# W6

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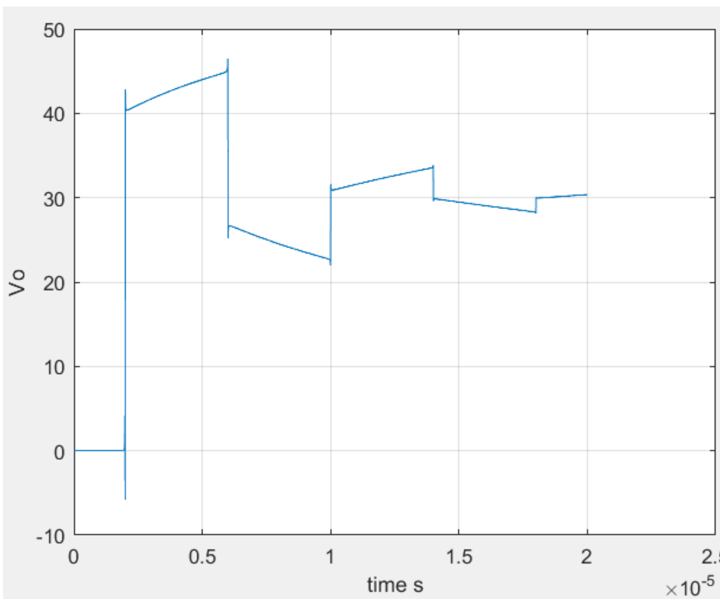
Consider the exact solution that is:

$$Y(s) = \frac{1}{\cosh\left(l\sqrt{(R+sC)(G+sC)}\right)}$$

Consider the following values for the impedance and an input of 30 volts:

$$R = 0.1\,, C = 10^{-10}, L = 2.5\ 10^{-7}, l = 400, G = 0, v_{in} = 30$$

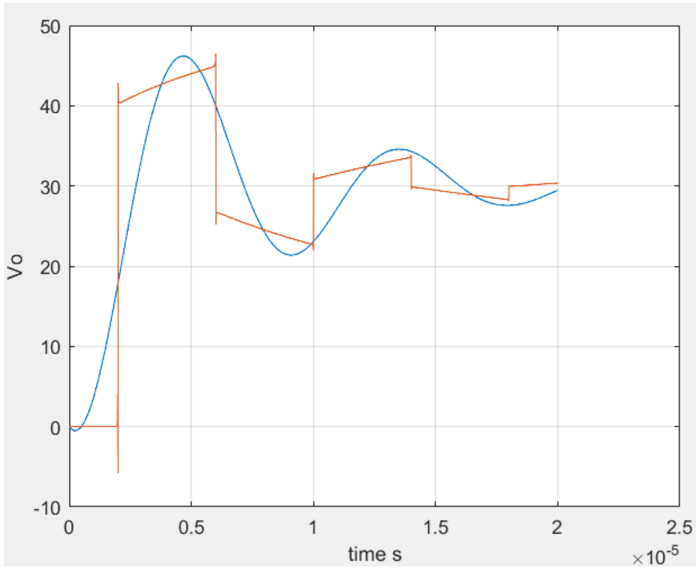
The unit step response looks as follows:




we can generate Y parameters out of this, consider the bellow table:

| $w$ | $y_r + y_i$ |
|---|---|
| 200 π | 1.0000 - 0.0005i |
| 400 π | 1.0000 - 0.0010i |
| 1000 π | 1.0000 - 0.0025i |
| 2000 π | 1.0001 - 0.0050i |
| 10000 π | 1.0014 - 0.0252i |

Using NILTcv to plot both we get.




With RMSE of 5.3425.

- Now let's consider 3 Y parameters and combine them.
- First lets change the code for generating the Y parameters :
- Generate Y parameters out of these values:

$$Y_{11} = \frac{(a_{nii}s^{n-1} + .. + a_{011})}{s^n + .. + b_{011}}$$

Consider n=3:

$$Y_R + jY_i = \frac{a_2 s^2 + a_1 s + a_0}{s^3 + b_2 s^2 + b_1 s + b_0}$$

At $s = jw$

$$(Y_R + jY_i)(-jw^3 - b_2 w^2 + b_1 jw + b_0) = -a_2 w^2 + a_1 jw + a_0$$

$$(-Y_R jw^3 - Y_R b_2 w^2 + Y_R b_1 jw + Y_R b_0 + Y_i w^3 - jY_i b_2 w^2 - Y_i b_1 w + jY_i b_0) = -a_2 w^2 + a_1 jw + a_0$$

Re-write this as:

$$(-Y_R b_2 w^2 + Y_R b_1 jw + Y_R b_0 - jY_i b_2 w^2 - Y_i b_1 w + jY_i b_0) + a_2 w^2 - a_1 jw - a_0 = Y_R jw^3 - Y_i w^3$$

Then,

$$A = \begin{bmatrix} -1 & Y_R^1 & 0 & -Y_i^1 w & w^2 & -Y_R w^2 \\ 0 & Y_i^1 & -jw^1 & jwY_R^1 & 0 & -jY_i w^2 \\ \ldots & .. & .. & \ldots & .. & .. \\ -1 & Y_R^N & 0 & -Y_i^N w & .. & .. \\ 0 & Y_i^N & -jw^N & -w^2 Y_i^N & .. & .. \end{bmatrix} \quad and\ C = \begin{bmatrix} -Y_i^1 w^3 \\ jY_R^1 w^3 \\ \ldots \\ Y_R^N w^2 \\ jY_i^N w^2 \end{bmatrix}$$

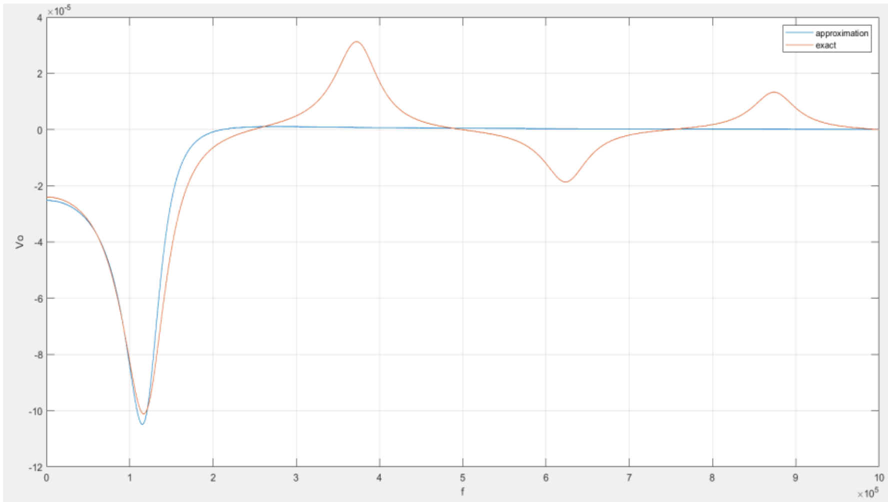
```
clear
clc
% Given the last 3 points
Yr = [0.2485, 0.2166, 0.1546]; % Real part of Y11
Yi = [-0.0195, -0.0848, -0.1210]; % Imaginary part of Y11
w = [1000*pi, 5000*pi, 10000*pi];
A = [];
C = [];
% Loop through each frequency point to construct A and C
for k = 1:length(w)
    wk = w(k);
    Yr_k = Yr(k);
    Yi_k = Yi(k);
    % Construct rows for A and C
    A_row1 = [-1, Yr_k, 0, -wk*Yi_k, wk^2, -Yr_k*wk^2]; % Real part
    A_row2 = [0, Yi_k, -wk, wk*Yr_k, 0, -Yi_k*wk^2]; % Imaginary part

    % Append to A
    A = [A; A_row1; A_row2];
    % C
    C_row1 = -wk^3 *Yi_k ; % Real part
    C_row2 = wk^3 * Yr_k; % Imaginary part
    % Append to C
    C = [C; C_row1; C_row2];
end

% Solve for B = [a0; b0; a1; b1]
B = A \ C;
% get cof
a0 = B(1);
b0 = B(2);
a1 = B(3);
b1 = B(4);
a2 = B(5);
b2 = B(6);
f = 0:100:10000;
w = 2*pi*f;
s = i*w;
% generated H
H = (a2*s.^2+a1*s+a0)./(s.^3+b2*s.^2+b1*s+b0);
plot(f,H)
```

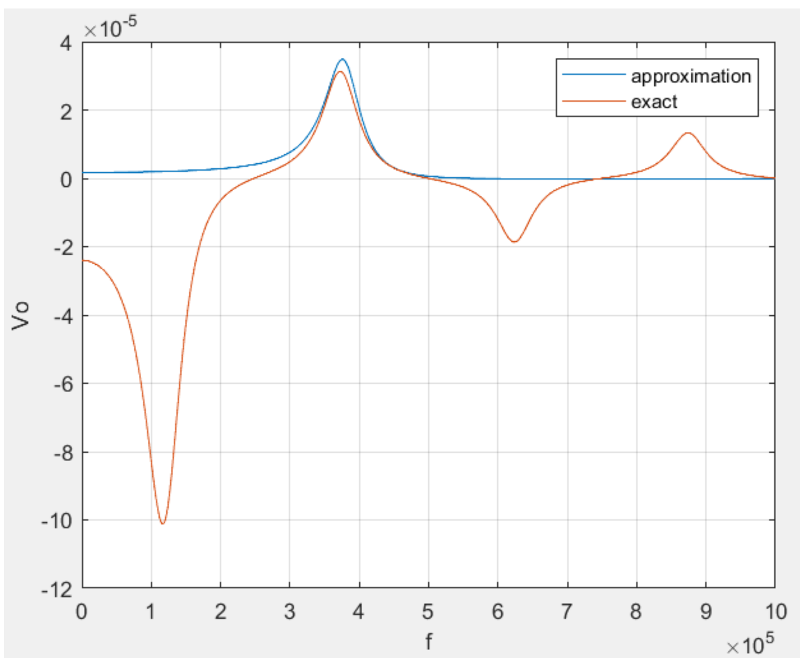
Moving on to generating Y parameters for the transmission line.

This is how the transmission line above looks like when s = jw as to the one approximated.



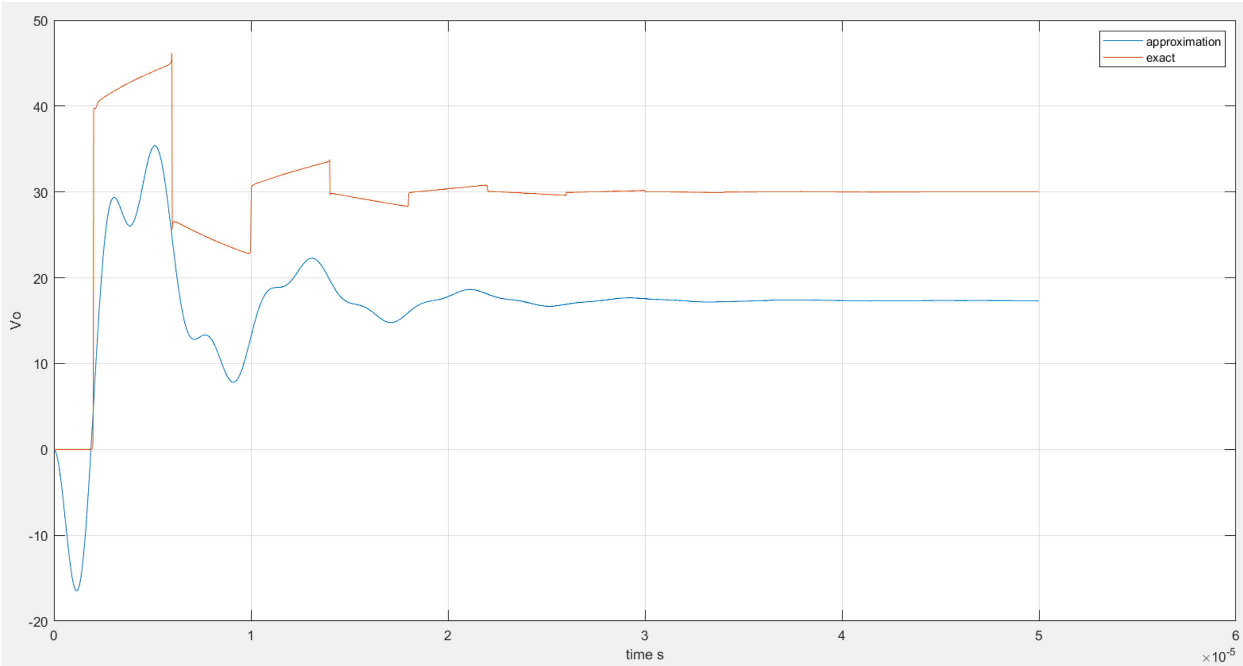

We can see that it almost matches the exact at low frequencies, but at high frequencies, it remains stable without an exact match. Therefore, we need to develop another model to accurately match the first section within the frequency range of 2.5×10^5 to 4.8×10^5.

Now, let's generate a y model for the frequencies above:




Now, let's try to combine these 2 approximations.

If we just simply add the two H1+H2, the result will look like this compared to the exact:




This is better in the shape but not accurate,

How can we add the two models and consider the first one for low frequency (i.e stable range ) and the second one for lets say high frequency (e.g.2.5x10^5:4.8x10^5)  because the combined when s=jw seems better.