EC630 - Modern Electronics Circuits
Noise Modeling

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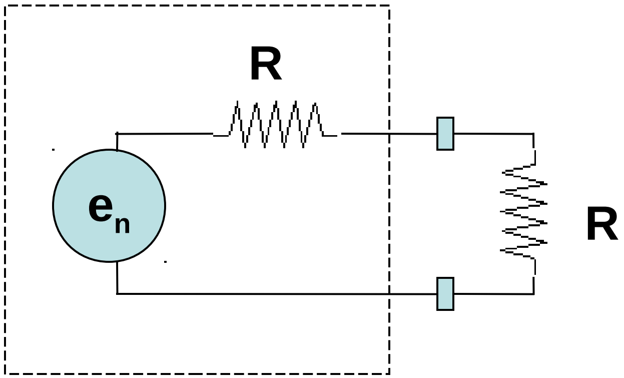
Outline

- **Thermal Noise Types in Resistors**
- **Thermal Noise Types in MOSFETs**

Thermal Noise of a Resistor "R"



- **Available noise power, P_{NA}:**

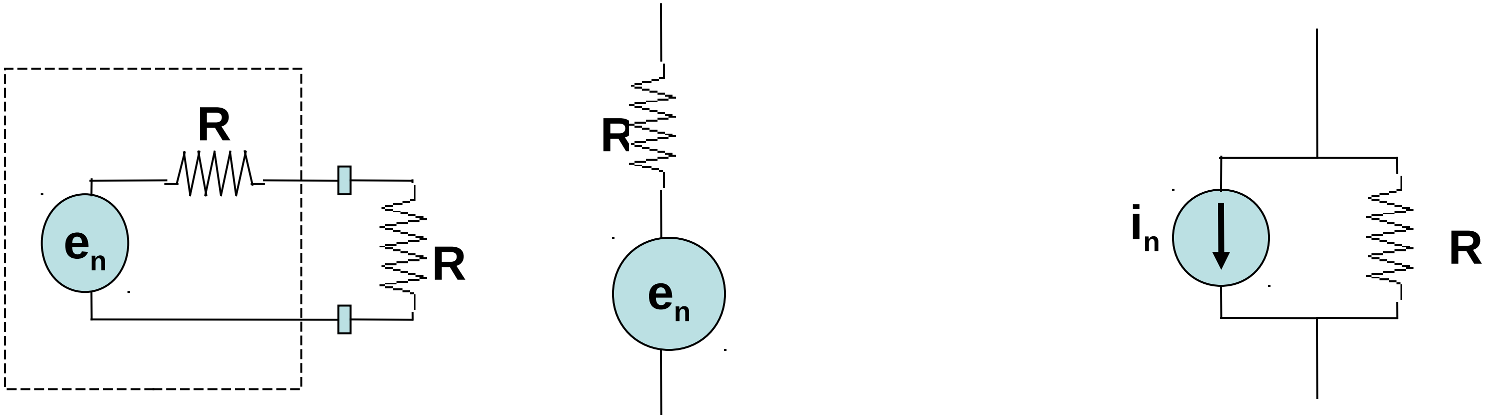
$$P_{NA} = kT\,\Delta f$$

P_{NA} = Max. power generated by noise source which can be delivered to load, i.e. to a load of same value "R"

Δf = Equivalent sharp filter cutoff frequency (usually higher than regular 3dB point, become close at higher order filters)

T = Absolute Temp., k = Boltzmann's Constant

Thermal Noise of a Resistor “R”



- **Max. power is delivered when load = R:**

$$P_{NA} = kT\,\Delta f = = e_n^2 / 4R$$

$$e_n^2 = 4kT\,R\,\Delta f$$

$$i_n^2 = e_n^2 / R^2 = 4kT\,\Delta f / R$$

Sources of Thermal Noise

- **Random motion due to thermal energy translates to potential fluctuations**

MOSFET Noise: Drain Current Noise

- **MOSFET channel, specially in triode region, is a voltage controlled resistance**
- **Drain current noise current, i_{nd}:**

$$i^2_{nd} = 4kT \gamma g_{do} \Delta f$$

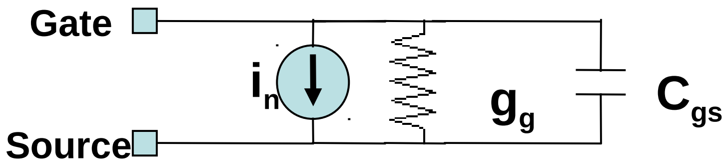
g_{do} = drain-source conductane as V_{ds} tends to zero

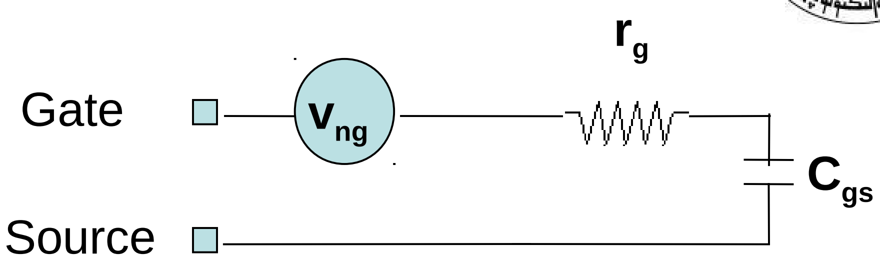
γ = a parameter that starts at 1 at V_{ds}=0, then tends to 2/3 in saturation, for long channel devices

- **Typically only for NMOS within normal operation range**

MOSFET Noise: Gate Noise

Van Der Ziel Model





- **Thermal agitation of electrons in channel cause potential fluctation, which in turns couples capacitively to gate**
- **Gate noise current, i_{ng}:**

$$i^2_{ng} = 4kT\,\delta\,g_g\,\Delta f$$

$g_g = \omega^2 C^2_{gs} / 5g_{do}$ **= equivalent shunt gate-to-source conductance**

δ **= a parameter that tends to 4/3 for long channel devices**

$$r_g = 1/[g_g\,(Q^2+1)] \sim 1/\,(g_g\,Q^2) = 1/\,5g_{do}$$

$$v^2_{ng} = 4kT\,\delta\,r_g\,\Delta f$$