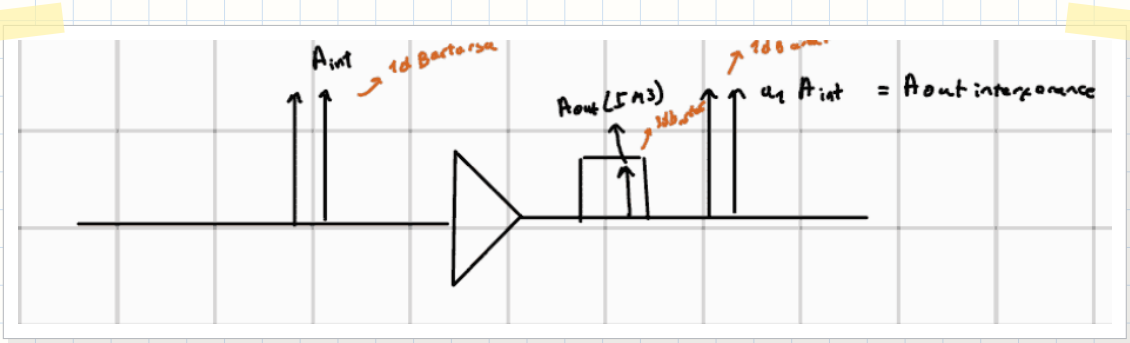
$$A_{1dB} = \sqrt{0{,}145 \left| \frac{a_1}{a_3} \right|}$$

$$A_{IIP3}(\text{dB}) - A_1(\text{dB}) = 9{,}6 \text{ dB}$$

$A_{IIP3} \uparrow \rightarrow$ more linear system



orijinal çizim, s. 2



orijinal çizim, s. 2

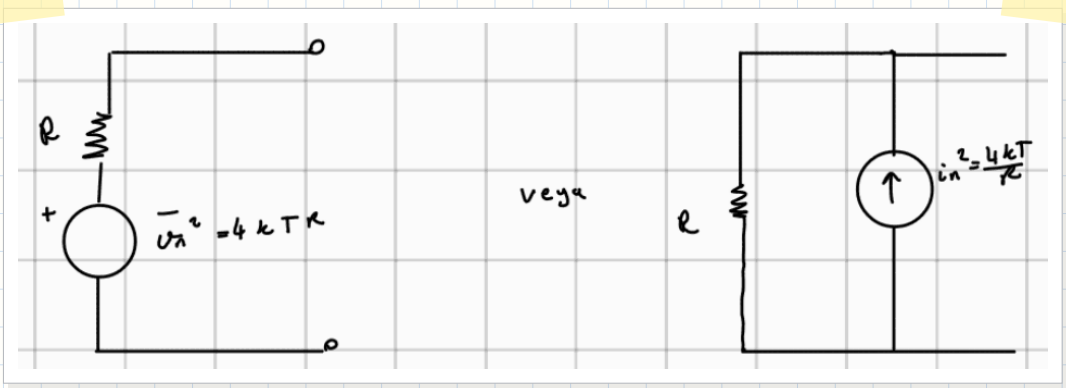
$$\frac{A_{out,int}(\omega_1,\omega_2)}{A_{out}(IM3)} = \frac{a_1 A_{int}}{\frac{3}{4}a_3 A_{int}^3} = \frac{a_1}{\frac{3}{4}a_3 A_{int}^2} = \frac{A_{IIP3}^2}{A_{int}^2}$$

$$A_{IIP3}^2 = \frac{A_{out,int}(\omega_1,\omega_2)}{A_{out}(IM3)} A_{int}^2 \quad \leftarrow \text{önemli}$$

orj. s. 3

Noise

Resistor Noise:



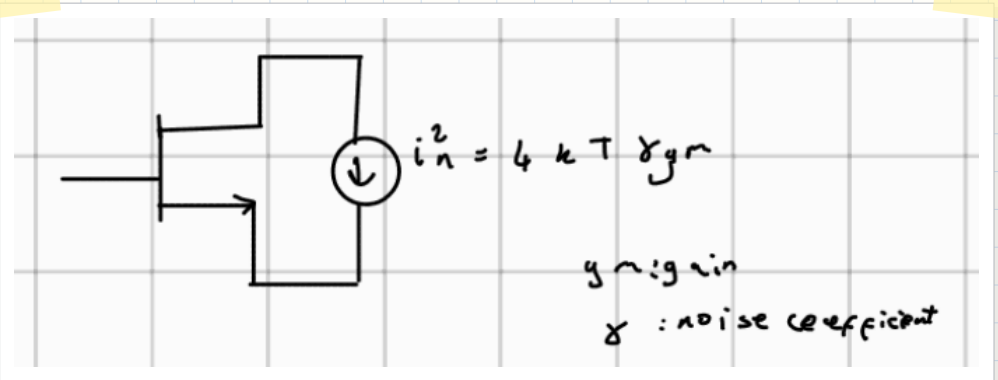
orijinal çizim, s. 3

$1{,}38 \times 10^{-23}$ J/K

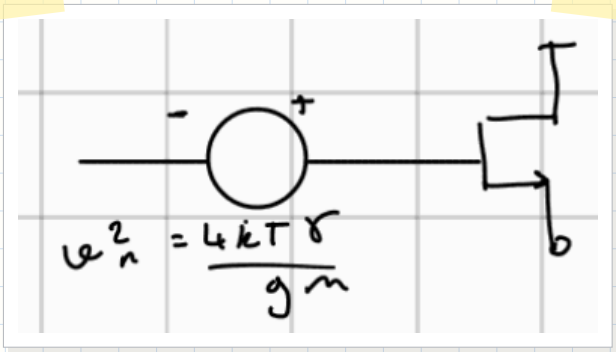
k: Boltzmann sabiti

T = (kelvin) sıcaklık

MOS Transistor Noise



orijinal çizim, s. 3



orijinal çizim, s. 3