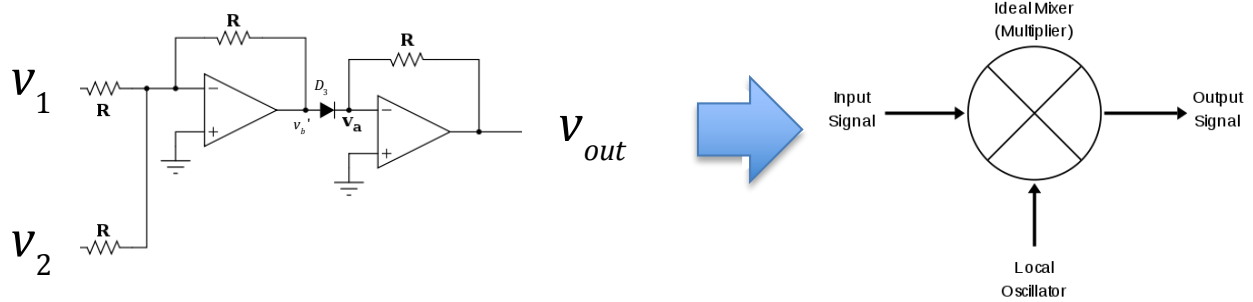


P116B Homework 5

Due 3/15/2019

1. H.&H. 8.1
2. H.&H. 8.11
3. Earlier this quarter, as part of our discussion of multiplication, we introduced the “exponentiation” circuit, shown below.



The output is approximated by

$$v_{out} \propto \left(e^{\frac{(v_1+v_2)}{V_T}} - 1 \right)$$

where V_T is the threshold voltage. Because this is a non-linear response, it can function as a mixer. If

$$v_1 = A_1 \sin 2\pi f_1 t$$

$$v_2 = A_2 \sin 2\pi f_2 t$$

list *all* the frequencies that will appear in the output spectrum when $f_1 = 1\text{MHz}$ and $f_2 = 1\text{kHz}$, if we keep terms up to third order in the exponential expansion; that is

$$e^x - 1 \approx x + \frac{1}{2}x^2 + \frac{1}{6}x^3$$

Don't worry about amplitudes. Just list the frequencies.