The George Washington University
School of Engineering and Applied Science
Department of Electrical and Computer Engineering
ECE 20 - LAB
Final Project Preparation

Initial Calculations for Final Project &
Characterization of iPod, function generator, and speaker

Objectives:

- Characterize the TIP31A NPN BJT
- Design Architecture for Final Project, implement in SPICE
- Characterize function generator, iPod (or other music source), and speaker

Prelab: ***(Submit electronically prior to lab meeting,*** *also have a printed copy for yourself during lab)*

1. Read through lab, generate a components and equipment list.
2. From the specification sheet for the TIP31A NPN BJT (on the lab website), gather the following specifications:

Parameter	Value (with units)
Maximum Collector-Emitter Voltage (V_{CEO})	
Maximum Emitter-Base Voltage (V_{EBO})	
Maximum Continuous Collector Current (I_C)	
Maximum Peak Collector Current (I_C)	
Maximum Collector-Base Voltage (V_{CBO})	
Maximum DC Current Gain (βeta or h_{FE})	
What is the range of βeta (h_{FE}) @25℃– see graph	
What happens to βeta as collector current increases?	
How much base current is required to get 1Amp of collector current? – see graph	

3. Read the tutorial "*Cascading Amplifier Stages (CE to CC)*" to help you design an amplifier to meet specifications below
4. Design an amplifier using NPN BJTs to meet the following specs (**hand in all calculations**):

Specification	Value
VCC	12V or 24V (choice is up to student)
RL	8Ω
Power dissipated by load	10Watts RMS
v*in*	.7V RMS @ 10kHz

   a) Show through calculations and specifications for the 2N3904, why the 2N3904 cannot reach the output power goal
   b) Can the TIP31A BJT be used to meet the output power goal? If so, use it to design the common-collector output stage.
      i. You will need to generate an IV-curve for the TIP31A to determine the base current the BJT requires (follow the process learned in lab 4 to do this)
      ii. Looking for the **TIP31A** part in spice? Read tutorial: *"How to load a new part into spice"*
5. Build the amplifier you've designed in SPICE, use 50 ohms for Rsig.
6. Perform a Bias Point Analysis for the circuit.
   a) Show the DC **voltages** and DC **currents** at each node; submit a separate screenshot for each. Verify that the DC currents and node voltage approximate your calculations.
7. Perform a Transient Analysis, show 5 cycles of:
   a) Plot Vin (not vsig), Vout for each stage (use markers to show values)
   b) Plot Iout for the CC stage

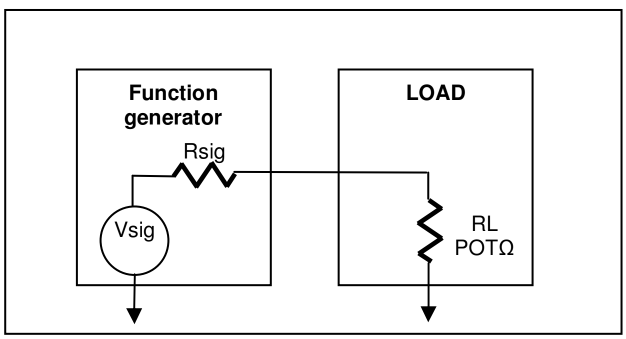
c) Calculate the voltage gain for each stage
d) Plot Vin, (not vsig), Vout, and peak power out for the entire amplifier (use markers to show values)
e) Calculate the overall voltage gain and current gain for the entire amplifier

Lab:

In your final project you will be asked to design a multistage amplifier for music. In parts 1-3 we will determine the input or output impedance for the lab function generator, your iPod (or other music source, lab pc perhaps), and an audio speaker.

Part 1 – Determining Output Impedance of the Function Generator

1. Set the lab function generator to produce a 2Vpp 440Hz wave
2. Attach the output of the function generator to the oscilloscope's channel 1
    a. Measure & record the output voltage of the function generator in the table below
    b. Adjust the frequency to 1kHz, then 10kHz record the output voltage at each step
3. Set a 100 ohm potentiometer to its **maximum** resistance, attach it to the function generator as shown in the figure below
    a. Set the frequency back to 440Hz
    b. Measure the voltage across the potentiometer
    c. Adjust the frequency to 1kHz, then 10kHz record the output voltage at each step
4. At 440Hz:
    a. Adjust the potentiometer until the voltage across the POT = ½ Vout (no load)
    b. Detach the potentiometer and measure its resistance (this equals Rsig at 440Hz)
5. Repeat step 4a-b for 1kHz, then 10kHz

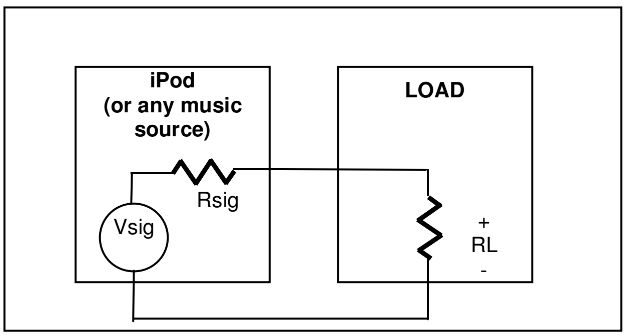


Frequency	Vout (peak) (no load)	Vout (peak) (100Ohms)	Vout (peak)	Rsig
440 Hz				
1 kHz				
10 kHz				

Part 2 – Determining Output Impedance of an iPod (or PC's audio out)

You could use a potentiometer to your iPod's output, but we don't want to accidentally short it out and break your iPod, so we will use resistors instead in this section.

1. On the iPod, play a 440Hz tone on a loop
2. Attach the output of the iPod to the oscilloscope's channel 1 to measure its Vout
    a. Adjust the volume on the iPod until Vout = 2Vpp (record below)
    b. Attach a 500kΩ resistor as RL to your iPod's output, measure Vout across RL
    c. Attach a 1kΩ resistor as RL to your iPod's output, measure Vout across RL
    d. Attach a 500Ω resistor as RL to your iPod's output, measure Vout across RL
    e. Attach a 100Ω resistor as RL to your iPod's output, measure Vout across RL
    f. Attach a 75Ω resistor as RL to your iPod's output, measure Vout across RL
    g. Attach a 50Ω resistor as RL to your iPod's output, measure Vout across RL
    h. Attach a 8Ω resistor as RL to your iPod's output, measure Vout across RL
3. Adjust the frequency to 1kHz, then 10kHz record the output voltage at each step
4. Calculate Rsig in each case, for each resistor value.



Frequency	Vout (peak) (no load)	Vout (500 kΩ)	1kΩ	500Ω	…
440 Hz					
1 kHz					
10 kHz					

Part 3 – Determining Input Impedance of a speaker

This procedure will be discussed in lab

Analysis

1. What is the output impedance of the iPod?
2. What is the output impedance of the function generator?
3. What is the input impedance of the speaker in your kit?