Compare RLC ladder approximation to NILT0 and NILTcv

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* A diagram of a circuit

  Description automatically generatedA transmission line can be approximated using the following exact solation:

A diagram of a rectangle with arrows

Description automatically generatedThis can be represented as the following to obtain the exact solution:

Then,

A screenshot of a graph

Description automatically generatedUsing NILT0, at M=2 and compare it with RLC ladder (not state space)

A graph of a graph

Description automatically generatedOr in one plot,

This with NILT0 without time stepping.

* RLC ladder using space state representation.

Telegrapher equations are known as.

in state space,

Moving this to Laplace domain we get,

Where Z (x, s) = R(x) + sL(x), and Y (x, s) = G(x) + sC (x, s) are series impedance.

Let,

So,

Then, W at the end of the transmission line (W (l , s)) should equal to,

If the initial conditions are zero, (i.e. at W(x,0) = 0) then,

Or matrix format,

If I(l,s) = 0 , Then,

This is in the S domain, one can implement an NILT to solve it and get V(l,t) and to do this the following steps can be followed:

1. Find e^Ml, MATLAB has a function can do that very easily called expm(M\*l).

Testing expm with the following example.

The answer to this is,

These can be obtained using the model matrix method, then y(t),

Using the following code in MATLAB, we get the same result easily,

A = [0 2; -3 -5];

B = [0;1];

C= [1 0];

eat = expm(A\*t);

y = mtimes(mtimes(C,eat),B);

Implemtning this to get an expression for V(l,s) we get,

Where Vs(s) is the input in the s domain.

Using the fact that,

A graph with red lines

Description automatically generatedA graph with a red line

Description automatically generated

* NILTcv

When passing the exact solution to NILTcv with R = G = 0, L= 2.5e-7, C=1e-10 and a unit step input, the output was like the following.

A graph with blue lines

Description automatically generated

However, changing the value of either G or R, get me a good result as below:

A screenshot of a graph

Description automatically generated

* Further reading includes

1. Understand how Niltcv works.
2. Look at the derived expression for the transmission Line in MATLAB for Engineers – Applications in Control, Electrical Engineering, IT and Robotics.

Where,