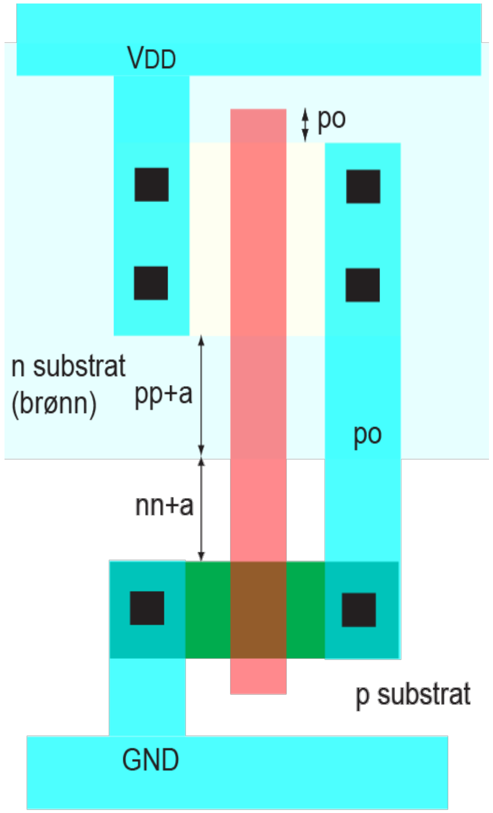
UiO : Universitetet i Oslo

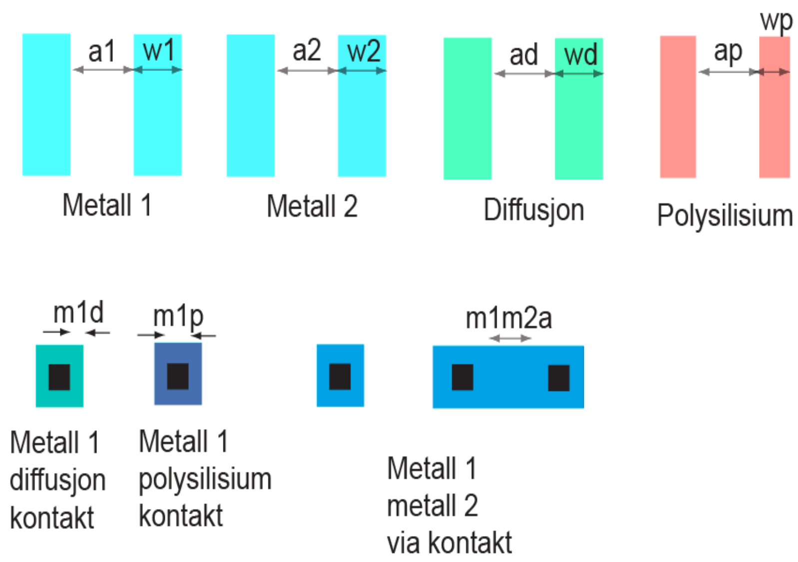
**INF3400 Del 4**

# Moderne MOS transistor modell, transient simulering og enkle utleggsregler

# Introduksjon til utleggsregler

Enkle utleggsregler:




Inverter

# Enkle MOS kapasitans modeller

Gatekapasitans:

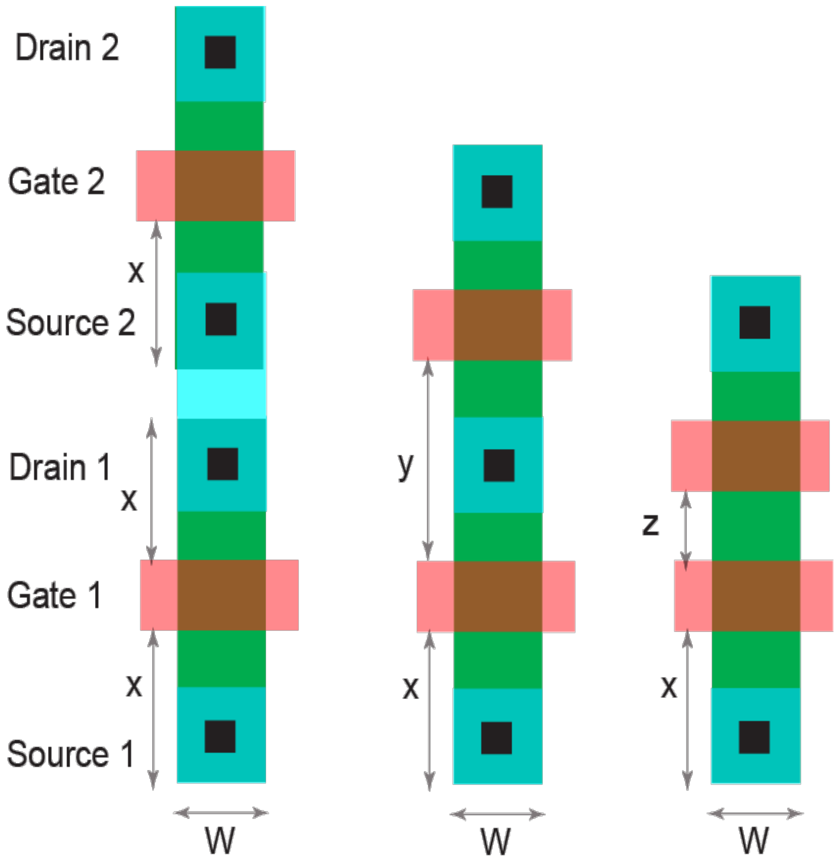
$$C_g = C_{ox}WL$$

der

$$C_g = C_{permicron}W$$

der

$$C_{permicron} = C_{ox}L$$



# Gatekapasitans detaljer

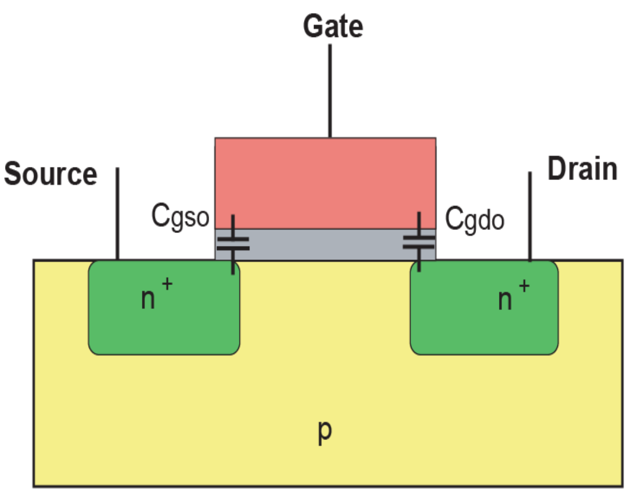
Ubiasert gatekapasitans:

$$C_0 = C_{ox}WL$$

Overlappskapasitanser (statiske):

$$C_{gs0} = C_{gsol}W$$

$$C_{gd0} = C_{gdol}W$$




Operasjonsområde **AV**:

$$C_{gb} = C_0$$

Operasjonsområde **LINEÆR**:

$$C_{gs} = C_{gd} = \frac{C_0}{2}$$

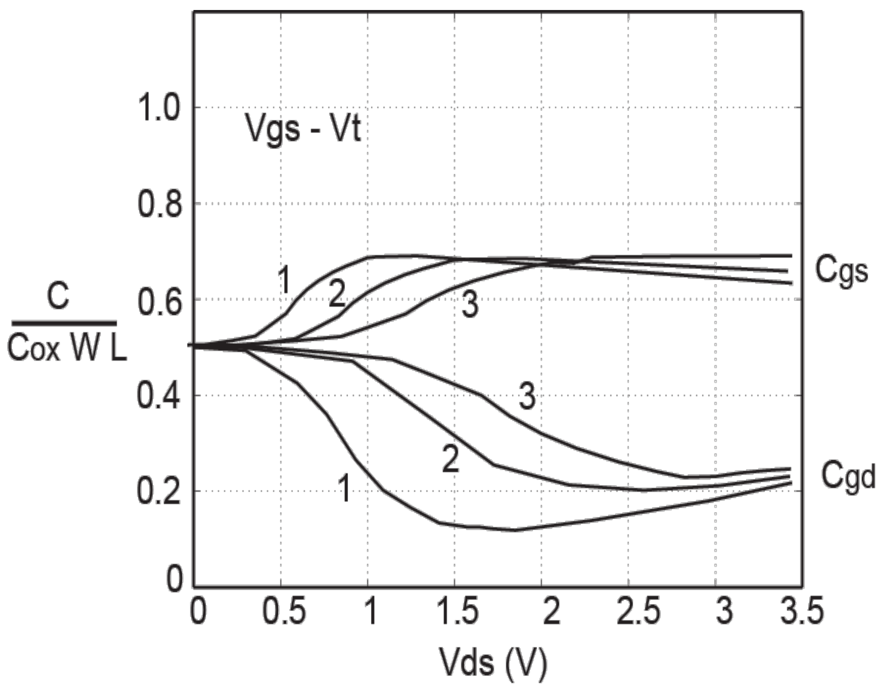
Operasjonsområde **METNING**:

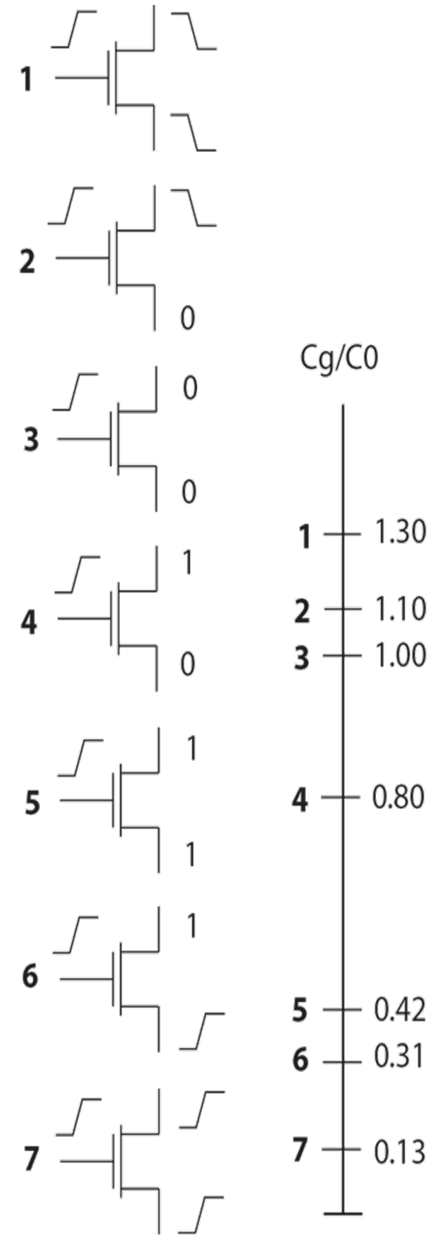
$$C_{gs} = \frac{2C_0}{3}$$

$$C_{gd} = 0$$

Gatekapasitans:

$$C_g = C_{gs} + C_{gd} + C_{gb} \approx C_0$$


1.0
0.8
0.6
0.4
0.2
0
Vgs - Vt
C / Cox W L
1
2
3
3
2
1
Cgs
Cgd
0
0.5
1
1.5
2
2.5
3
3.5
Vds (V)


1
2
0
3
0
0
4
1
0
5
1
1
6
1
7
Cg/C0
1 1.30
2 1.10
3 1.00
4 0.80
5 0.42
6 0.31
7 0.13

# Diffusjonskapasitans detaljer

Diffusjonskapasitans source:

$$C_{sb} = AS \cdot C_{jbs} + PS \cdot C_{jbssw}$$

der:

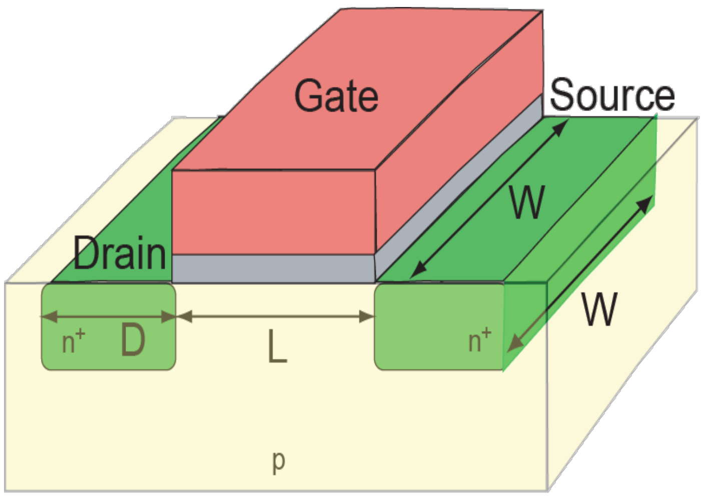
$$AS = W \cdot D$$

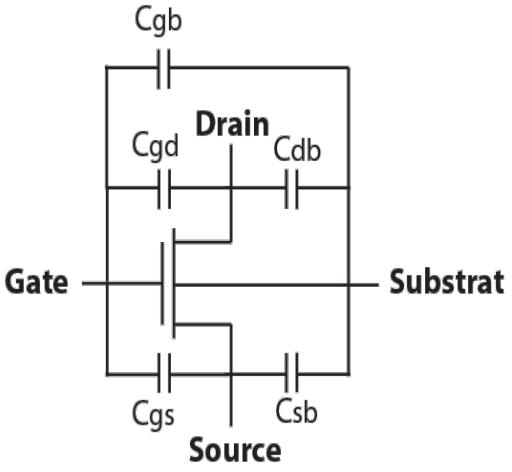
$$PS = 2W + 2D$$

$$C_{jbs} = C_j \left(1 + \frac{V_{sb}}{\Psi_0}\right)^{-M_J}$$

$$\Psi_0 = V_T \ln \frac{N_A N_D}{n_i^2}$$

$$C_{jbssw} = C_{JSW} \left(1 + \frac{V_{sb}}{\Psi_0}\right)^{-M_{JSW}}$$



# ENKLE RC modeller

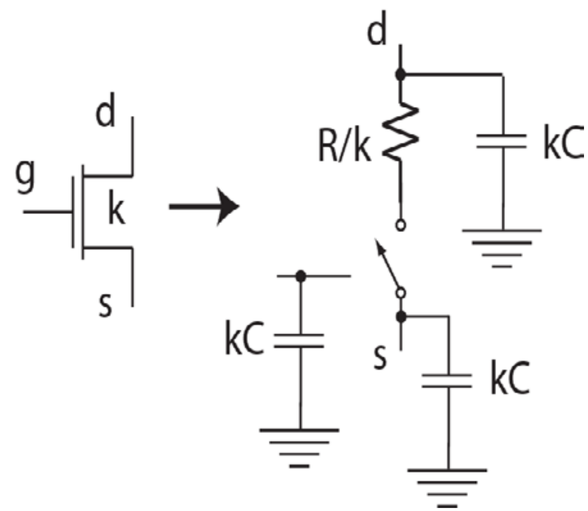
$$k = W$$

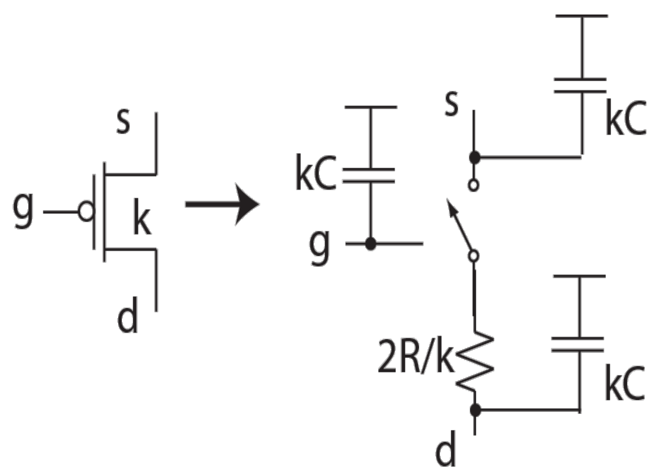
Motstand i transistor:

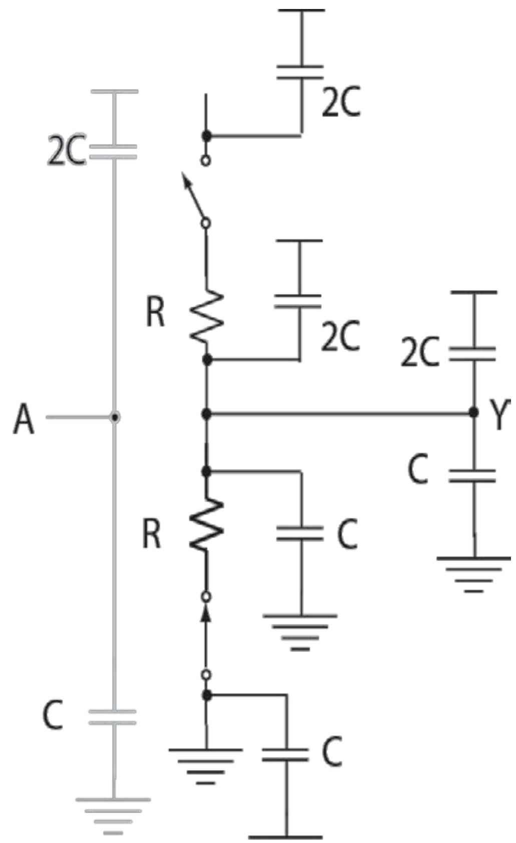
$$R = \left( \frac{\partial I_{ds}}{\partial V_{ds}} \right)^{-1}$$

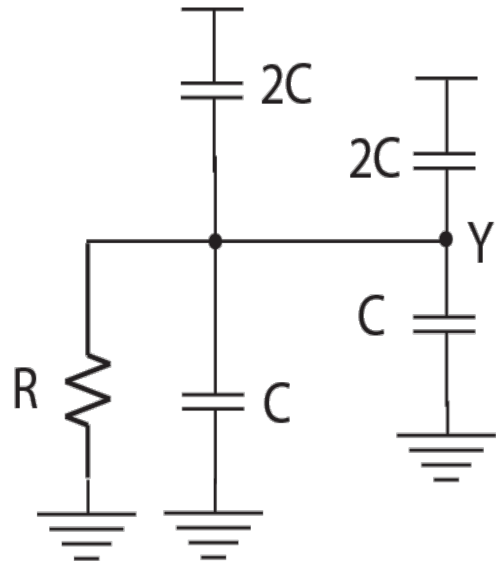
$$\approx \left( \beta \left( V_{gs} - V_t \right) \right)^{-1}$$

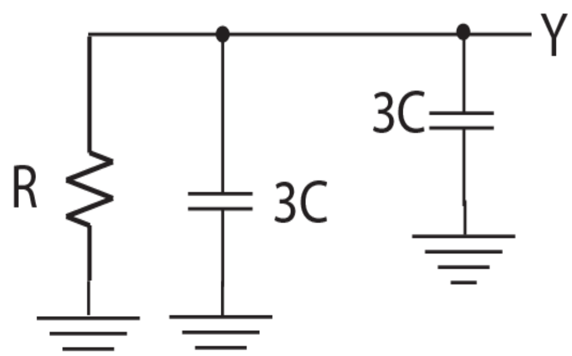
$$\approx \frac{1}{\mu C_{ox}} \frac{L}{W} \left( V_{gs} - V_t \right)^{-1}$$

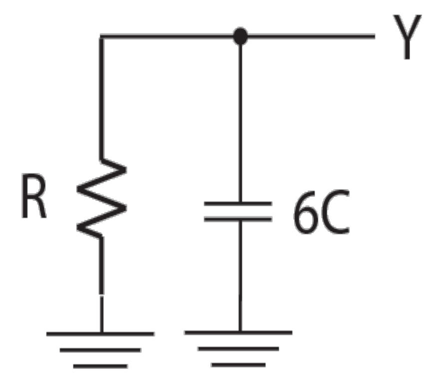


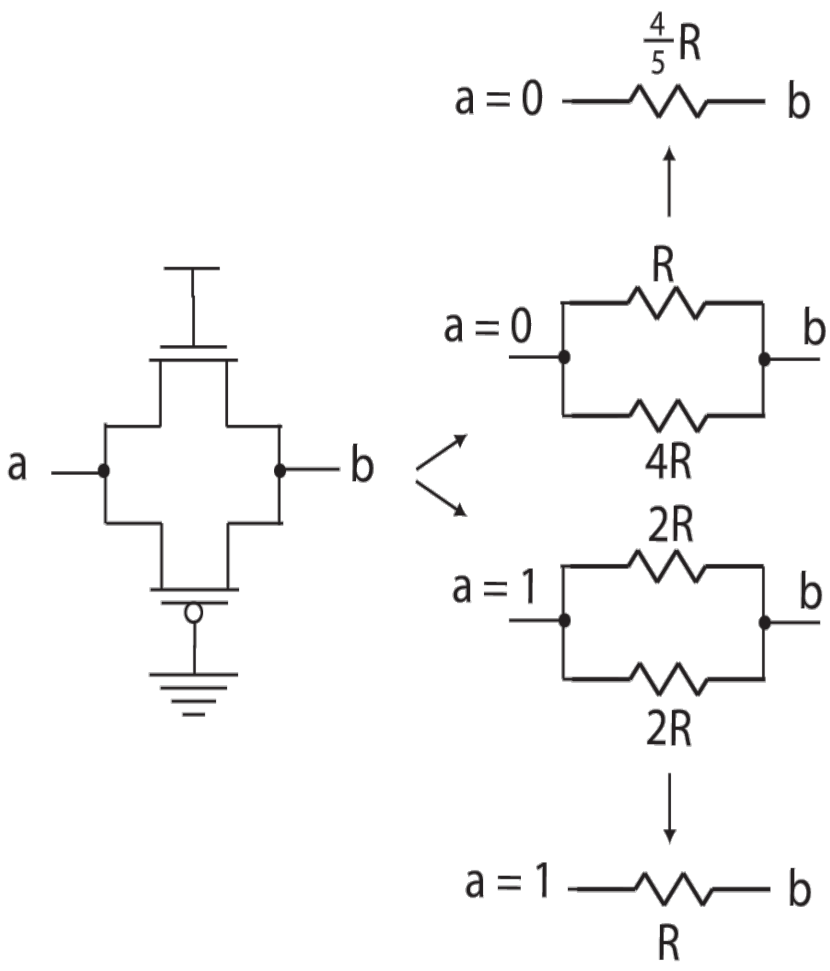

2C
2C
R
2C
2C
A
Y
C
R
C
C
C


2C
2C
Y
C
R
C


Y
3C
R
3C


Y
R
6C

# Transmisjonsport:

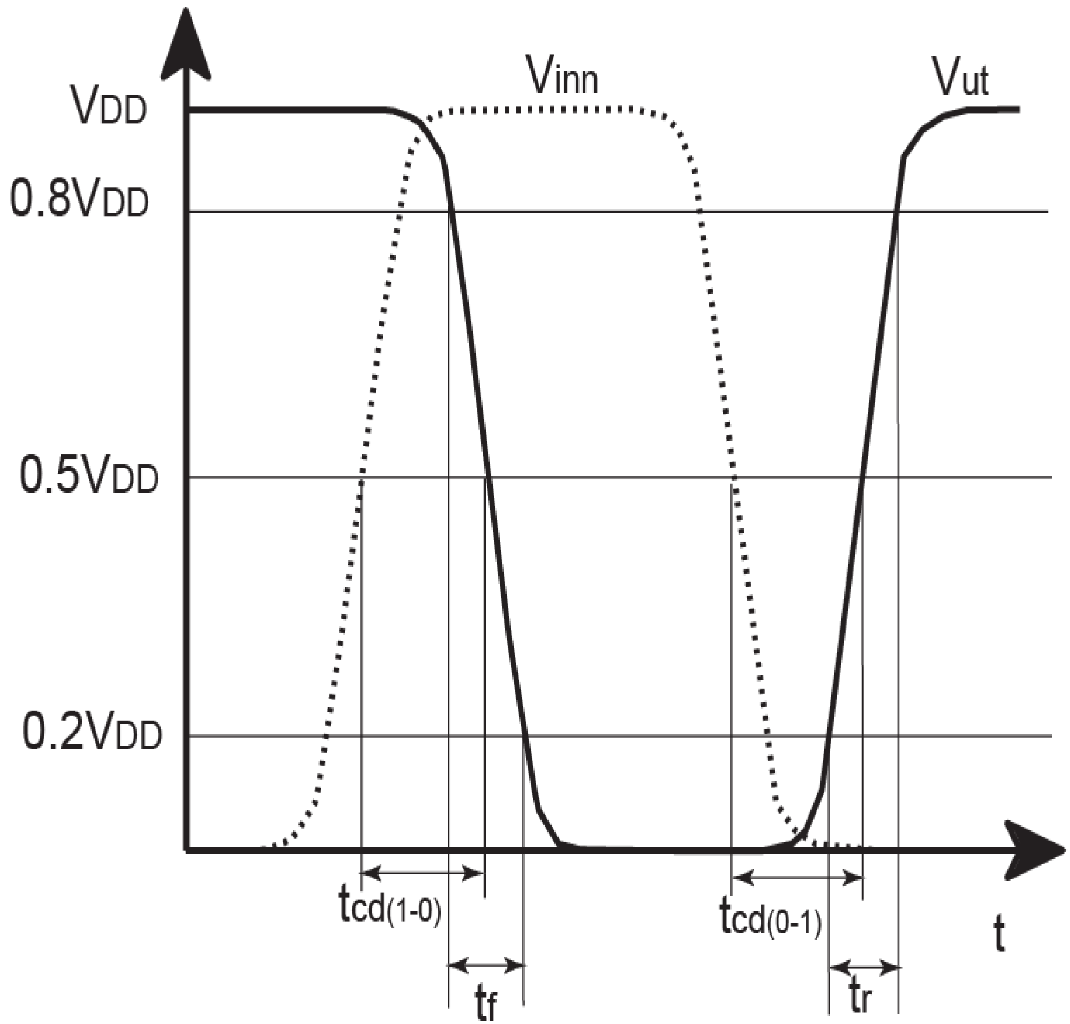



Parallelle motstander:

$$R_{\parallel} = R_1 \parallel R_2$$

$$= \frac{R_1 \cdot R_2}{R_1 + R_2}$$

# RC forsinkelsesmodeller



## Seriekobling av transistorer:

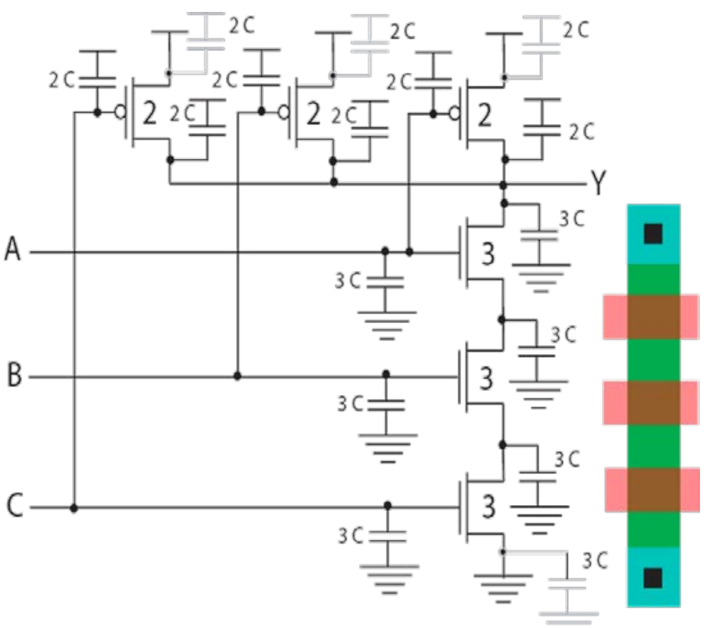
$$R_{effektiv} = \sum_{i=1}^{n} \frac{R}{k_i} \qquad k = W$$

## Parallellkobling av transistorer:

$$R_{effektiv} = R \| R$$

$$= \frac{R}{2}$$

## Eksempel NAND3:




## Transisjon fra 0 til 1:

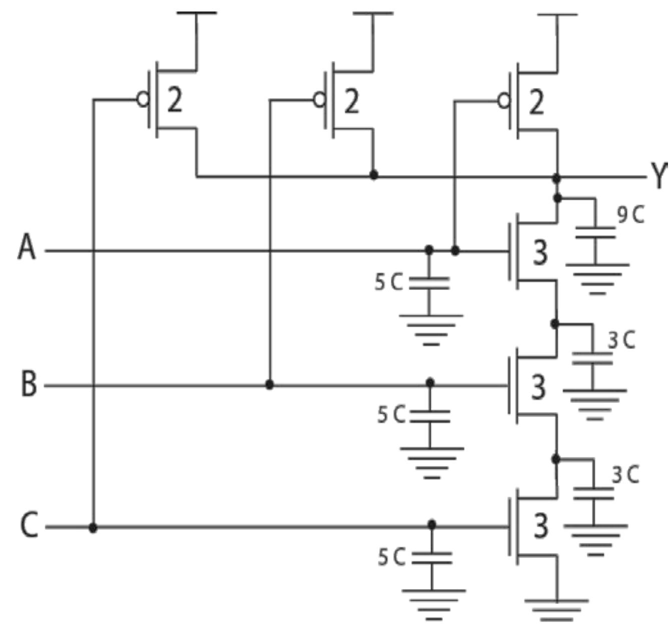
$$R_{effektiv} = \frac{2R}{2}$$

$$= R$$

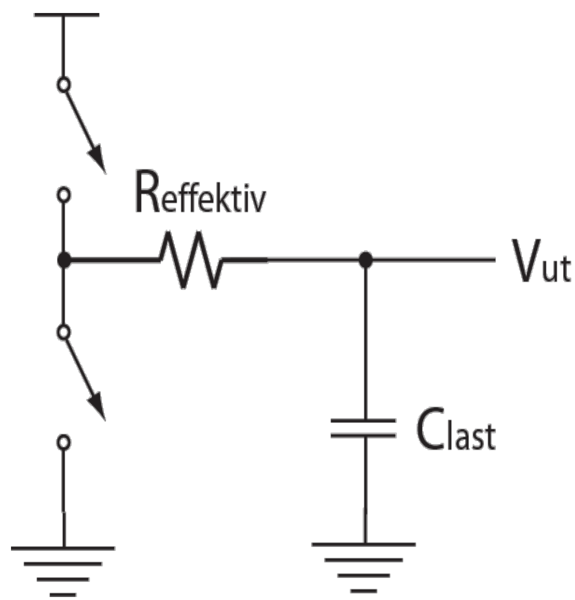
## Transisjon fra 1 til 0:

$$R_{effektiv} = \left(\frac{1}{3} + \frac{1}{3} + \frac{1}{3}\right) R$$

$$= R$$



# RC modell



# Hastighetsmetning

Hastigheten til ladningsbærere:

$$v = \frac{\mu E_{lat}}{1 + \frac{E_{lat}}{E_{sat}}}$$

der:

$$E_{lat} = \frac{V_{ds}}{L}$$

Transistormodeller:

$$I_{ds} = 0$$

AV

$$I_{ds} = P_c \frac{\beta}{2} \left(V_{gs} - V_t\right)^{\alpha} \frac{V_{ds}}{V_{dsat}} \left(1 + \lambda V_{ds}\right)$$

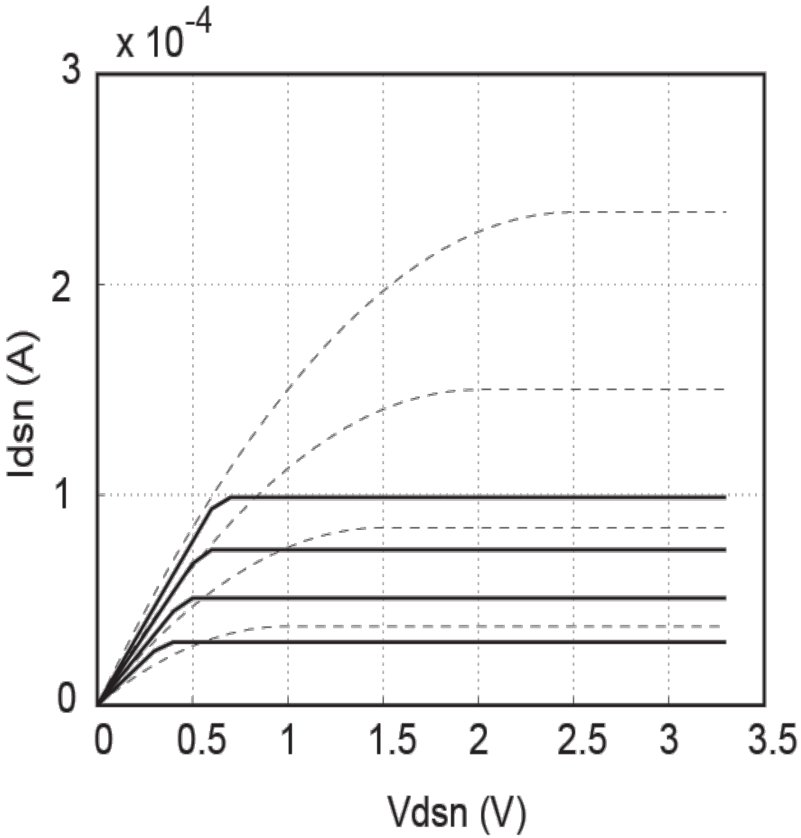
LINEÆR

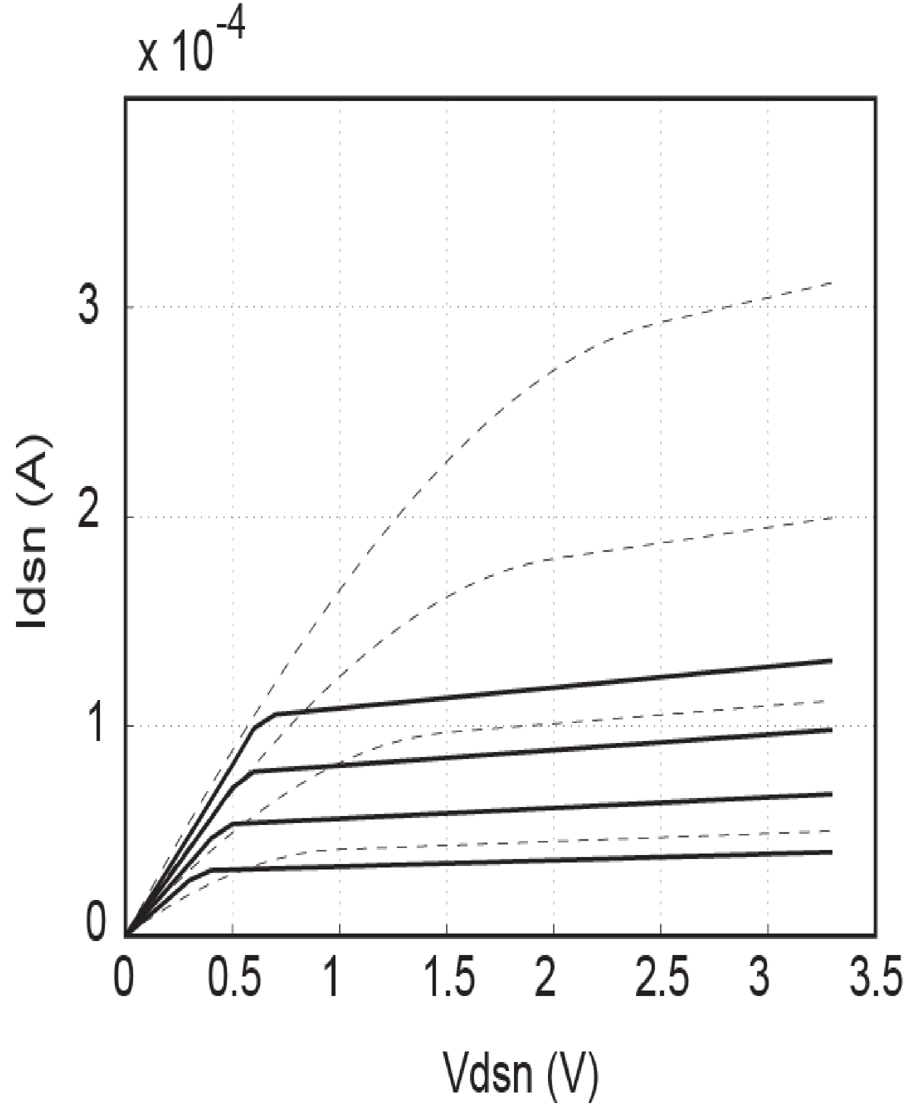
$$I_{ds} = P_c \frac{\beta}{2} \left(V_{gs} - V_t\right)^{\alpha} \left(1 + \lambda V_{ds}\right)$$

METNING

Metningsspenning

$$V_{dsat} = P_v \left(V_{gs} - V_t\right)^{\frac{\alpha}{2}}$$


x 10^-4
3
2
1
0
Idsn (A)
0
0.5
1
1.5
2
2.5
3
3.5
Vdsn (V)


x 10^-4
3
2
1
0
Idsn (A)
0
0.5
1
1.5
2
2.5
3
3.5
Vdsn (V)