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610 Fall 2018 – Homework 4 Due Th 10/04/18

1. (40 points, negative & positive C's,L's)
   Given that a capacitor, of capacitance C>0, and four OTAs are available (of gains g_{mi} for i=1, …,4). Assume that the $g_{mi}>0$ with signs determined by the OTA input connections and use these to
   a) Draw a circuit for a positive inductor giving inductance value L; give the value of L in terms of C and the different g_{mi} used.
   b) Draw a circuit for an inductor giving a negative inductance value –L, where L is the value obtained in part a).
   c) Draw a circuit to give a capacitor of negative capacitance and give the value of this capacitor.
   d) Comment upon where gyrators can be used in any of the above.

2. (40 points, circulators)
   a) For the three port circulator used in class give its admittance matrix and from that draw a circuit using gyrators to realize its scattering matrix.
   b) Show that $Y=-Y^T$ and investigate the total instantaneous power in, $p(t)=v(t)^T i(t)$.
   c) Give also its impedance matrix and compare with the Y of part a).

3. (20 points, multiport circulator and use)
   A 3n-port circulator is obtained by replacing each 1 in the 3-port circulator by 1_n, the nxn identity, in the 3n-port device.
   a) Give the 3n-port circulator scattering matrix, S_{3n}.
   b) Load the second set of n ports in an n-port of scattering matrix S_a and the last n ports in S_b. Give the resulting input scattering matrix S_{in} seen at the first n-ports.
   c) Showing all the ports, draw a schematic diagram for the connection of part b) when n=2. For this a two-level 3D drawing with odd circulator ports on one level and even on another may be convenient.