SerDes analog circuits description

Fávero Santos
favero.santos@gmail.com

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1 Introduction

Employed notation:

i A DC only voltage/current is represented by an italic uppercase letter(s) followed by italic uppercase subscript letter(s).

A DC voltage drop across the *GATE* and *SOURCE* of a transistor is represented by V_{GS}.

ii An AC only voltage/current is represented by an italic lowercase letter(s) followed by italic lowercase subscript letter(s).

An AC voltage drop across the *GATE* and *SOURCE* of a transistor is represented by v_{gs}.

iii A combined DC and AC voltage/current is represented by an italic uppercase letter(s) followed by italic lowercase subscript letter(s).

A combined DC and AC voltage drop across the *GATE* and *SOURCE* of a transistor is represented by V_{gs}.

An example of such notation is presented in Figure 1.

Analysis of an RC channel

1.1 Transfer function

Consider the circuit

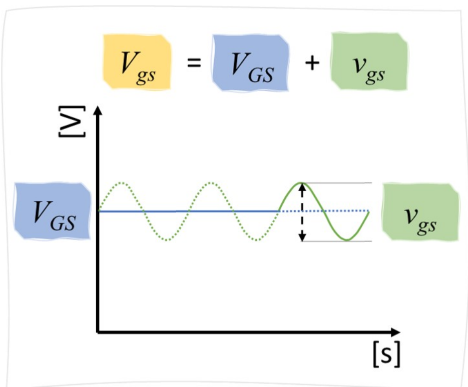

Figure 1: Examples of the employed notation in this work.

Netlist in terms of time of an RC circuit
R1 vin(t) vout(t) R
C1 vout(t) gnd!(t) C

in which the a current i(t) is sourced in the vin(t) node and drained at gnd!
Applying the Laplace transform, the circuit becomes

Netlist in terms of frequency of an RC circuit
R1 vin(s) vout(s) R
C1 vout(s) gnd!(t) 1/sC

At node vout(s):

$$v_{out}(s) = i(s) \cdot 1/(s \cdot C)$$

$$v_{in}(s) - v_{out}(s) = i(s) \cdot R$$

$$v_{in}(s) - i(s) \cdot 1/(s \cdot C) = i(s) \cdot R$$

$$v_{in}(s) = i(s) \cdot (R + 1/(s \cdot C))$$

Thus

$$\frac{v_{out}(s)}{v_{in}(s)} = H(s) = \frac{i(s) \cdot 1/(s \cdot C)}{i(s) \cdot (R + 1/(s \cdot C))}$$

Transfer function for an RC circuit

$$H(s) = \frac{\omega_a}{s + \omega_a}$$

Where $\tau = R \cdot C$ and $\omega_a = 1/\tau$.

1.2 Impulse response

Applying the inverse Laplace transform in the transfer function, it is obtained:

Impulse response for an RC circuit

$$h(t) = \omega_a \cdot \exp(-t * \omega_a)$$

for t > 0.

1.3 Magnitude of the transfer function

$$|H(s)| = |\frac{\omega_a}{s + \omega_a}|$$

Magnitude of H(s)

$$|H(s)| = \frac{\omega_a}{\sqrt{w^2 + \omega_a^2}}$$

1.4 Phase of the transfer function

$$\theta(s) = \arctan\left(\frac{\Im H(s)}{\Re H(s)}\right)$$

$$H(s) = \frac{\omega_a}{i\cdot\omega+\omega_a} = \frac{\omega_a\cdot(-i\cdot\omega+\omega_a)}{(i\cdot\omega+\omega_a)\cdot(-i\cdot\omega+\omega_a)}$$

$$H(s) = \frac{\omega_a^2 - i\cdot\omega\cdot\omega_a}{\omega^2+\omega_a^2}$$

$$\Re H(s) = \frac{\omega_a^2}{\omega^2+\omega_a^2}$$

$$\Im H(s) = \frac{-\omega\cdot\omega_a}{\omega^2+\omega_a^2}$$

Phase of H(s)

$$\theta(s) = \arctan\left(-\omega/\omega_a\right)$$

1.5 Quantization of the model

Considering that $\omega_a = \omega_d/FS$, where FS is the sampling frequency, the quantized model is:

Transfer function for an RC circuit

$$H[m] = \frac{\omega_d/FS}{s+\omega_d/FS}$$

Where m is a discrete frequency vector.

Impulse response for an RC circuit

$$h[n] = (\omega_d/FS)\cdot\exp(-t*\omega_d/FS)$$

Where n is a discrete time vector.

Magnitude of H(s)

$$|H[m]| = \frac{\omega_d/FS}{\sqrt{w^2+\omega_d/FS^2}}$$

Phase of H(s)

$$\theta(s) = \arctan\left(-\omega/\omega_d/FS\right)$$

2 Example code

An example code for such study can be found at: https://github.com/faverosantos/SerDes

References