EE 554 – Miniproject II

Introduction

Many feedback systems have components that load each other. The two RC circuits shown in Figure 1 are connected in cascade, so that the output from the first circuit is the input to the second.

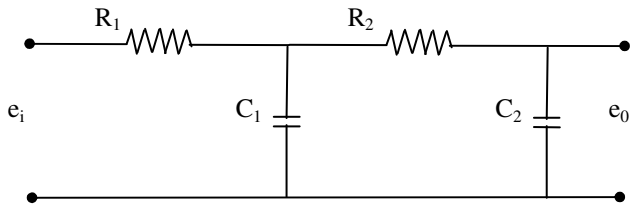

Figure 1. Electrical System

Where e_i is the input voltage, and e_0 is the output voltage, or the voltage at the capacitor C_2. The capacitances C1 and C2 are not charged initially. The second stage of the circuit (R_2C_2 portion) produces a loading effect on the first stage portion (R_1C_1 portion). The transfer function between $E_0(s)$ and $E_i(s)$ is given by:

$$\frac{E_0(s)}{E_i(s)} = \frac{1}{(R_1C_1s+1)(R_2C_2s+1)+R_1C_2s}$$

$$= \frac{1}{R_1C_1R_2C_2s^2+(R_1C_1+R_2C_2+R_1C_2)s+1}$$

The term R_1C_2s in the denominator of the transfer function represents the interaction of two simple RC circuits. Since $(R_1C_1+ R_2C_2+ R_1C_2)^2 > 4\ R_1C_1R_2C_2$, the two roots of the denominator are real.

Description of the project

Your team is required to investigate the closed-loop implementation of the system described above, on an Altera FPGA board. Use the values $R_1 = R_2 = 10\ k\Omega$ and $C_1 = C_2 = 33\ \mu F$. A unity gain yields an overdamped system response. However, a proportional controller may be used to speed up the response of the system (by increasing the gain), at the expense of some overshoot.

A complete system is to be simulated on the FPGA. Using NIOSII and Quartus II, you need to design a system that will have one digital input and one digital output, as shown in Figure 2. The input will be connected to the reference input, i.e. a square wave signal. The output will be connected to a PWM subsystem and a driver. This arrangement will

allow you to connect the output to a scope, and be able to show the response of the system in real-time.

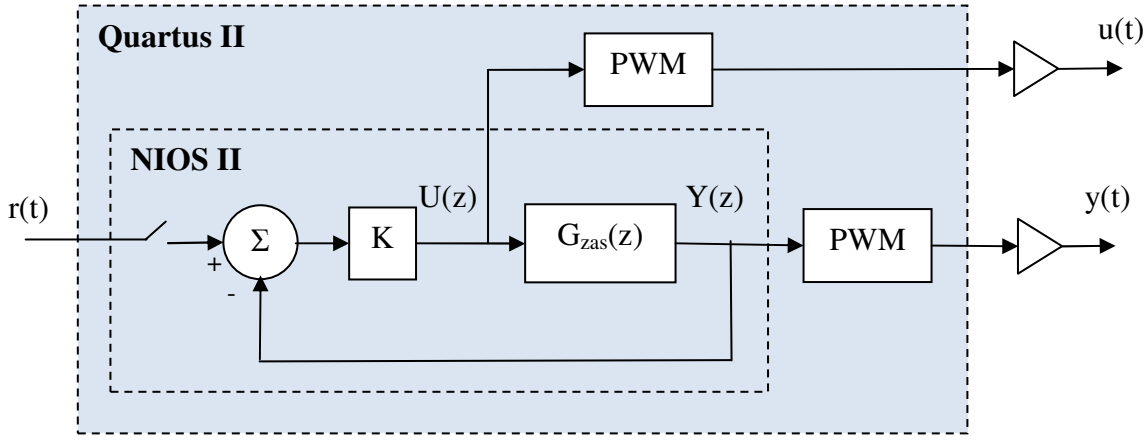

Figure 2. The closed-loop dynamic system

Requirements

Your team needs to demonstrate a working system for a square wave signal. The system should be able to track the input by using different gain values for the proportional controller and sampling frequencies, as per your design.

Documentation

You need to deliver a report that includes:

- A description of the process you followed to derive the digital system, i.e. difference equation.
- MATLAB code and plots of system simulation for the different parameters, i.e. gains and sampling intervals.
- Listing of the C code used to implement the digital system on the FPGA.
- Plots of the outputs of the system for the different parameters, as seen on the scope (if you can save the output to a file).

This project will be graded as follows:

- **50% report.**
- **50% demonstration.**