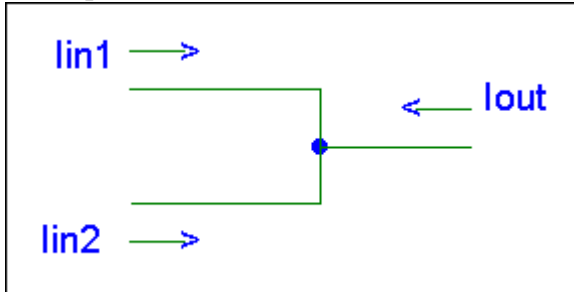


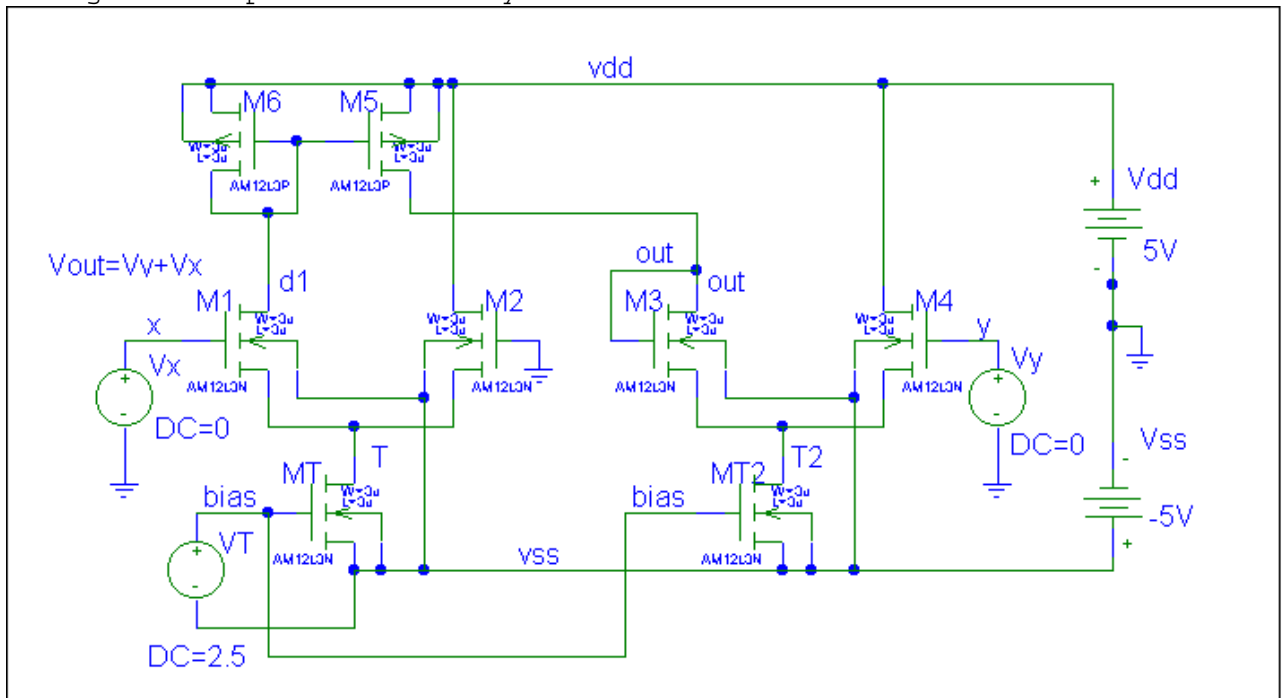
ENEE 610 Fall 2002

Problems to consider #4

1. Currents can be added by connecting nodes together as shown. Show that the circuit is passive. Is it lossless?



2. Adding voltages is more complicated. The following circuit of Kimura adds voltages. Is it passive? Assuming ideal current sources and mirrors (MT, MT2, M5, M6) give an analysis to show under what conditions the circuit adds voltages. Run Spice to confirm your results.



For Reference see Fig. 11 of: K. Kimura, "An MOS Four-Quadrant Analog Multiplier Based on the Multitail Technique Using a Quadritail Cell as a Multiplier Core," IEEE Transactions on Circuits and Systems - I, Vol. 42, No. 8, August 1995, pp. 448 - 454.

3. Besides addition, multiplication is a key operation needed to be performed by circuits. Figure 12 of the above Kimura reference gives an excellent multiplier with voltages as input and current as output; it uses the voltage adder given above. A PSpice schematic for this is given below. Is a multiplier passive in theory? Analyze the Kimura circuit to find the gain constant GM in $I_{out} = GM \cdot V_x \cdot V_y$ and check by a Spice run. Over what range of input voltages is this a valid multiplier?

