Assignment 4- Labs in VLSI

Design and Analysis of an Analog Computer

A radioactive sample contains parent and daughter nuclei. At some time t = 0, the population of the parent is estimated to be 10 times $10^6$ atoms and the daughter 1/5 as many. The parent’s half-life is 0.693 sec. and the daughter’s half-life twice as long. How does the daughter population vary with time?

The job calls for the computer in Fig except for the initial conditions [AC1]. But what are the initial conditions?

Hints: An initial population of 10 times $10^6$ atoms can be simulated by an initial voltage of 10 volts on the I integrator. What then, is the initial condition on the X integrator? Calculate the values of $\alpha$ and $\beta$ (beta) and set the potentiometers accordingly.

What is the analytical solution? Make some quick checks on the accuracy of the computer. Now proceed to plot curves for various values of $\alpha$ and $\beta$. Can you interpret them physically?

Damped Free Oscillations
The one dimensional oscillatory motion obeying the second order differential equation is given as:

$$\frac{d^2x}{dt^2} + \gamma \frac{dx}{dt} + \omega_0^2 x = 0$$

with $\gamma$ providing a damping term and $\omega_0$ being the natural frequency.

The nature of the solution of this equation depends on the extent of damping, or whether $(\frac{\gamma}{2} - \omega_0)$ is greater than, less than or equal to zero (over damping, under damping or critical damping.)

This equation may be computer modelled using two integrators (one of these a summing integrator) and an inverter (gain of -1 amplifier), plus two attenuators.
It is left as an exercise to model this as a computer model that should include potentiometers to set $\gamma$ and $\omega_0^2$ and should include a way of setting the initial values of $x$ and $dx/dt$.

(Hint: The model is most easily set-up making one integrator the $x$ integrator, and the other the (-dx/dt) integrator.)

Set-up the circuit and obtain solutions to the equation for various values of $\gamma$ and $\omega_0$ and for various values of the initial conditions. Explore values of $\gamma$ which produce over-, under-, and critical damped conditions.

Submission date: Presentation + Report on November 14th