
Lecture23:




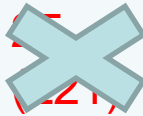

Small-signal simulation

Sung-Min Hong (smhong@gist.ac.kr)

Semiconductor Device Simulation Lab.
School of Electrical Engineering and Computer Science
Gwangju Institute of Science and Technology

Calendar

- Plan for remaining lectures
 - IEDM business trip

Mon	Tue	Wed	Thu	Fri	Sat	Sun
			17	18	19	20
	22		24		26	27
28 (No lecture)	29		Dec.1	2 (L23)	3	4
5 (No lecture)	6	7 (No lecture)	8	9	10	11
12 (L24)	13	14 (L25)	15	16 (Final)	17	18

Small-signal simulation

- Continuity equation

$$\frac{\partial}{\partial t} n + \nabla_r \cdot \mathbf{F}_n = 0$$

- In the last lecture, we considered the transient simulation.
 - Using the simplest backward Euler,

$$\left. \frac{\partial n}{\partial t} \right|_t \approx \frac{n(t) - n(t - \Delta t)}{\Delta t}$$

- Today, we consider the small-signal simulation.

Basic assumption

- It is assumed that quantities are decomposed into two terms.
 - DC and time-varying
 - The time-varying term is small. (Limitation of this analysis)
 - For example,

$$n(t) = n_{DC} + \delta n(t)$$

- What happens?
 - In the case of the continuity equation,
$$\frac{\partial}{\partial t} \delta n(t) + \nabla_r \cdot \mathbf{F}_n(\mathbf{E}_{DC} + \delta \mathbf{E}(t), n_{DC} + \delta n(t)) = 0$$
 - Up to now, no approximation has been introduced.

Linearization

- Now, using the small magnitude of the time-varying terms, the linearization is performed.

- The electron flux is given by

$$\mathbf{F}_n = -\mu_n n \mathbf{E} - D_n \nabla n$$

- Using the linearization,

$$\mathbf{F}_n \approx -\mu_n n_{DC} \mathbf{E}_{DC} - \mu_n \delta n(t) \mathbf{E}_{DC} - \mu_n n_{DC} \delta \mathbf{E}(t) - D_n \nabla n_{DC} - D_n \nabla \delta n(t)$$

- It can be decomposed into two terms.

$$\begin{aligned}\mathbf{F}_{n,DC} &= -\mu_n n_{DC} \mathbf{E}_{DC} - D_n \nabla n_{DC} \\ \delta \mathbf{F}_n(t) &= -\mu_n \delta n(t) \mathbf{E}_{DC} - \mu_n n_{DC} \delta \mathbf{E}(t) - D_n \nabla \delta n(t)\end{aligned}$$