EE539: Analog Integrated Circuit Design;

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1 Jan. 2006

1 NOISE IN PASSIVE LINEAR CIRCUITS:

1.1 RC CIRCUIT:

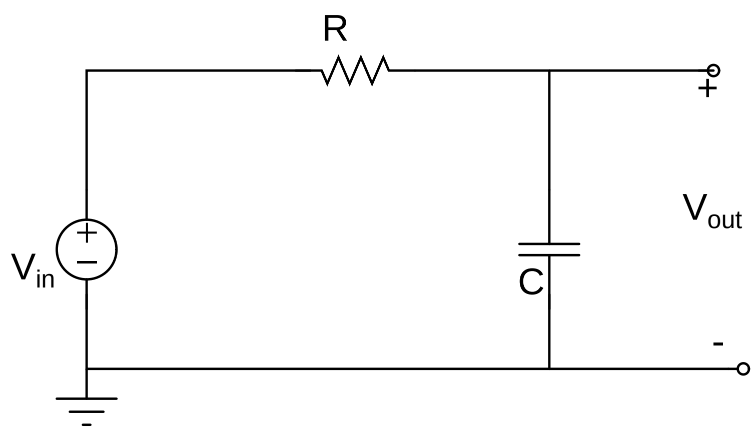

Figure 1: RC circuit

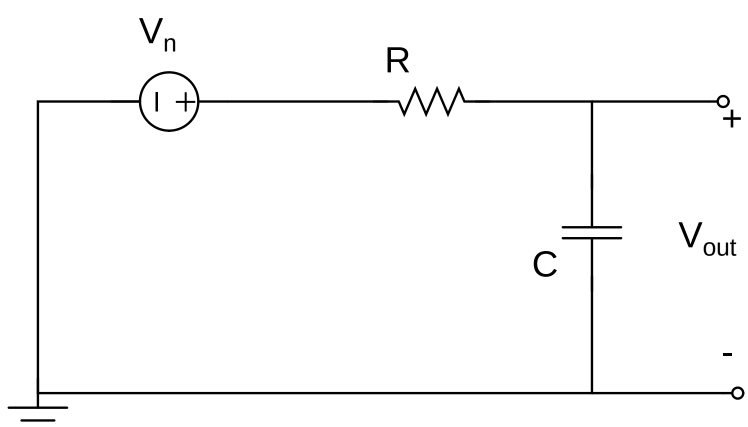

Figure 2: Noise equivalent circuit

For any LTI system,

$V_O(s) = V_i(s)H(s)$

$V_O(f) = V_i(f)H(f)$

$S_{VO}(f) = S_{Vi}(f)|H(f)|^2$

$\Rightarrow S_{VO}(f) = 4KTR(\frac{1}{1+4\pi^2 f^2 R^2 C^2})$

here, $f_c = \frac{1}{2\pi RC}$

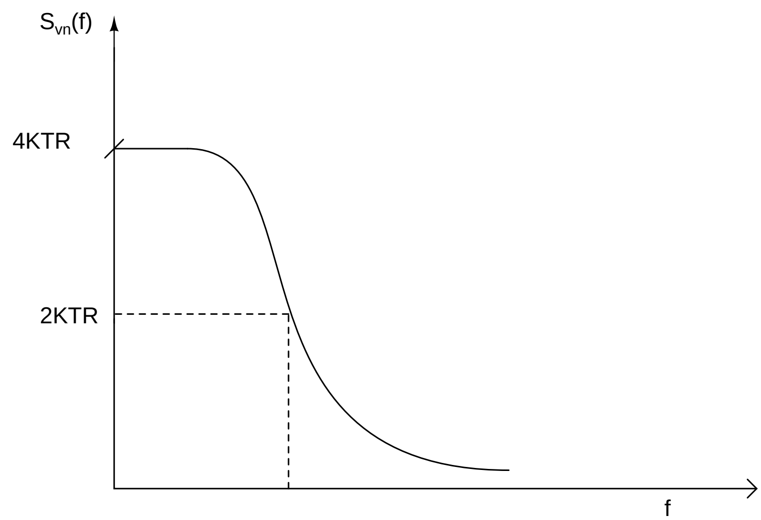

Figure 3: Spectral density Vs frequency

If we put rms voltmeter at output,

$V_n^2 = \int_0^\infty \frac{4KTR}{1+4\pi^2 f^2 R^2 C^2} df$

$V_n = \sqrt{\frac{KT}{C}}$

INTERESTINGLY RESULT IS INDEPENDENT OF RESISTANCE R ???

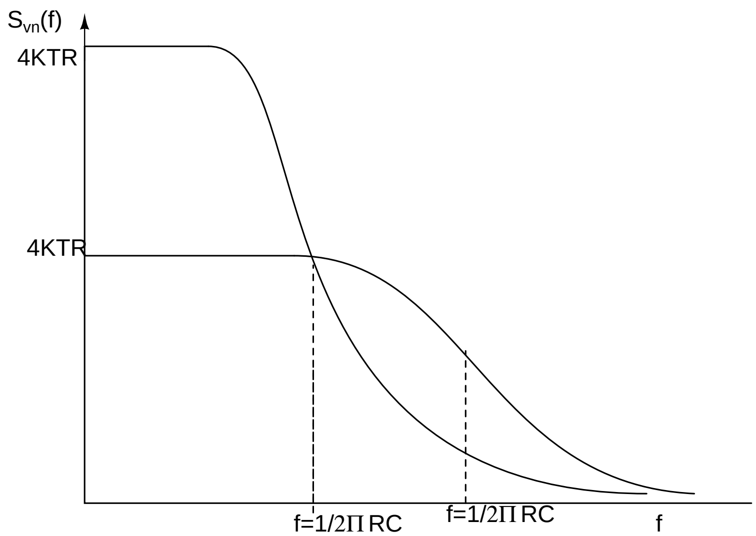

Figure 4: spectral density VS frequency

1.2 RL CIRCUIT:

Here rms noise output voltage is

$$I_n = \sqrt{\frac{KT}{L}}$$

Here also RESULT IS INDEPENDENT OF RESISTANCE R ???

2 NOISE IN MOS TRANSISTORS:

2.1 THERMAL NOISE IN MOS:

Main motivation for MOS is MODULATION OF RESISTANCE.

TRIODE REGION:
Spectral density,

$$S_{in}(f) = \frac{4KT}{R_{ds}|_{V_{ds}=0}}$$

$$\Rightarrow S_{in}(f) = 4KT\mu C_{ox}\frac{W}{L}(V_{gs} - V_T)$$

SATURATION REGION:
In this region,

$$I_d = f(V_{gs}, V_{ds}) + i_{d,noise}$$

$$\Rightarrow S_{in}(f) = \gamma\frac{8}{3}KTg_m$$

$$S_{in}(f) = \gamma \frac{8}{3} KT \mu C_{ox} \frac{W}{L} (V_{gs} - V_T)$$

2.2 FLICKER NOISE IN MOS:

Due to impurities @ interface $\Rightarrow$ Flicker noise

Spectral desity$\alpha \frac{1}{f}$ $\Rightarrow$ Flicker noise is also called $\frac{1}{f}$noise.

$$S_{\frac{1}{f}}(f) = K_{\frac{1}{f}} \frac{I_d}{L^2} \frac{1}{f}$$

Spectral desity

$$S_{\frac{1}{f}}(f) \alpha I_d$$

$\Rightarrow$ at $V_{ds} = 0$ there is no flicker noise.

At LOW FREQUENCIES (up to 100MHz) flicker noise dominates.