

ECE 4043

Homework Assignment No. 1

Spring 2020 Homework Problem Set No. 1 for Experiment No. 2

Due Week of January 20

1. Shown below are two single stage common emitter amplifiers using a NPN BJT as the active amplifying device. Circuit 1 is biased with an ideal current source while circuit two is biased with an op amp current source. The dc power supply voltages are $V^+ = 15\text{ V}$ and $V^- = -15\text{ V}$. It is given that $C_1 = 10\ \mu\text{F}$, $C_2 = 22\ \mu\text{F}$, $C_E = 330\ \mu\text{F}$, $R_L = 10\ \text{k}\Omega$, $R_B = 51\ \text{k}\Omega$, and $R_C = 6.8\ \text{k}\Omega$. Design the circuits so that the magnitude of the midband voltage gain is 10. and the circuits clip symmetrically. For circuit 2 determine the pot value that results in this current. (For the calculations assume that $\beta = \infty$. For the simulation use the value given below Prob 2. For the Zener diode pick R_1 small enough to cause enough current to flow though the diode to insure that it is in Zener breakdown. But not enough current to assume that maximum power dissipation of 0.25 W .)

2. For each circuit, use National Instruments SPICE, Multisim, to determine:

- the dc operating point of the circuit, viz. the dc voltage at each terminal of the transistor and the current flowing into the collector and base leads and out of the emitter. (DC Operating Point or OP analysis)
- the small signal ac voltage gain, viz. a plot of the gain, A_v versus frequency where the frequency range is from 10 Hz to 100 MHz. (AC Analysis)
- plot of the output voltage versus time for 2 cycles of the input for an input signal a sine wave with a frequency of 1 kHz and a peak values for which the output is not clipped, is on the verge of clipping, and significantly clipped (hard clipping). (Transient Analysis)
- plot of the output voltage versus frequency for a frequency span from dc to 10 kHz, viz. the spectra of the output with an input signal a sine wave with a frequency of 1 kHz and a peak value which causes the output to clip. Plot the output voltage on a log scale. Determine the THD (Fourier Analysis)
- plot the noise spectral density at the output (noise analysis). Also determine the total noise at the output.

Assume that the SPICE parameters for the NPN BJT are: saturation current [IS], $6.734\ \text{fA}$; forward beta [BF], 100; Early voltage [VAF], $170\ \text{V}$, zero-bias base collector capacitance [CJC], $3.638\ \text{pF}$; forward transit time [TF], $301.2\ \text{ps}$, and base spreading resistance [RB], $10\ \Omega$.

3. Verify the SPICE solution for the above with a hand calculation using the parameters given for the SPICE simulation. Calculate the dc operating point, mid-band small signal voltage gain, and positive and negative clipping levels.

