MT240_NR_5_3_1 Inverting Op-Amp

Table of Contents

Title

Last Updated 2/5/2016

Description

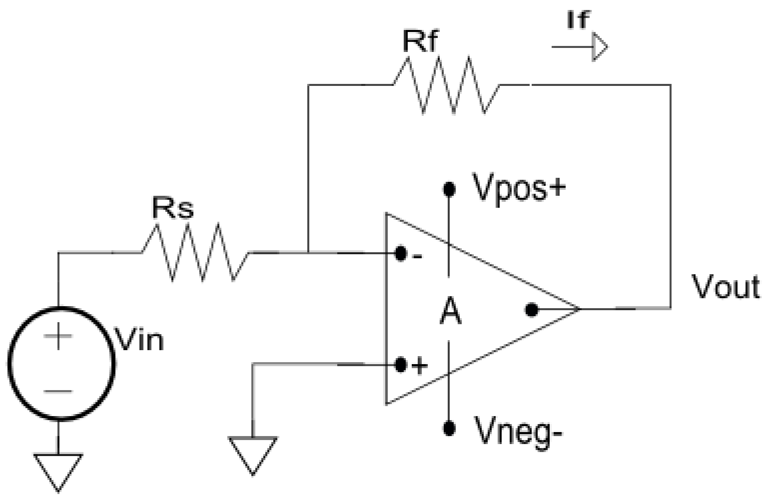
This script is used in conjunction with MATLAB Problem mt240_nr_5_3_1_inverting_op_amp_function. Exercise 1 on the assignment will have the you complete this problem.

Operational Amplifiers (Op-Amps) can amplify a signal so that the signal's magnitude is equal to the magnitude of the op-amp's rails. For example, consider an inverting op-amp with a gain of -10 and voltage rails at +/-10V . If the signal $ x = \cos{2\pi t} $ was passed through the op-amp, the rails would prevent the output from reaching a magnitude of 30V. Instead, the rails would limit the signal at a magnitude of 10V and the output would resemble a square wave.

You have been given the op-amp as shown in the image below. The different components of the op-amp have the following values.

```
Rs = 1e3 Ohms
Rf = 1e3:1e3:6e3 Ohms
Vpos = 20 V
Vneg = -20 V
Vin = 5*cos(200*pi*t) V
```

```
Rf is a potentiometer that can assumes the values 1k Ohms to 6k Ohms
with a step size of 1k Ohms.
```



Exercise

1. Write a function file that simulates the inverting op-amp and takes in the parameters Rs, Rf, Vpos, Vneg, and Vin. Ensure that the function takes into account clipping. This means that the output voltage must be within the rails, Vneg <= Vout <= Vpos. The function needs to be able to handle the cases when Vin and Rf are arrays. Refer to MATLAB Problem mt240_nr_5_3_1_inverting_op_amp_function to complete exercise 1.

2. Use the function created in part 1 to calculate Vout as a function of Rf and time (from t = 0s to 2T, T is the period of the signal, and a time step of 10us). Then plot it using a mesh plot.

3. Change the input signal do DC 5V and Rf to range from 1k Ohms to 5k Ohms with a step of 100 Ohms. Calculate Vout as a function of Rf.

4. Using the output voltage calculated in the previous step, calculate the feedback current 'If' as a function of Rf. Be sure to capture the behavior of 'If' in the linear and non-linear region.

5. Plot 'If' as a function of Rf.

Here is a link to the assignment mt240_nr_5_3_1_inverting_op_amp_function. mt240_nr_5_3_1_inverting_op_amp_function

Questions

1. By analysing the first figure, approximate the value of Rf that causes the output signal to clip?

2. By analysing the second figure, approximate the value of Rf when 'If' begins to enter the non-linear region (begins to decrease). Why does 'If' begin to decrease?

Useful Information

Assignment mt240_nr_5_3_1_inverting_op_amp takes you through creating the function. This section will walk you through using the mesh plot command.

mesh

This plot creates a 3-D mesh surface. The inputs to the mesh command are X, Y, Z, and C.

- X is an array of data points that sets the x plane
- Y is an array of data points that sets the y plane
- Z is a matrix whose values can be a function of X and Y where every value of X was evaluated with every value of Y and vice-versa.
- C is the color scaling. In this assignment you will not use this parameter.

The syntax is

mesh(X,Y,Z)

In this assignment * Let Z be Vout whose values are a function of Vin and Rf. * Let Y be Rf * Let X be t instead of Vin in order to visually see how Vout changes with time instead of Vin. This works since Vin is a function of time, t.

Using the above substitutions, the command can be written as

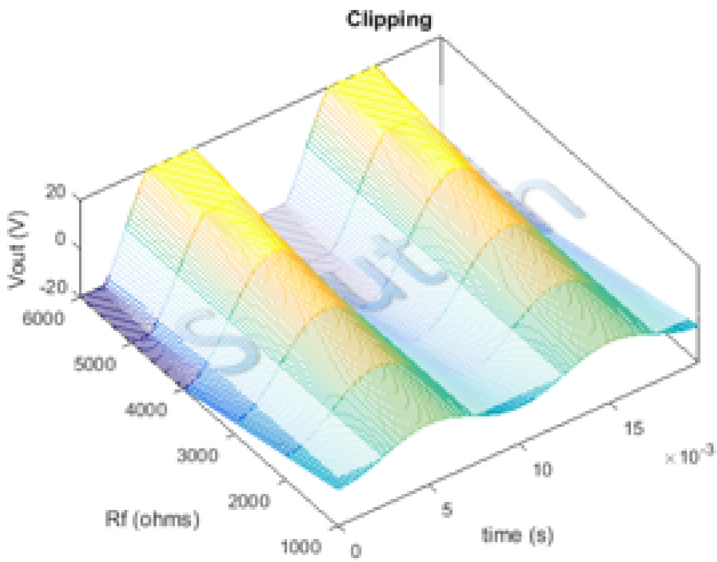
mesh(t,Rf,Vout)

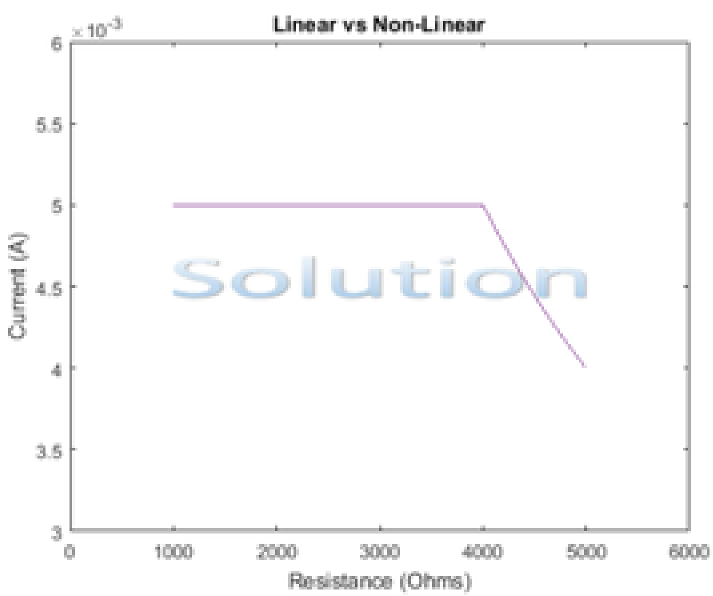
Provided Code

```
% Part 1)
% For part 1 complete the assignment
% mt240_nr_5_3_1_inverting_op_amp_function

% Part 2)
% Parameters
Vpos = 20;                % Positive rail, Volts
Vneg = -20;               % Negative rail, Volts
Rs = 1e3;                 % Source resistance, Ohms
Rf = 1e3:1e3:6e3;         % Feedback resistance, Ohms
w = 200*pi;               % Frequency of the signal, rads/s
T = 2*pi/w;               % Period of the signal, s
t = 0:.0001: 2*T-.0001;  % Time array, s
Vin = 5*cos(w*t);         % Input signal Vin, V

% Call function to calculate Vout
[Vout] =  Inverting_OpAmp(Vin, Rf, Rs, Vpos, Vneg);

% Plot
figure(1);
mesh(% INSERT CODE HERE);
xlabel('time (s)');
ylabel('Rf (ohms)');
zlabel('Vout (V)');
title('Clipping');

% Part 3
% Parameters
Vin = 5;          % Input signal Vin, V
Rs = 1e3;         % Source resistance, Ohms
Rf = 1e3:100:5e3; % Feedback resistance, Ohms

% Call function to calculate Vout
```

```
[Vout] =Inverting_OpAmp(Vin, Rf, Rs, Vpos, Vneg);

% Part 4)
If = % INSERT CODE HERE;  % Calculate If, Amps

% Part 5)
% Plot figure
figure(2);
plot(Rf, If);
xlabel('Resistance (Ohms)');
ylabel('Current (A)');
title('Linear vs Non-Linear');
axis([0 6e3 0.003 0.006]);
```

Solution





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