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Department of Electrical, Electronic and Computer Engineering

Control Systems EBB 320

Practical 1

Realization of a Transfer Function

13 August 2013

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FORM A

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Subject of the work Practical 3 – Realization of a Transfer Function

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Introduction and Aim

In control systems one seeks to control a plant to reach a desired output. The plant needs to be modeled mathematically so that it can be analyzed using control theory. The aim of this practical is to relate a mathematical model to a real world electronic circuit. Further we aim to prove how any transfer function can be estimated by and approximate electronic circuit using operational amplifiers, resistors, and capacitors. It is shown how non-linearity can be approximated using Padé approximation. Circuits to achieve negative resistor values are also explored

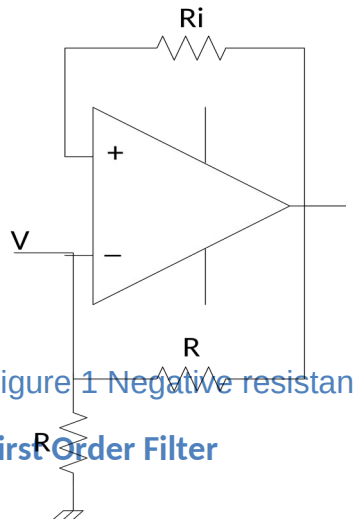
Design and Implementation

Padé Approximation

1.

2.

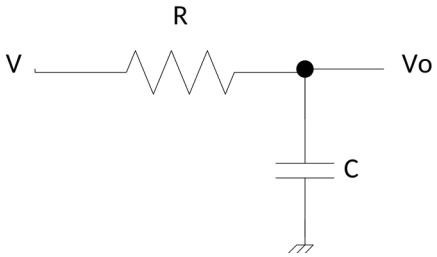
Negative resistance



3.

Figure 1 Negative resistance circuit

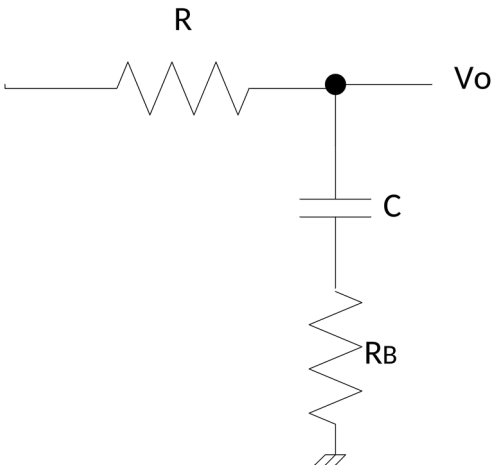
First Order Filter



4.

Figure 2 first order filter

Actual Realization of Time Delay Using Padé Approximation



Substitute

5.

Figure 3 Padé approximation circuit

Relation Equations for G(s)

2.

6.

Substitute and in equation 2.

7.

8.

9.

Choose Substitute in 9.

Choose Substitute in 7.

Substitute , Choose for 8.

Circuit Diagram

Below is the full circuit design including op amp buffers to reduce loading between the different stages.

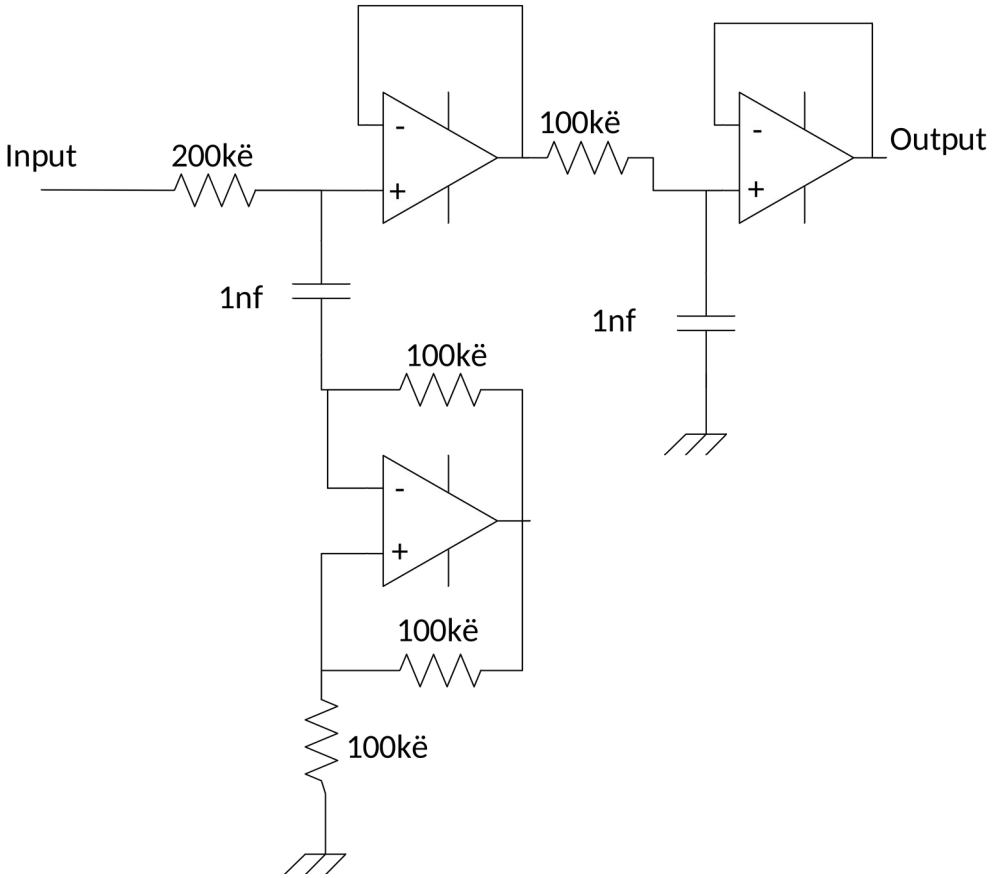


Figure 4 Full Design

Simulation

PSPICE

The designed circuit was simulated using Cadence ORCAD a simulation suit for circuit design an PSPICE. The simulation result below show the expected response.

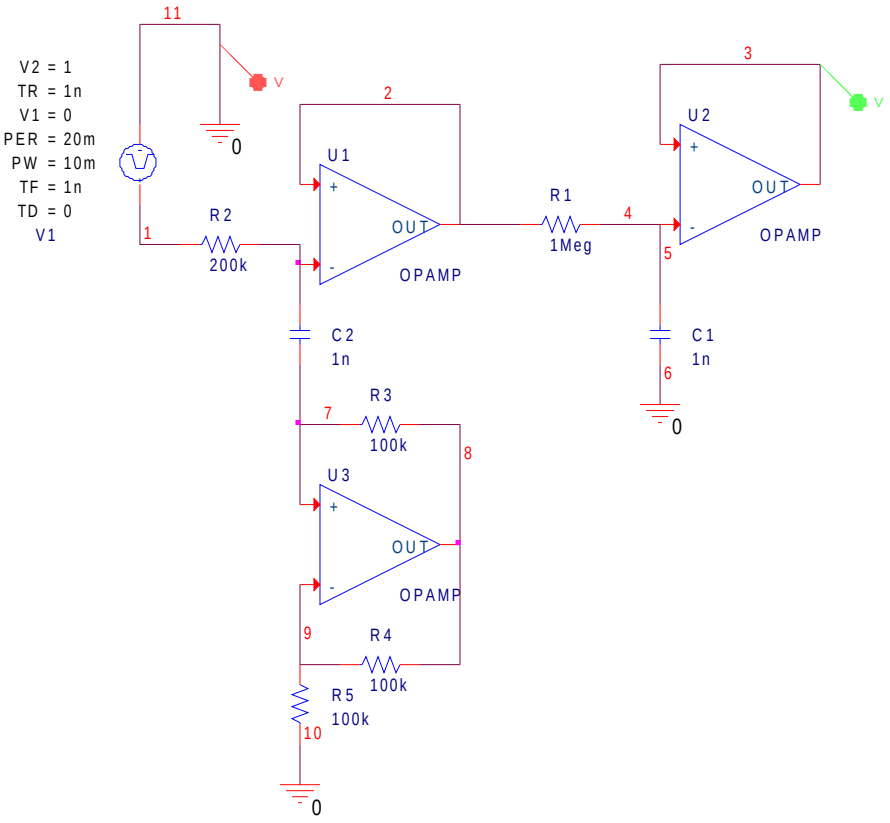


Figure 5 Circuit Design

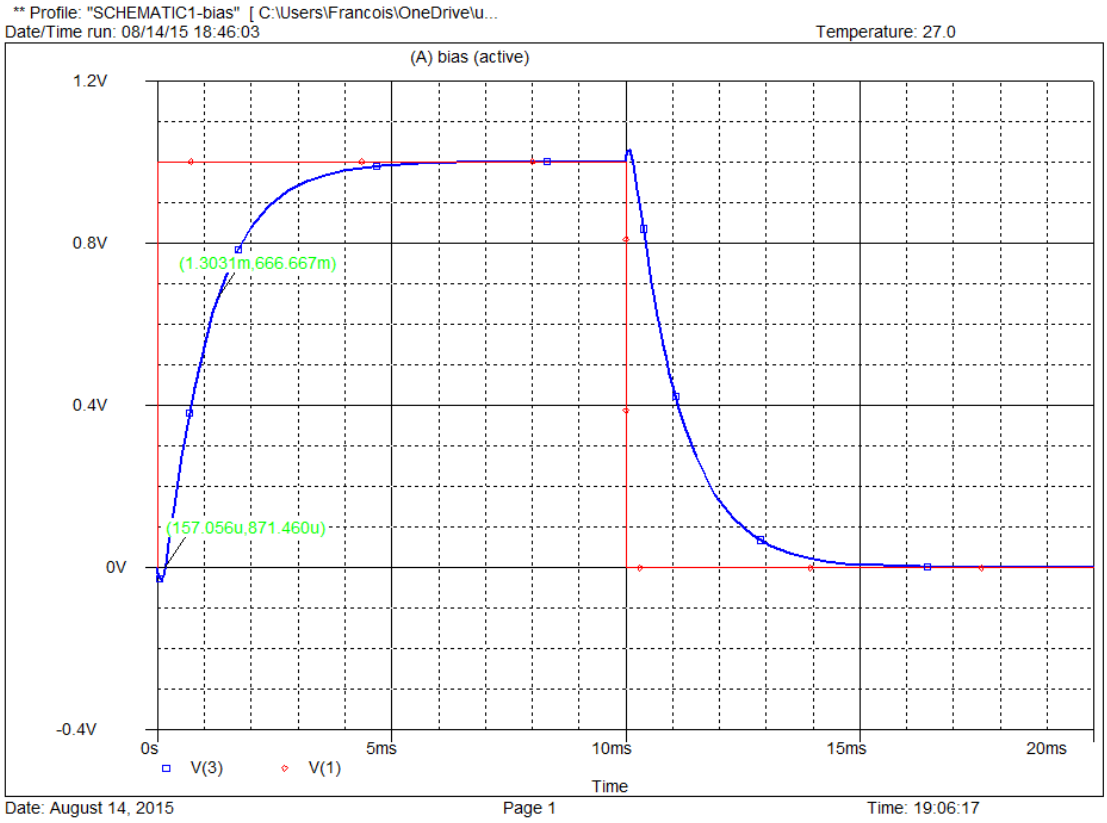


Figure 6 simulated results

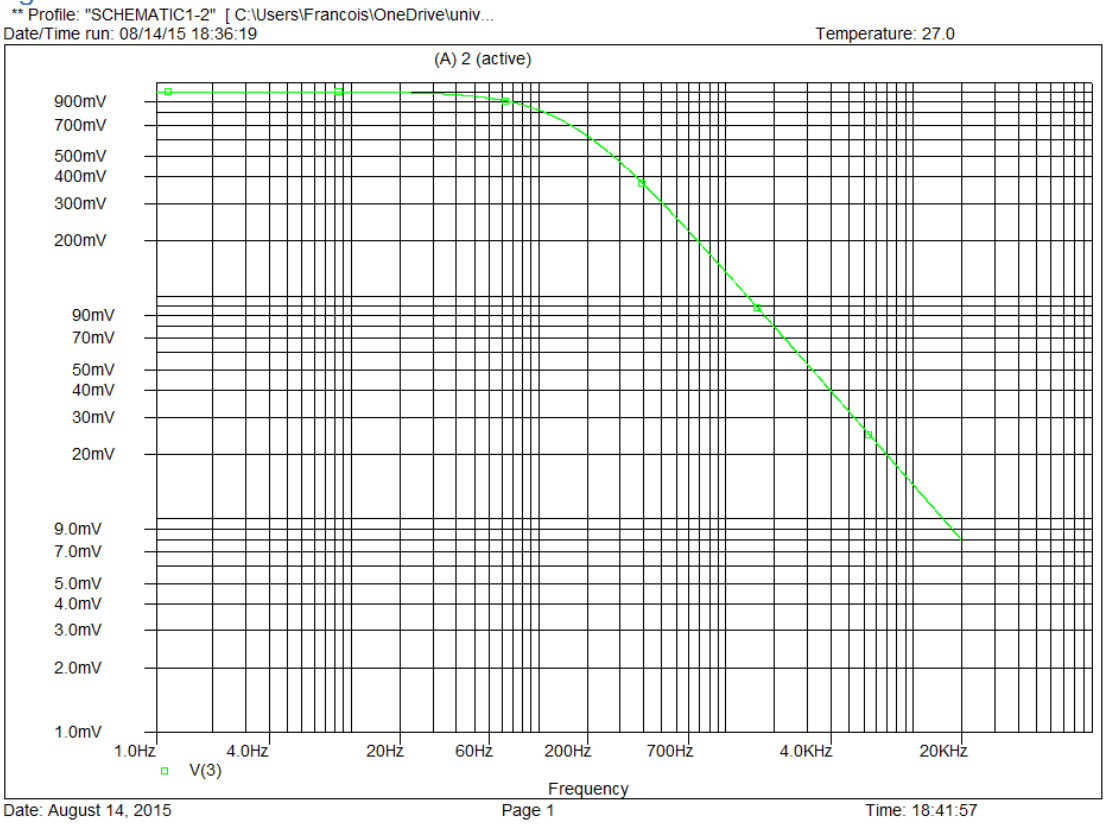


Figure 7 Bode Plot

Matlab

The functions where Entered into matlab using transfer function “tf(NUM , DEN)” in the control systems toolbox, and plotted using the step response function “Step(sys)”

The code and plots are shown Below

```
>>s = tf('s')
>> G = (exp(-0.0002*s))/(0.001*s+1)

G =

                    1
  exp(-0.0002*s) * -----------
                 0.001 s + 1

Continuous-time transfer function.

>> Gp = ((1-s*(0.0002/2))/(1+s*(0.0002/2)))/(0.001*s+1)

Gp =

      -0.0001 s + 1
  ------------------------
  1e-07 s^2 + 0.0011 s + 1

Continuous-time transfer function.

>> step(G,Gp)
>> step(G)
>> step(Gp)
```

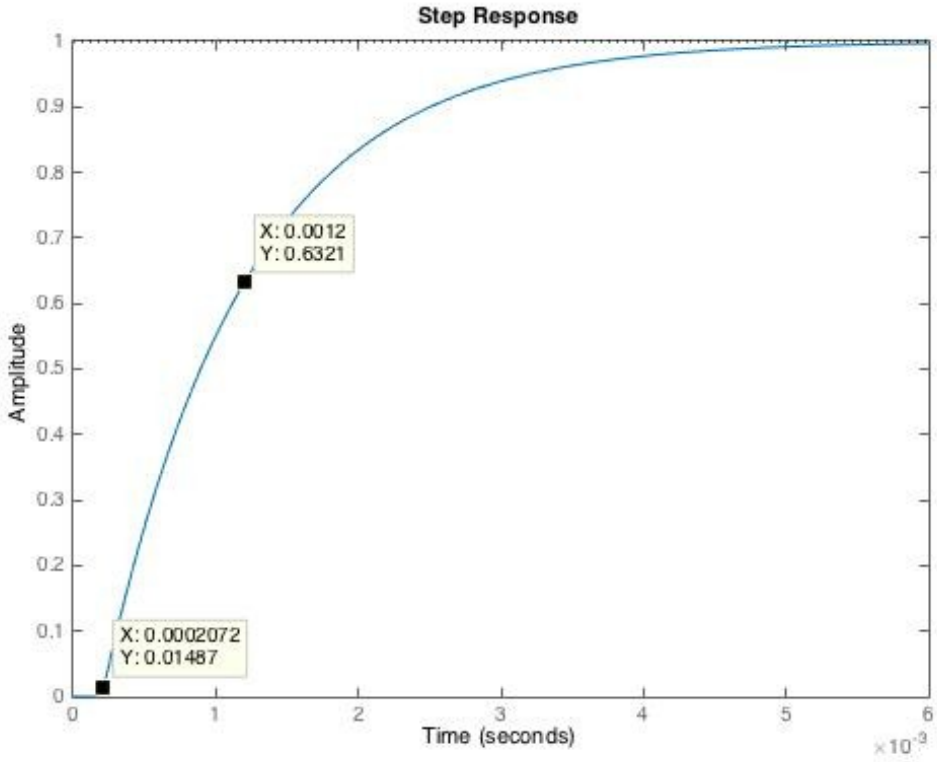


Figure 8 Step Response

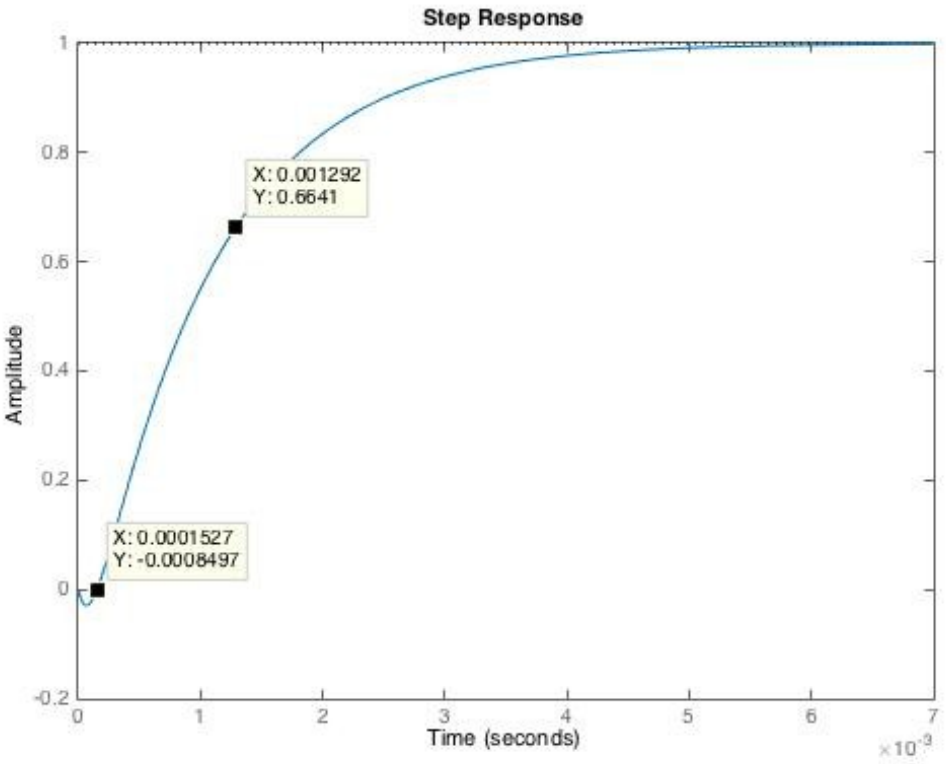


Figure 9 Step Response of Padé Approximation

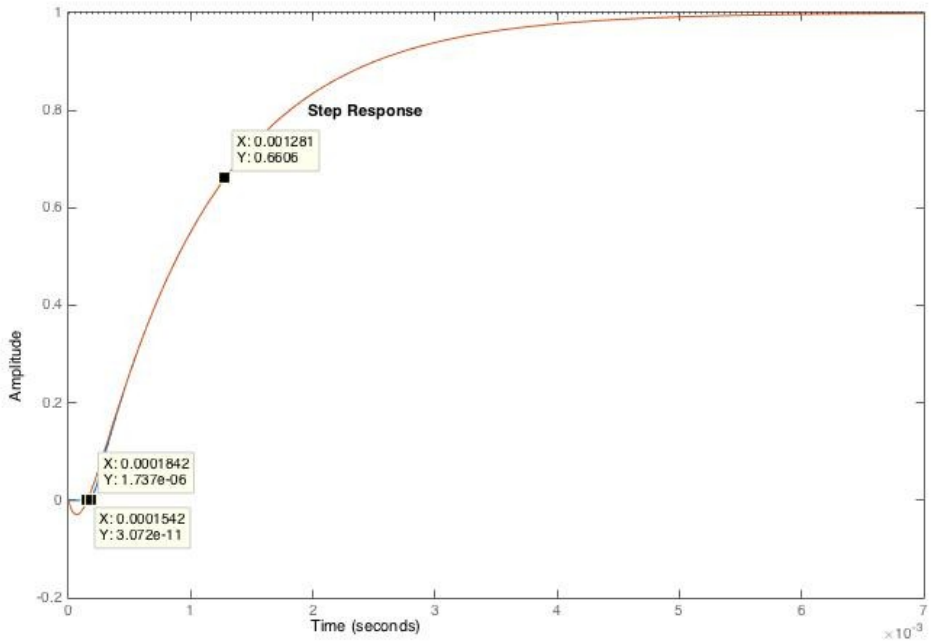


Figure 10 Comparison of system and Padé approximation

It is clear from this simulation that the first order Padé approximation is indeed a good approximation.

Experimental Results

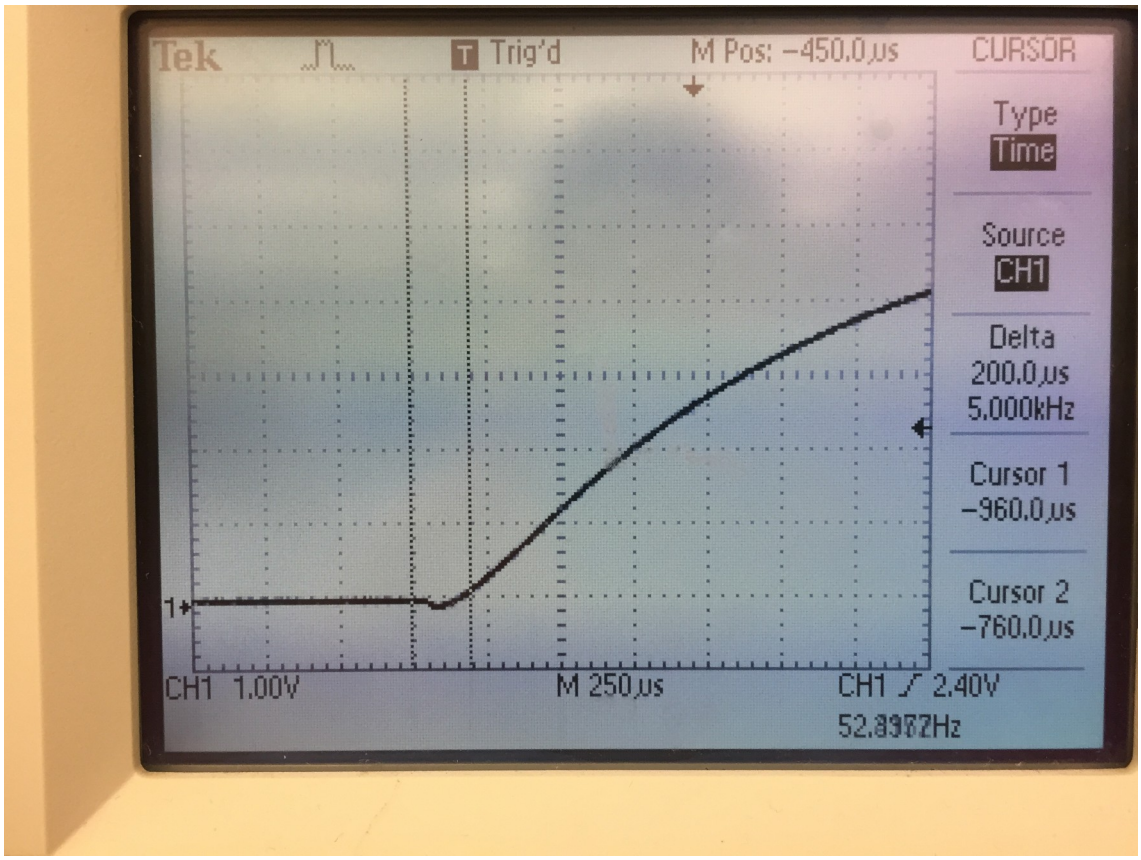


Figure 11 Delay in circuit a.

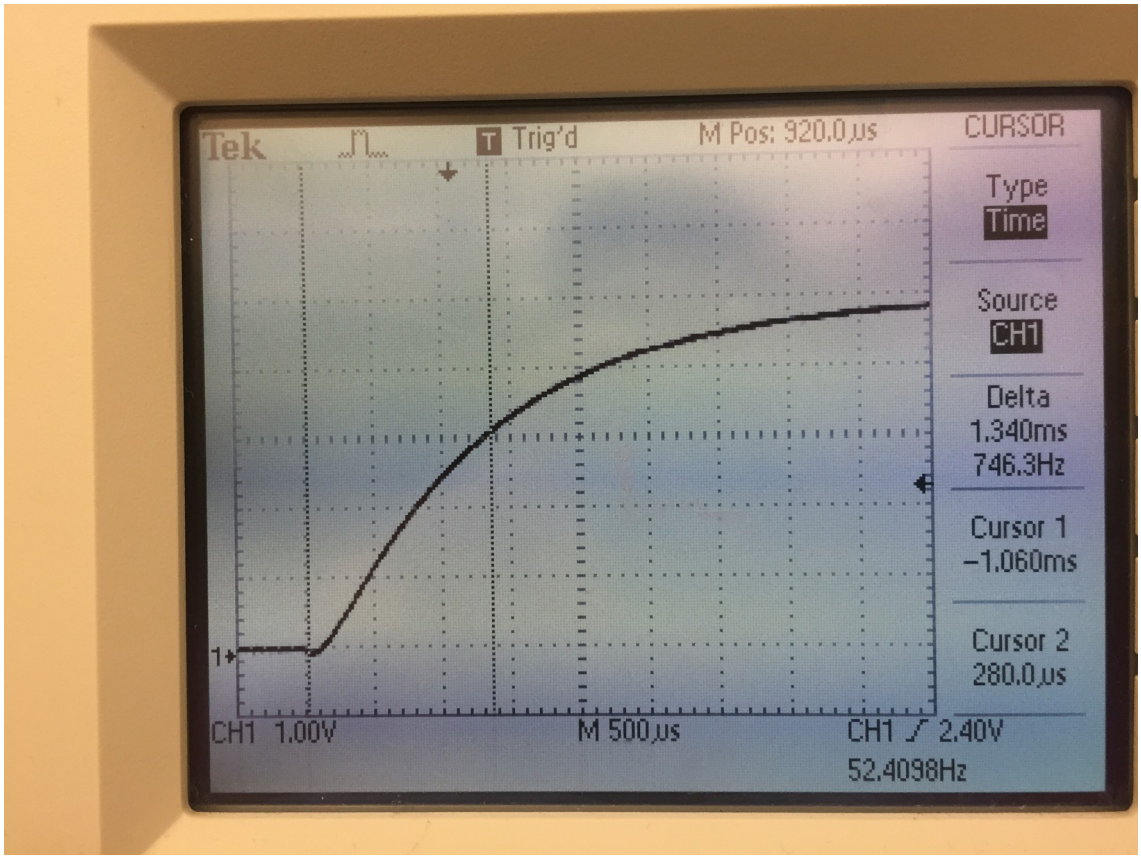


Figure 12 Time constant of circuit a.

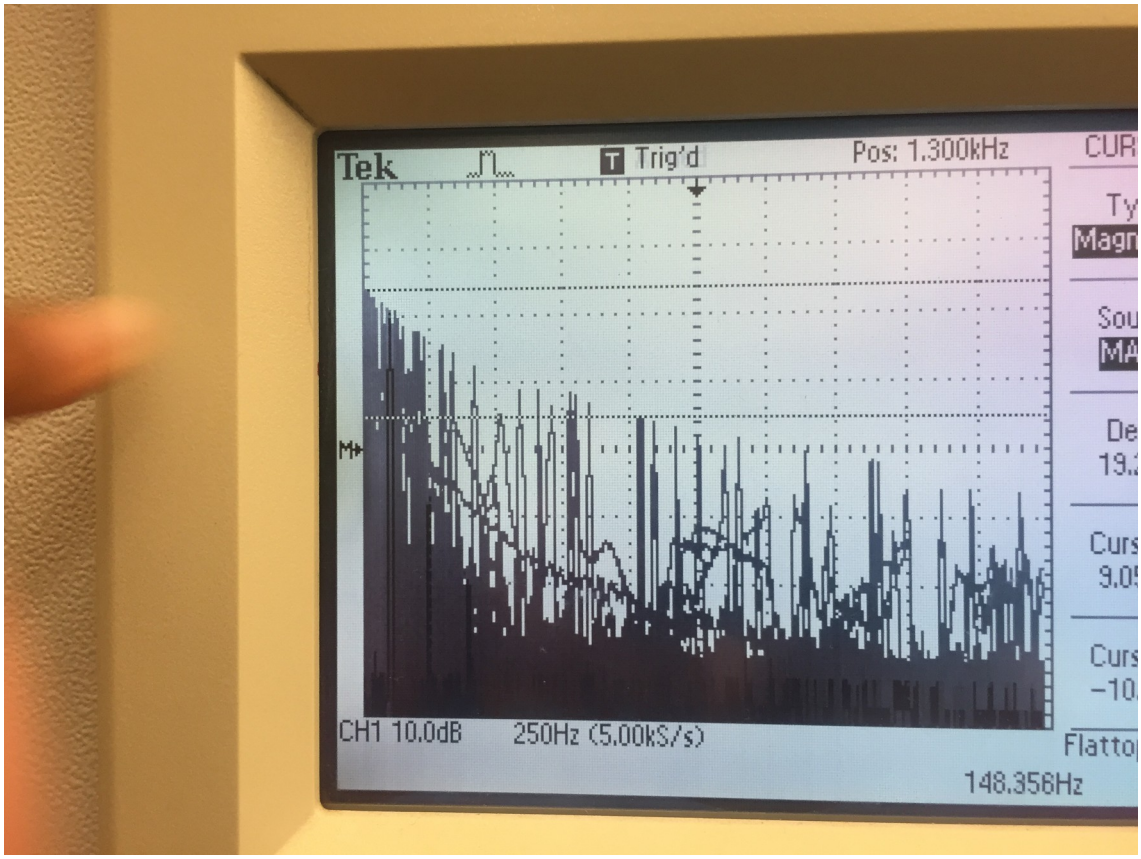


Figure 13 Frequency response of circuit a showing a 20db decrease of power at 1kHz

Table 1 Comparison of results

	Theoretical	Matlab	PSPICE	Practical
t_d	0.2ms	0.15ms	0.2ms	0.15ms
τ	1ms	1.292ms	1ms	1.22ms

Observations and Conclusions

It has been shown that a mathematical model can be successfully estimated using electronic circuits. It is worth nothing though that the are some differences from the original model due to the estimates made.

References

Camisani-Calzolari, F.R. and Swart, S. 2013. Practical 3 Guideline Control Systems: EBB 320. Pretoria: University of Pretoria

Norman S. Nise, Control Systems Engineering, 6th Ed., 2011, John Wiley & Sons.