Control

Wondering Waves

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Summary

State Space

The state space is a unified method use to model multiple input and multiple output systems. It also applied to non-linear system although it not concerned in this course

Answered Questions

Q: Why beta can be imaginary?
A: Wave number or k is defined as $k = j\omega\sqrt{\mu\epsilon}$. This definition inspired from Wave Equation in a lossless medium. So for Lossy media it changed to *Complex Propagation Constant* or γ. The Complex Propagation Constant is splitted into real and imaginary part which the former called attenuation constant or α and the latter is phase constant or β. note that this definition only apply to TEM mode. Thus in solution to TE and TM Mode, β is used to show the media is lossless. So in these mode β can be a complex number.

Q: Find Surface current if z is the propagation direction
A:

$$J_s = \int_0^\infty J \cdot \mathrm{d}\vec{z} = \int_0^\infty \sigma E \cdot \mathrm{d}\vec{z} = \sigma \int_0^\infty E_0 e^{-\gamma z} \cdot \mathrm{d}\vec{z}$$

Q: What is group velocity?
A: Phase velocity which is calculate from

$$v = \frac{\omega}{\beta}$$

is the speed of single frequency propagate down to space. In many cases transmission signal is consists of more than a single frequency which is the velocity for each single wave is slightly different due to phase velocity frequency dependent nature. In this case we define group velocity, the speed which the wave packet (overall shape of the waves) propagate, please understand that group velocity is just an approximated value to the wave packet speed. and it's only valid for $\Delta\omega \ll \omega_0$.

$$v_g = \frac{d\omega}{d\beta}$$

Q: Why we put inductance and capacitance into transmission line?
A: We put them because they exist in the line. They are exist in all frequencies but they have become considerable only in high frequencies so we have to calculate each wire inductance and the coupling factor between lines. If we deal with distributed circuits two phenomenon occurred at the same time, propagation delay and transmission line intrinsic Impedance. note that these two events are developed independently of each other to model individual wave propagation aspect. For a mid range high frequency the PCB tracks are only exhibit as a pure resistance aka lossless line but if the frequency move toward microwave frequencies, skin-depth effect, in the practical design must take into accounts

Q: What is Z_{in} and what is it difference with Z_o
A: Z_{in} only defined where the line is in the steady-state. on the other hand Z_o exist every where on the transmission line. It relates V^+ to I^+ independently of the load and generator. Z_o employed in calculating V^+ when a step pulse applied to the transmission line with

$$V^+ = \frac{Z_o}{Z_o + Z_g} V_g$$

where Z_g is generator output resistance on the other hand Z_in relates the $V(z)$ to $I(z)$ in any point on the transmission line but only for the steady state

$$Z_{in} = \frac{V_s}{I_s}$$