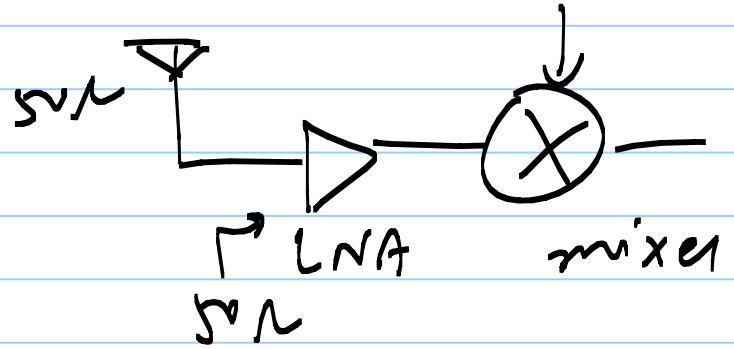
22/1/20

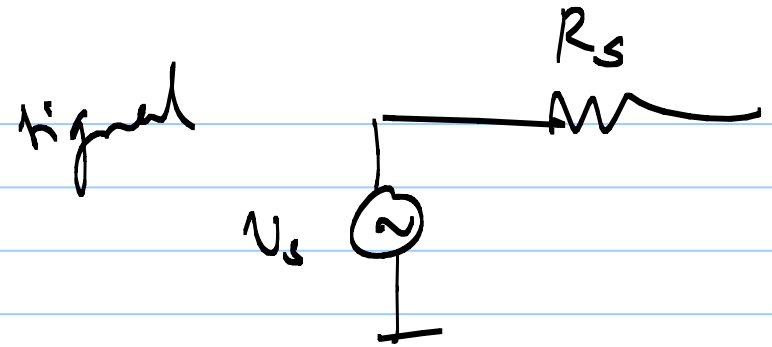
Lec 5

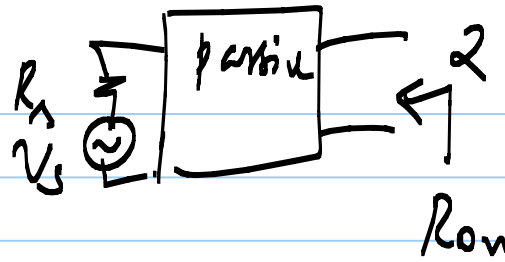
HW

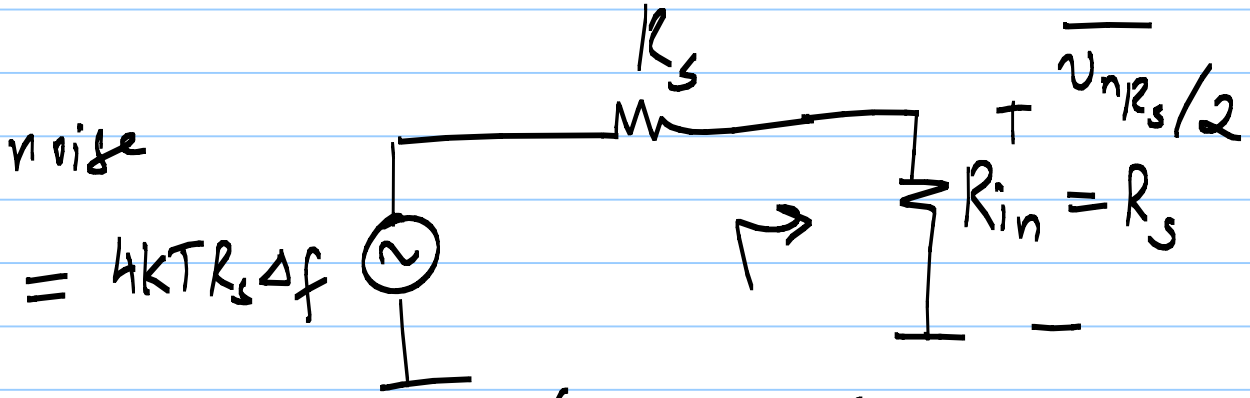
1) L- match 200Ω to 50 + j20 Ω
f = 1GHz

2) T- match 200Ω to 50 + j20 Ω
f = 1 GHz
Q = 5

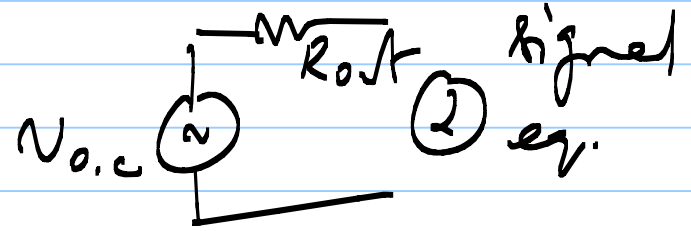




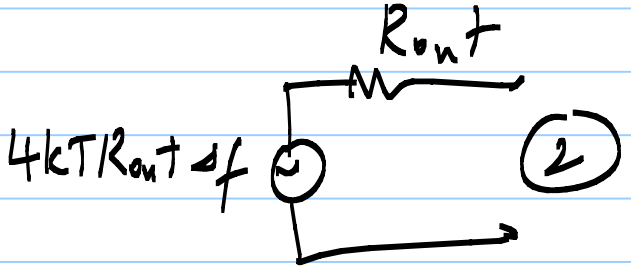




@ port 2:



$$\overline{v_{nR_s}^2} = 4kTR_s\Delta f$$



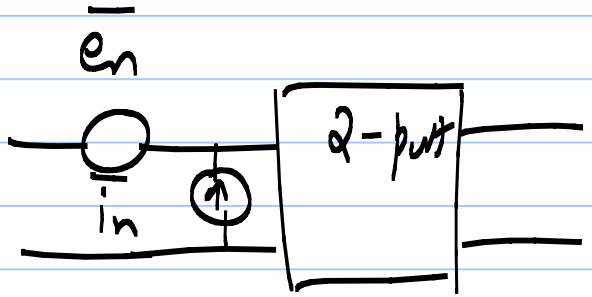
$$N_{in} = \frac{\left(\overline{v_{nR_s}/2}\right)^2}{R_{in}}$$

$$= \frac{4kTR_s\Delta f}{4R_{in}} = kT\Delta f \text{ if } R_{in} = R_s$$

If BW of interest = B,

N_{in} = kTB Watts = "Available noise power"

$N_{in_{dB}}$ = -174 dBm/Hz + $10\log(B)$.



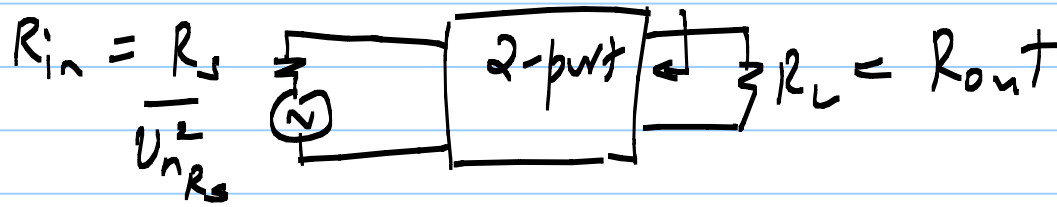
In RF systems:

Noise is characterized by

Noise factor 'F'

or Noise figure NF in dB

$$NF = 10\log(F)$$

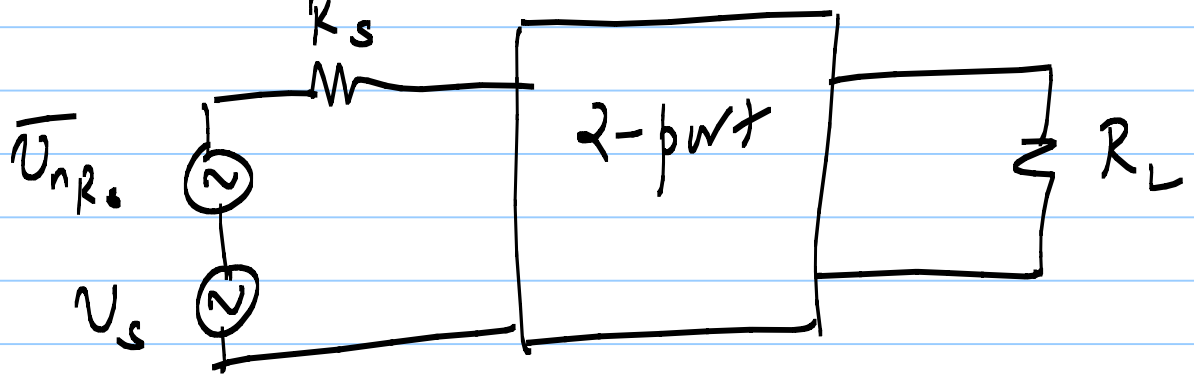


$$F = \frac{\text{Total noise at output of 2-port}}{\text{Noise @ output due to } R_s \text{ alone}}$$

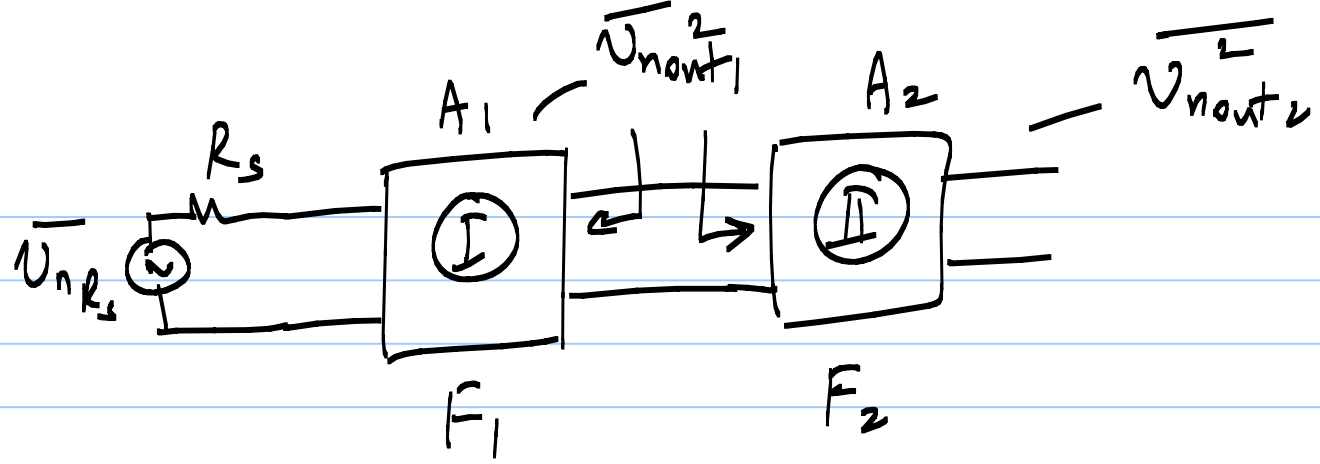
$$F = \frac{N_{out_{R_s}} + N_{out_{2\text{-pwt}}}}{N_{out_{R_s}}}$$

$$= - 1 + \frac{N_{out_{2\text{-pwt}}}}{N_{out_{R_s}}}$$

Ideal noiseless 2-pwt : $F = 1$, $NF = 0\,dB$



$$F = \frac{SNR_{in}}{SNR_{out}}$$

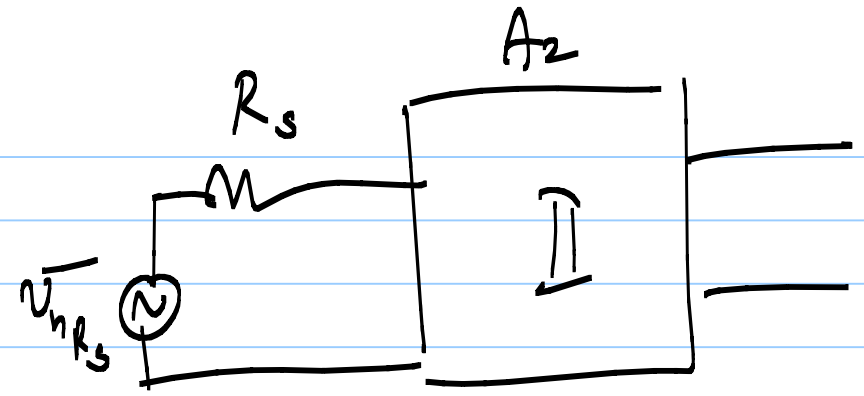


$$F = \frac{\overline{v_{nR_s}^2} \cdot A_1^2 \cdot A_2^2 + \overline{v_{nout_1}^2} \cdot A_2^2 + \overline{v_{nout_2}^2}}{\overline{v_{nR_s}^2} \cdot A_1^2 \cdot A_2^2}$$

$$= 1 + \frac{\overline{v_{nout_1}^2}}{A_1^2 \cdot \overline{v_{nR_s}^2}} + \frac{\overline{v_{nout_2}^2}}{A_1^2 A_2^2 \overline{v_{nR_s}^2}}$$

$$F_1 = \frac{\overline{v_{nR_s}^2} \cdot A_1^2 + \overline{v_{nout_1}^2}}{\overline{v_{nR_s}^2} \cdot A_1^2} \; ; \; F_2 = \frac{\overline{v_{nR_s}^2} \cdot A_2^2 + \overline{v_{nout_2}^2}}{\overline{v_{nR_s}^2} \cdot A_2^2}$$

$$F_1 = 1 + \frac{\overline{v_{nout_1}^2}}{\overline{v_{nR_s}^2} \cdot A_1^2} \; ; \; F_2 = 1 + \frac{\overline{v_{nout_2}^2}}{\overline{v_{nR_s}^2} \cdot A_2^2}$$



$\Rightarrow F_2$

$$F = 1 + (F_1 - 1) + \frac{(F_2 - 1)}{A_1^2}$$

$$F = F_1 + \frac{(F_2 - 1)}{A_1^2} + \frac{F_3 - 1}{A_1^2 A_2^2} + \cdots \frac{F_n - 1}{A_1^2 \cdot A_2^2 \cdots A_{n-1}^2}$$

Friis Equation

$$F = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} + \cdots$$

(

power gain $= A_1^2$ etc.

$A_1 =$ loaded voltage gain