MT240_NR_5_3_1
Inverting Op Amp Function

Table of Contents

Title

Last Updated 2/6/2016

Description

This function is used in conjunction with with MATLAB Problem mt240_nr_5_3_1_inverting_op_amp.

The function takes in the parameters: Vin, Rf, Rs, Vpos, Vneg and returns Vout.

- Vin is the input voltage signal in volts. It can be a single value or an array of values.
- Rf is the feedback in ohms. It can be a single value or an array of values.
- Rs is the source resistance, Ohms.
- Vpos is the positive voltage rail, V
- Vneg is the negative voltage rail, V
- Vout is the output voltage of the inverting operational amplifier. It can assume one value, an array of values as a function of time or feedback resistance, Rf, or a matrix as a function of both time and feedback resistance, Rf.

Exercise

1. Create a function file named Inverting_OpAmp that takes in the values Vin, Rf, Rs, Vpos, and Vneg and returns Vout.
2. Calculate the gain of the op-amp. If Rf is an array, the gain will be an array whose values are a function of Rf.
3. Calculate Vout ignoring clipping due to the rails.
4. Use logical expressions to clip Vout at the rails instead of using a nested for-loop. Remember that your function must be able to compute Vout when both Rf and Vin are arrays of different length.

Useful Information

The objective is to calculate Vout as a function of Vin, Rf, Rs when Vin and Rf can be arrays of different values. A for-loop could be used to calculate Vout, but for-loops are messy and slow compared to other methods. A better method is to use matrix multiplication. The process is outlined below.

The calculation of Vout will be broken down into three parts.

Gain

The gain of an inverting op_amp has the relationship

$$G = -R_f/R_s$$

This relationship holds true even if Rf is an array representing a spectrum of resistances.

For example, if Rf is a 1x5 matrix and ranges from 1 to 5 with steps of 1 Ohm, and Rs has the value of 1 Ohm then the Gain would be a 1x5 matrix of the form

$$R_f = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 \end{pmatrix}$$

$$R_s = 1$$

$$G = \begin{pmatrix} -1 & -2 & -3 & -4 & -5 \end{pmatrix}$$

Gain*Vin

Vout is the product of the gain and the input voltage.

$$V_{out} = G * V_{in}$$

This process is straightforward unless the gain and the input voltage are both arrays of different length. The solution is matrix multiplication.This will be demonstrated using the same gain calculated above and letting Vin 1x4 matrix with values

$$V_{in} = \begin{pmatrix} 1 & -2 & 3 & -4 \end{pmatrix}$$

Each element in Vin needs to be multiplied by each element of G. To do this, multiply the transpose of G by Vin. This will change G from a 1x5 matrix to a 5x1 matrix. Thus Vout will be a 5x4 matrix. Each row will represent a different gain, and each column will represent a different input voltage.

$$V_{out} = G^T V_{in}$$

$$V_{out} = \begin{pmatrix} -1 \\ -2 \\ -3 \\ -4 \\ -5 \end{pmatrix} \begin{pmatrix} 1 & -2 & 3 & -4 \end{pmatrix}$$

$$V_{out} = \begin{pmatrix} -1 & 2 & -3 & 4 \\ -2 & 4 & -6 & 8 \\ -3 & 6 & -9 & 12 \\ -4 & 8 & -12 & 16 \\ -5 & 10 & -15 & 20 \end{pmatrix}$$

Clipping

Vout has been calculated without taking into account clipping. To take into account clipping use logical expressions. This is demonstrated below.

$$V_{out}(V_{out} < V_{neg}) = V_{neg}$$

This logical expression goes through every value of Vout, and if the value is less than the negative rail, Vneg, that value will be assigned the value of the rail. For example, assume that the op-amp's rails are at +/- 14V. Applying the logical expression demonstrated above for both the positive and negative rails on the previously calculated Vout. Vout would become

$$V_{out} = \begin{pmatrix} -1 & 2 & -3 & 4 \\ -2 & 4 & -6 & 8 \\ -3 & 6 & -9 & 12 \\ -4 & 8 & -12 & 14 \\ -5 & 10 & -14 & 14 \end{pmatrix}$$

```
Note that three values changed.
```

Provided Code

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

G = % INSERT CODE HERE                    % Calculate Gain
Vout = % INSERT CODE HERE                 % Calculate Vout, V
Vout(Vout < Vneg) = % INSERT CODE HERE;  % Clip Vout at the negative
 rail.
Vout(Vout > Vpos) =% INSERT CODE HERE;   % Clip Vout at the positive
 rail.
```

Solution

Published with MATLAB® R2015a