MT240_NR_5_4_1 Summing Amplifier

Table of Contents

Title

Last updated 2/15/2016

Description

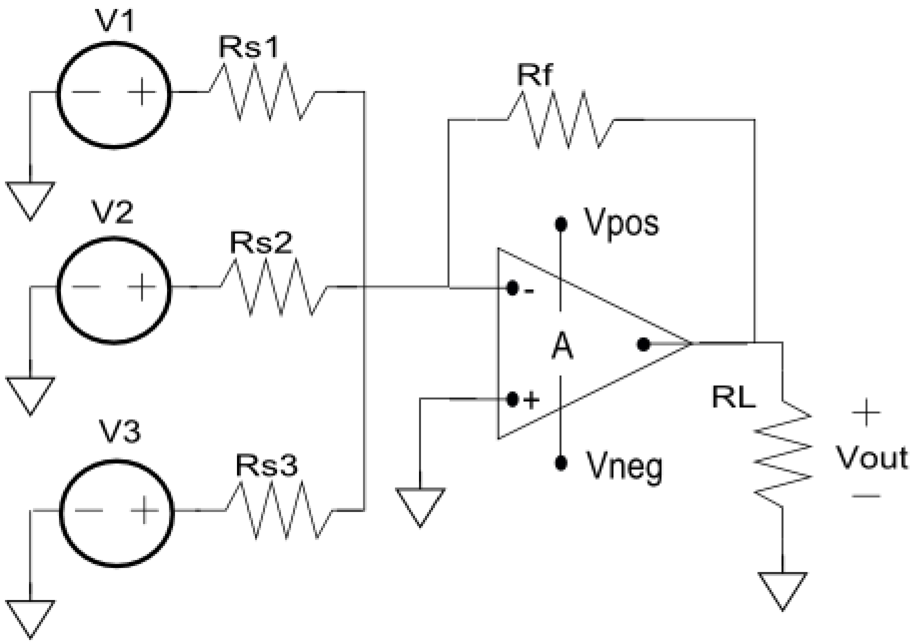
Any signal can be thought of as a summation of cosine and sine waves. However, there are some limitations. Signals with discontinuities cannot be exactly represented as a sum of cosine and sine waves, and experience a phenomenon known as Gibb's phenomenon.

For example, a square wave has a discontinuity since it jumps from one value to another almost instantaneously. Because of this, it cannot be exactly be represented as a sum of cosine and sine waves. However, an approximation is achievable.

In this assignment, you will approximate a square wave by adding together multiple sines using the summing operational amplifier depicted below.

The operational amplifier has the following values:

$V1 = \frac{4}{\pi} \sin 2\pi t$
$V2 = \frac{4}{3\pi} \sin 6\pi t$
$V3 = \frac{4}{5\pi} \sin 10\pi t$
$Rs1 = 2k\Omega$
$Rs2 = 2k\Omega$
$Rs3 = 2k\Omega$
$Rf = 30k\Omega$
$Vpos = 20V$
$Vneg = -20V$



Exercise

1. Create a function file that simulates a summing operational amplifier. See the associated document on how to create it.
2. Calculate Vout as a function of time. The time array, and the input voltage sources are given to you in the provided code. #Plot V1, V2, V3, and Vout, as a function of time, in the same figure using the subplot command. Be sure to include titles and labels.
3. Calculate Vout again using the following input voltages, assume that every input resistance is 2k Ohms.

```
V1 = 4/pi*sin(2*pi*t);
V2 = 4/(3*pi)*sin(6*pi*t);
V3 = 4/(5*pi)*sin(10*pi*t);
V4 = 4/(7*pi)*sin(14*pi*t);
V5 = 4/(9*pi)*sin(18*pi*t);
V6 = 4/(11*pi)*sin(22*pi*t);
V7 = 4/(13*pi)*sin(26*pi*t);
V8 = 4/(15*pi)*sin(30*pi*t);
V9 = 4/(17*pi)*sin(34*pi*t);
V10 = 4/(19*pi)*sin(38*pi*t);
```

5. Plot the new Vout as a function of time in a separate figure.

Click on the link below to navigate to the Summing Op Amp function assignment in order to complete exercise 1.

[Sum Op-Amp Function]

Question

1. What impact does adding more input voltage sources have on Vout?

Useful Information

Subplot

```
A figure can display more than one plot using the subplot command. The
subplot command divides the figure into mxn sections (axes), and selects
the axes for the current plot. The syntax is shown below.

subplot(m,n,p)
```

- m indicates the number of rows
- n indicates the number of columns
- p selects the p-th axes for the current plot.

Example:

```
figure(1);
subplot(2,1,1);    % Divides the figure into a 2-by-1
%                  % matrix and selects the first axes.
plot(0:10,0:10)    % Plot 1
%
subplot(2,1,2);    % Divides the figure into a 2-by-1
%                  % matrix and selects the second axes.
plot(0:10,10:-1:0) % Plot 2
```

```
The code divides figure(1) into a 2-by-1 matrix of small axes, and draws
Plot 1 in the first axes, and draws plot 2 in the second axes. Run the
code for a visual demonstration if needed.

For more information type 'help subplot' in the command window.
```

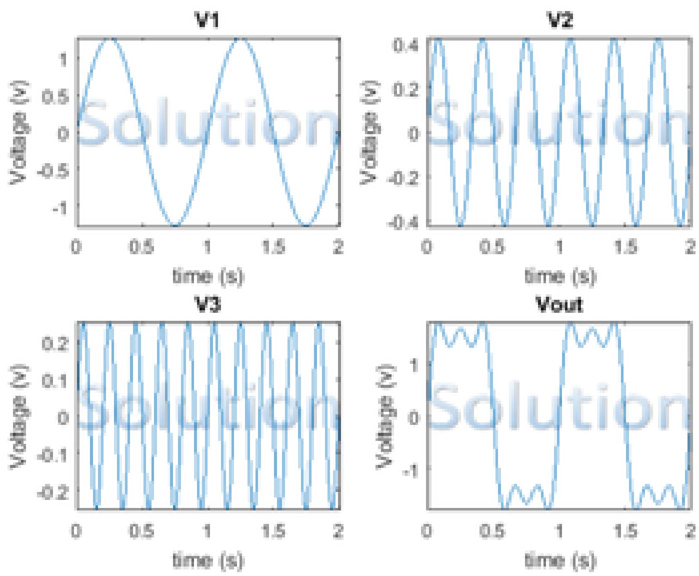
Provided Code

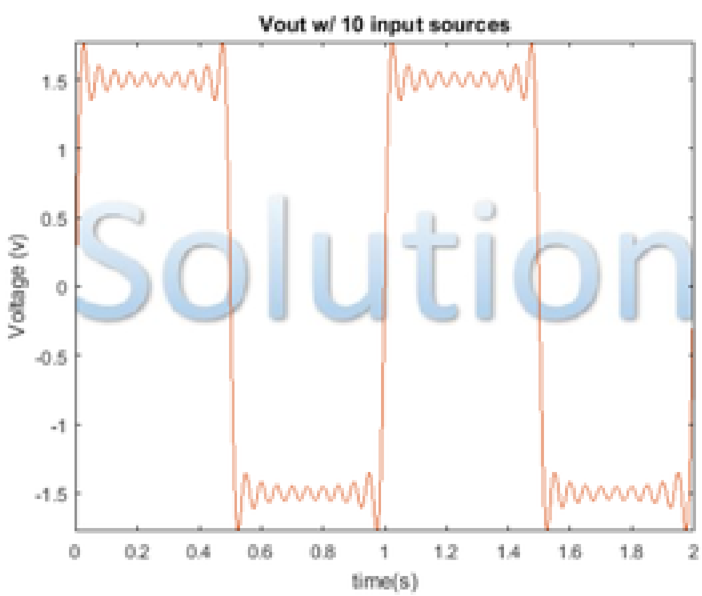
```
% Part 2 )
% Parameters
Rs = [2e3 2e3 2e3]';                  % Input voltage source
                                     %   resistances, Ohms
Rf = 3e3;                             % Feedback resistance, Ohms
Vpos = 20;                            % Positive voltage rail, V
Vneg = -20;                           % Negative voltage rail, V
time_begin = 0;                       % Beginning of time array, s
ts = 0.0001;                          % Time step, s
time_end = 2-ts;                      % End of time array, s
t = time_begin:ts:time_end;           % Time array, s
V1 = 4/pi*sin(2*pi*t);                % Input voltage source, V
V2 = 4/(3*pi)*sin(6*pi*t);            % Input voltage source, V
V3 = 4/(5*pi)*sin(10*pi*t);           % Input voltage source, V
Vs = [V1' V2' V3'];                   % Matrix that contains the
                                     %   input voltage sources, V

% Vs is a matrix that looks like
%       V1           V2                     Vn
% | V1(t = 0)    V2(t = 0)      ...     Vn(t = 0) |
```

```
% | V1(t = ts)   V2(t = ts)     ...     Vn(t = ts) |
% |      :             :        ...         :       |
% | V1(t = n*ts) V2(t = n*ts)   ...     Vn(t = n*ts) |

% Call the function to calculate Vout
[Vout] = Summing_OpAmp(Vs, Rs, Rf, Vpos, Vneg);

% Part 3)
figure(1);
subplot(2,2,1); % creates a subplot 2X2 organized as shown below
              % | Vin1    Vin2 |
              % | Vin3    Vout |

% plots V1 as a function of time
plot(t, V1);
title('V1');
xlabel('time (s)');
ylabel('Voltage (v)');

% plots V2 as a function of time
subplot(2,2,2);
plot(t, V2);
title('V2');
xlabel('time (s)');
ylabel('Voltage (v)');

% plots V3 as a function of time
subplot(2,2,3);
plot(t, V3);
title('V3');
xlabel('time (s)');
ylabel('Voltage (v)');

% plots Vout as a function of time
subplot(2,2,4);
plot(t, Vout);
title('Vout');
xlabel('time (s)');
ylabel('Voltage (v)');

% Part 4)
% Additional Parameters
% Input voltage source resistances, Ohms
Rs = [2e3 2e3 2e3 2e3 2e3 2e3 2e3 2e3 2e3 2e3]';

% Input voltage sources, V
V1 = 4/pi*sin(2*pi*t);
V2 = 4/(3*pi)*sin(6*pi*t);
V3 = 4/(5*pi)*sin(10*pi*t);
V4 = 4/(7*pi)*sin(14*pi*t);
V5 = 4/(9*pi)*sin(18*pi*t);
V6 = 4/(11*pi)*sin(22*pi*t);
V7 = 4/(13*pi)*sin(26*pi*t);
V8 = 4/(15*pi)*sin(30*pi*t);
V9 = 4/(17*pi)*sin(34*pi*t);
V10 = 4/(19*pi)*sin(38*pi*t);
```

```
% Matrix of input voltage sources, V
Vs = [V1' V2' V3' V4' V5' V6' V7' V8' V9' V10'];

% Call the function to calculate Vout
[Vout] = Summing_OpAmp(Vs , Rs, Rf, Vpos, Vneg);

% Part 5)
% Plot it
figure(2);
plot(t, Vout);
xlabel('time(s)');
ylabel('Voltage (v)');
title('Vout w/ 10 input sources');
```

Solution





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