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Title: Electronics Engineering virtual laboratory for COVID 19 pandemic

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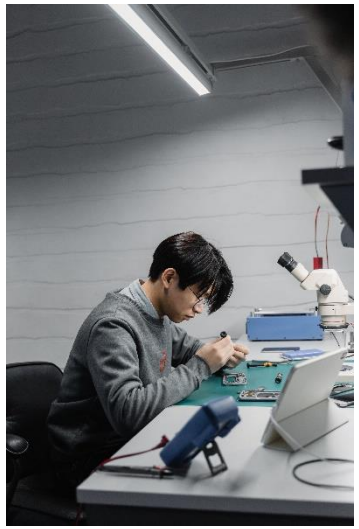
Introduction

- Due to the pandemic that we have experienced in recent months, different learning methods have been used, for example, virtual classes (Chang, 2020; Roatta & Tedini, 2021).
- Universities changed from traditional face-to-face learning to a virtual learning environment to continue working during the lockdown (Morales-Alarcón, 2021).
- Due to the quarantine, it has not been possible to carry out physical practices in laboratories. Therefore, several simulation programs and strategies can help carry out these practices (Gomes da Silva et al., 2021; Klein et al., 2021).
- Simulators allow an approximation of how a circuit would behave if built, considering physical factors, representing a helpful tool for the student to practice and experiment with electronic circuits virtually, quickly, and safely. In addition, a simulator represents an easy-to-use and learning tool since the user can create any circuit as desired.



Platforms used by the Universidad Autónoma de Baja California during pandemic

Blackboard

Blackboard collaborate

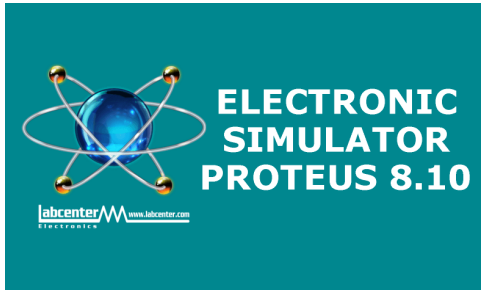
POR LA REALIZACIÓN PLENA DEL HOMBRE

UNIVERSIDAD AUTÓNOMA DE BAJA CALIFORNIA

Google Classroom

Proteus

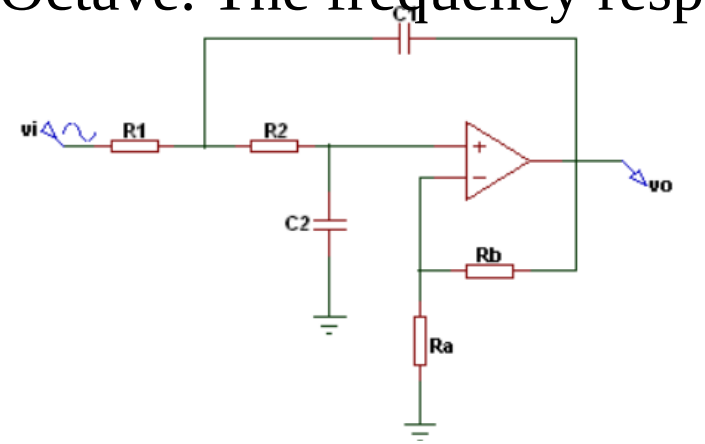
- Proteus, also known as Proteus Design Suite, is an electronic design automation software developed by Labcenter Electronics Ltd (Labcenter, 2021).
- This software is helpful to design, simulate and draw electronic circuits and is one of the most widely used engineering programs, especially electronics (Mandal, 2017).
- It allows instructors to perform virtual laboratories.
- It offers students a dynamic and fun learning tool.
- Virtual prototypes can be helpful to test the system before transferring it to the physical printed circuit board.
- Circuit design takes less time than practical construction of the circuit.

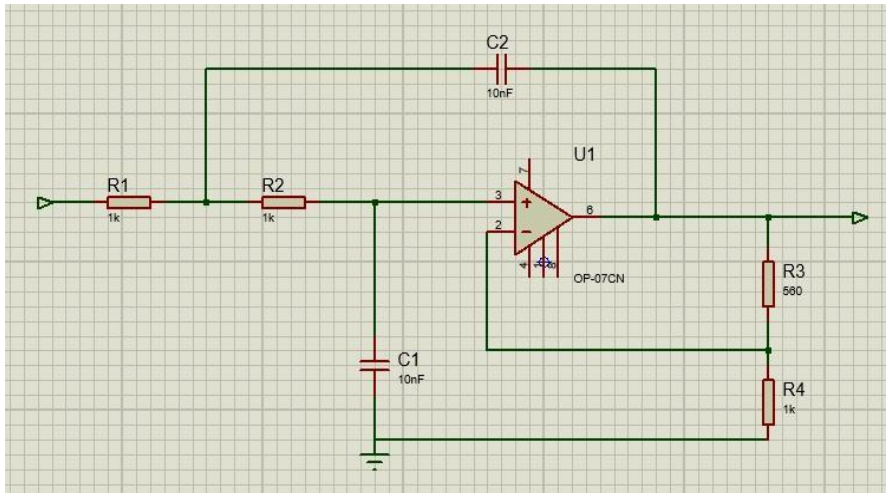


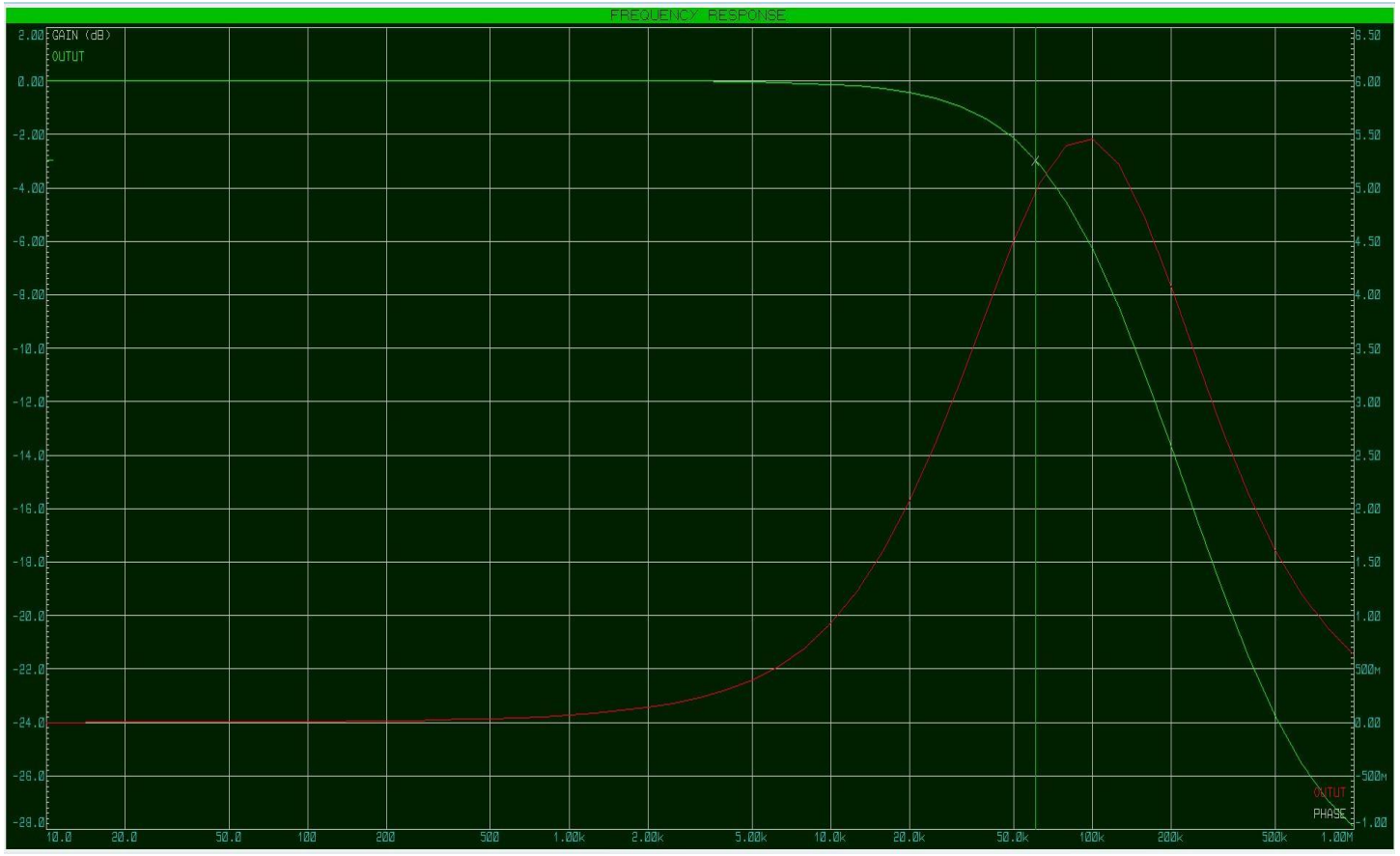
Low-pass filter design and implementation

Subject: Circuits.

A common way to obtain the Bode Diagram is using the simulators from Matlab and Octave. The frequency response in the Bode Diagram is also available in Proteus.



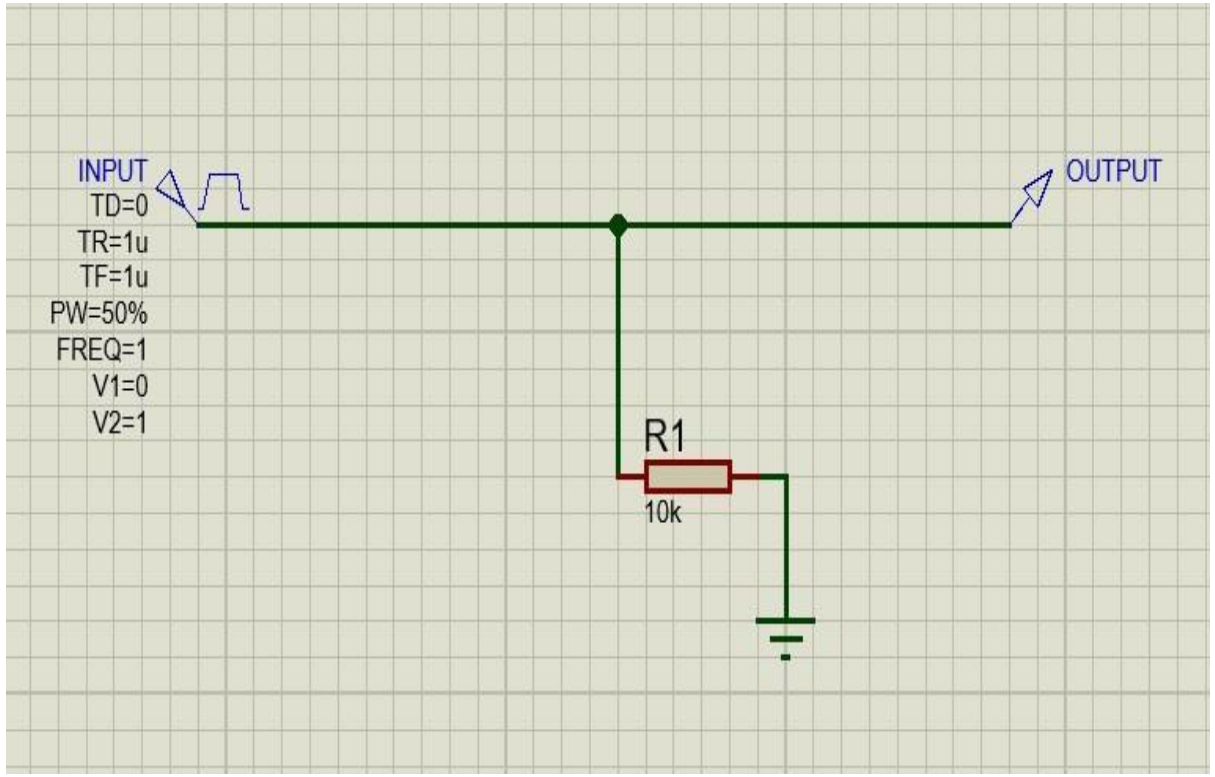


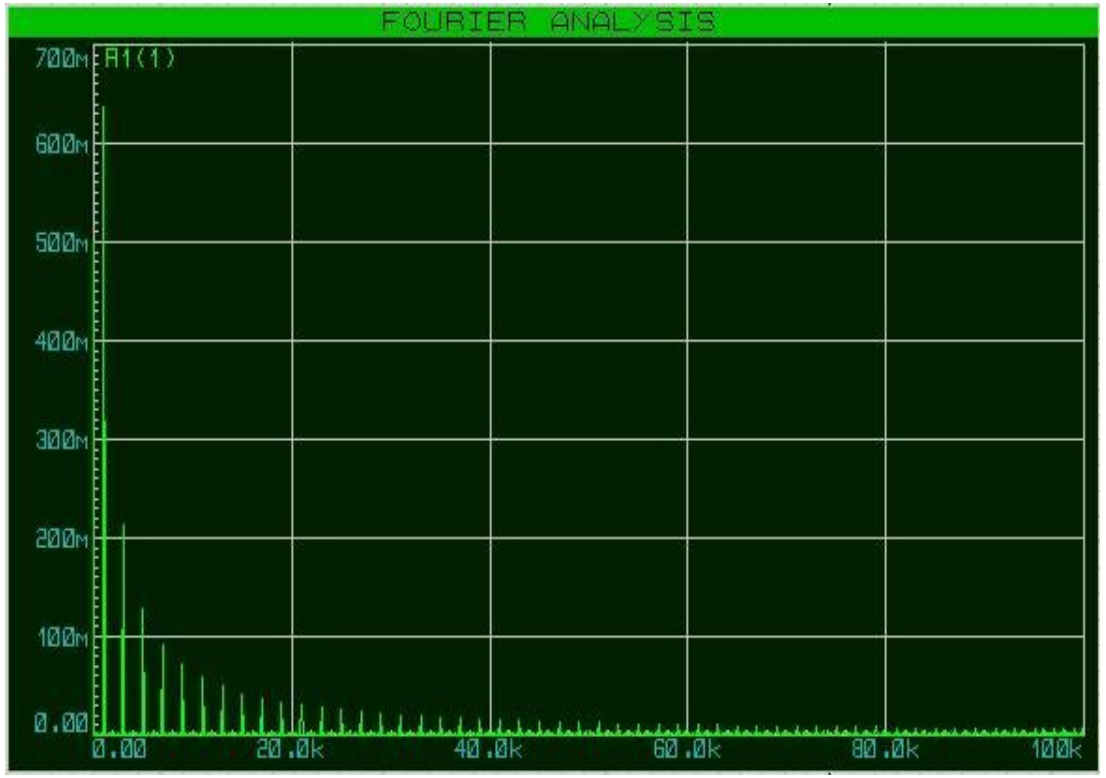


Fourier Analysis (Spectrum)

Subject: Signals and Systems.

Fourier analysis is helpful to analyze the frequency content of signals, and its harmonic behavior, converting a signal to the frequency domain. Fourier plots represent periodic functions, which are the infinite sum of harmonically related sinusoidal functions.

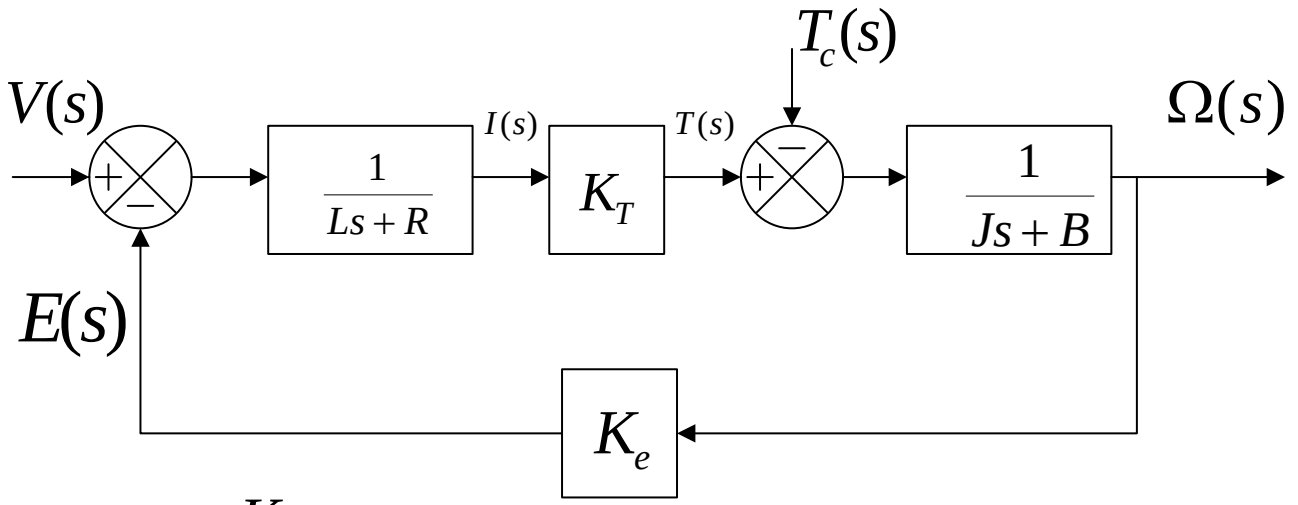




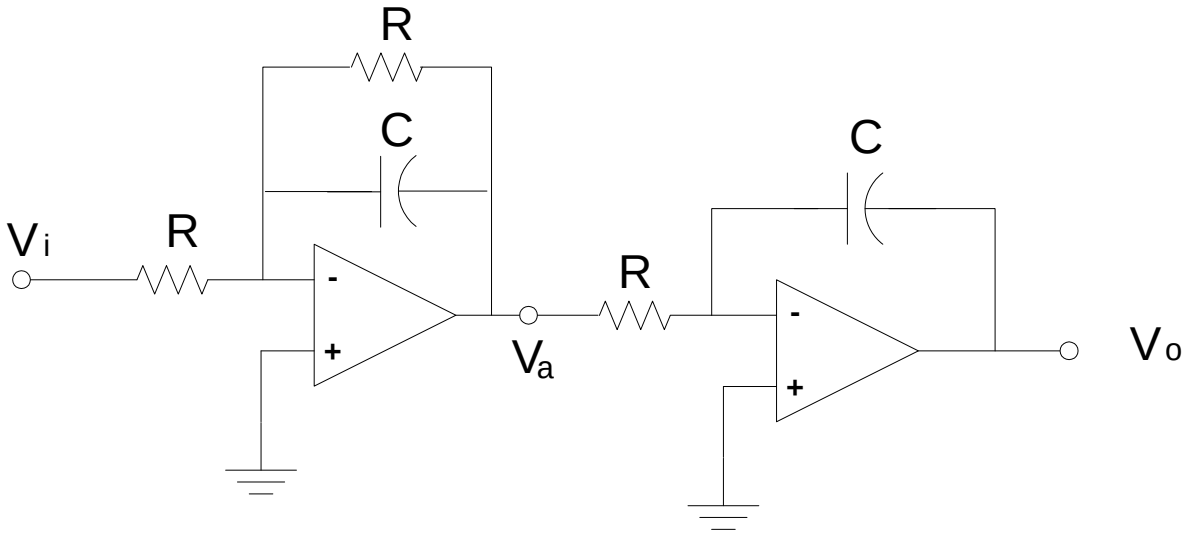
Control

Subject: DC motor system.
Parameters, blocks and equivalent circuit.

R	Armor resistance (Ohms)	1.1648
L	Armor Inductance (Henrys)	0.0068
J	Equivalent moment of inertia $(Kg\ m^2)$	1.0271
J_m	Motor inertia moment $(Kg\ m^2)$	0.0271
J_c	Load inertia moment $(Kg\ m^2)$	1
B	Equivalent coefficient of viscous friction $(N\ m/(rad/seg))$	0,23646
B_m	Motor's coefficient of viscous friction $(N\ m/(rad/seg))$	0.00776
B_c	Load's coefficient of viscous friction $N\ m/(rad/seg.)$	0.2287
K_T	Constant drive torque $(N\ m/Ampere)$	0.55
K_e	Constant counter-electromotive force $(V/(rad/seg.))$	0.82
i	Current in the armor (Amperes)	I(s)
V	Voltage applied to the armor (Volts)	V(s)
ω	Angular speed motor (radians/seg)	$\Omega(s)$
T	Torque developed by the motor (Newton-meter)	T(s)
T_C	Perturbation or Disturbance (Newton-meter)	Tc(s)

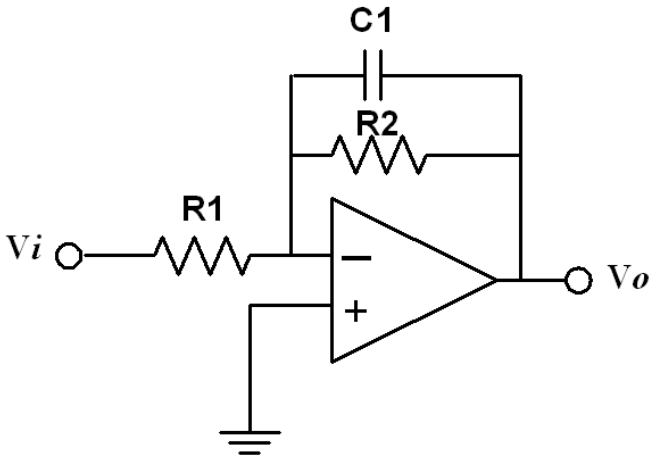


$$\frac{\Omega(s)}{V(s)} = \frac{K_T}{JL\,s^2 + (JR + BL)s + RB + K_T K_e}$$

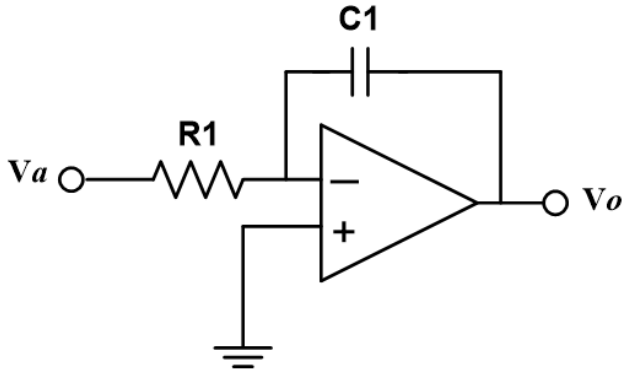


Control

Subject: Circuit for the DC motor under load with L=0



$$G_1(s) = -\frac{1/R_1C_1}{s + 1/R_2C_1}$$



$$G_2(s) = -\frac{1/R_1C_1}{s}$$

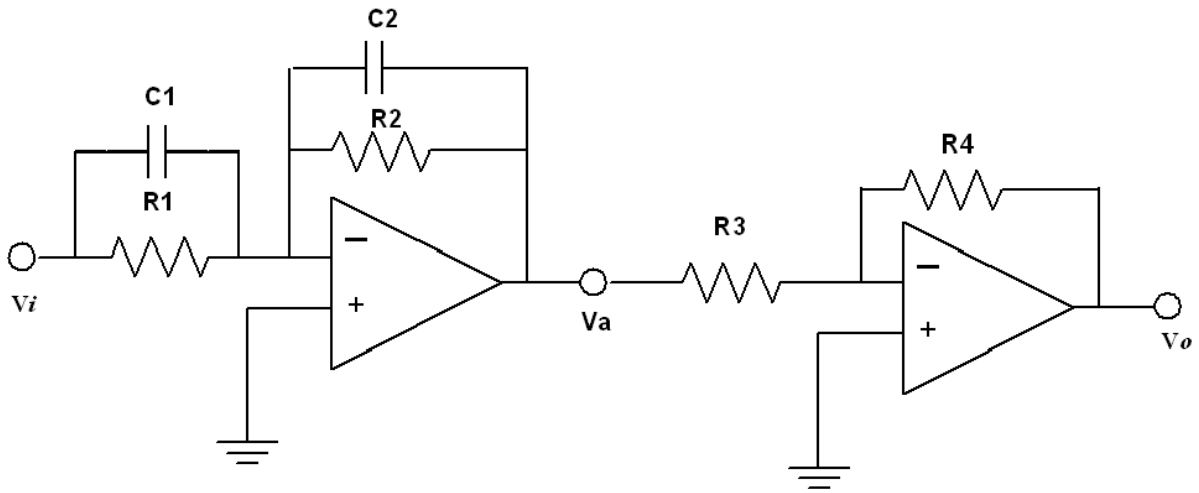
FDT	FDT escalada
$G(s) = \frac{K}{s(s+a)}$	$G(s) = \frac{K * 1e6}{s(s + a * 1e3)}$
$G_C(s) = \frac{K_C(s+c)}{s+p}$	$G_C(s) = \frac{K_C(s + c * 1e3)}{s + p * 1e3}$

Control

Subject: Circuit for the compensator.

Design a feedforward compensator by the root locus method for the DC motor under load with L=0 to control the position θ(t), whose desired requirements are:

$\zeta = 0.5$ and $\omega n = 5$ rads/s.

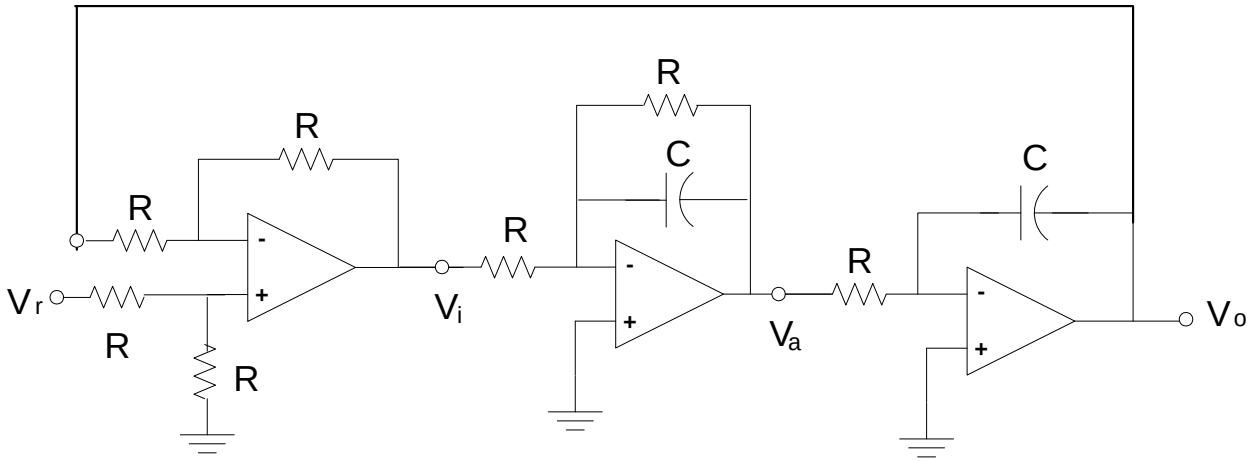


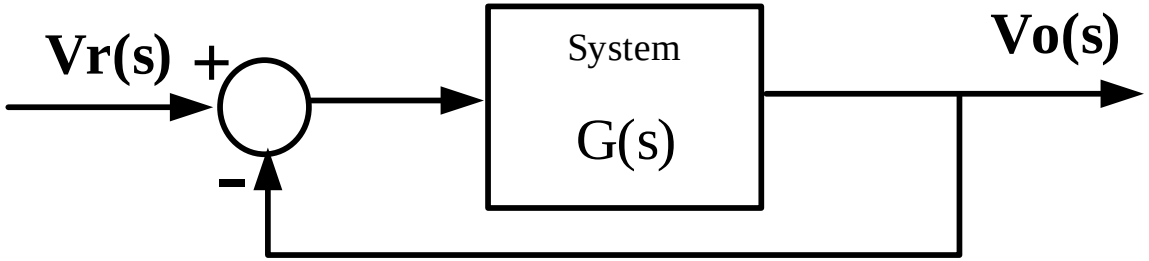
Tipo	Función de transferencia del compensador y condiciones	Fórmulas para el cálculo de R's y C's.
Adelanto	$G_C(s) = K_C \dfrac{s + 1/T}{s + 1/\alpha T}$ $0.07 < \alpha < 1$	Donde: $T = R_1 C_1$, $\alpha T = R_2 C_2$ y $K_c = \dfrac{R_4 C_1}{R_3 C_2}$

Control

Subject: Uncompensated closed loop system.

Obtain the closed-loop system to watch its behavior without compensation to notice what parameters need to be adequate to the requirements.

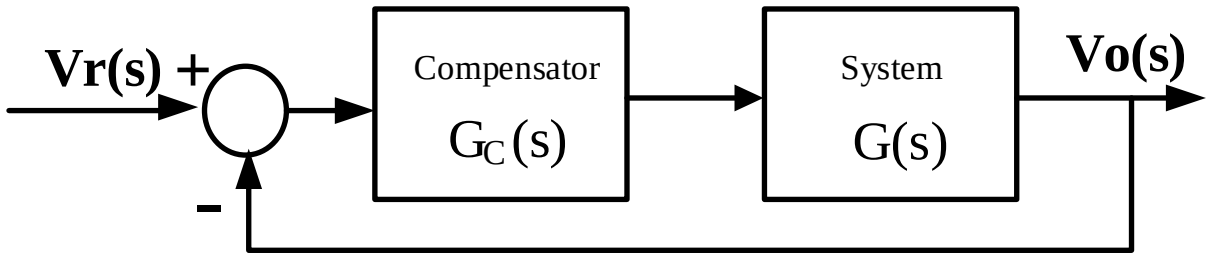


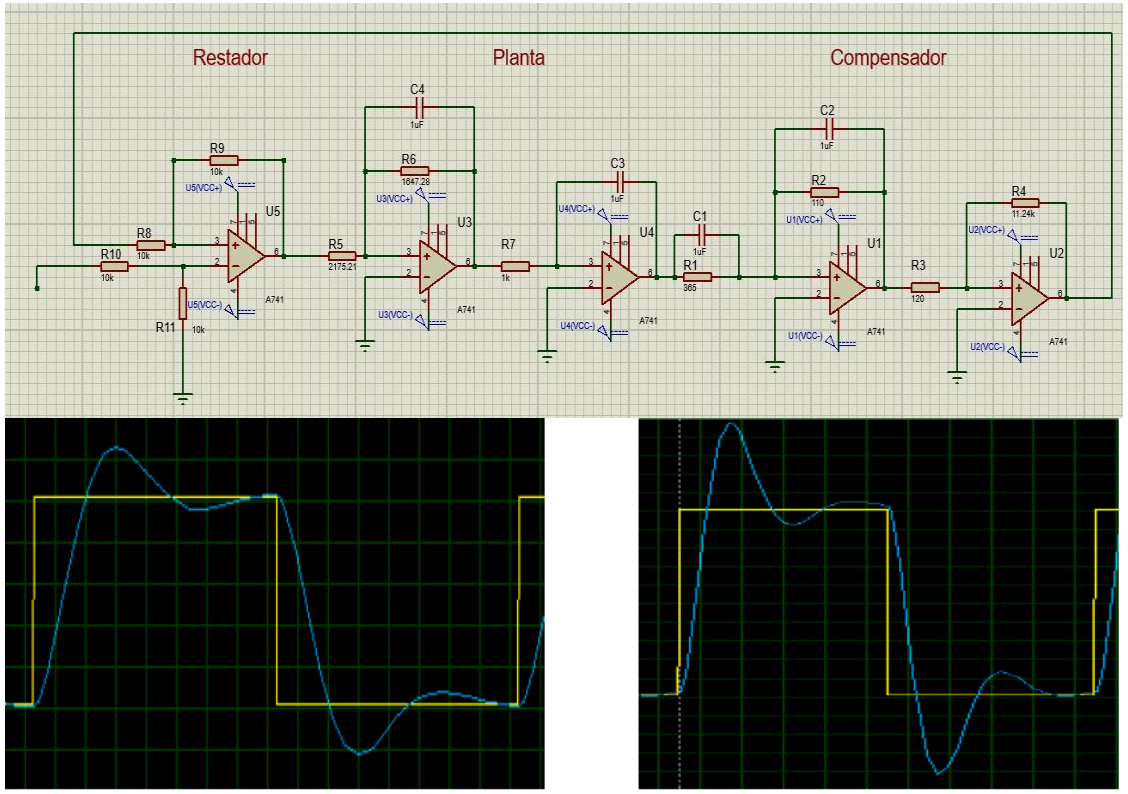


Control

Subject: Compensated closed-loop system.

Implementation of a feedforward compensator design using operational amplifiers to control the position of a DC motor under load.





Uncompensated

Compensated

Conclusions

As it is known, traditional students prefer face-to-face learning, but with the COVID-19 pandemic, everything changed, and the way students and instructors work is one of them.

The use of software simulators simplified the transition to online education.

The Proteus platform lets the students obtain part of the knowledge they get in traditional learning.

The students experiences the different stages of design, simulation and implementation using operational amplifiers that represent a position control loop by means of compensation for a DC motor model.

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