ECE2280 Review For EXAM 3

The material we have covered so far this semester is summarized (but NOT limited to) below:

1. Understand the basic operation of a BJT:
- Cutoff, saturation, active. Analyze a circuit for all current equations and voltages (current relationships)
  - Make sure to be able to take a Thevenin Equivalence and use Resistance Reflection Rules.
2. Understand the bias point concept for linear amplification.
3. Be able to separate the DC and AC analysis for a circuit containing a BJT.
4. Be able to analyze a circuit (with or without cap in it) containing a BJT for DC operation.
5. Be able to draw a small-signal model of a BJT circuit.
6. Analyze a small-signal circuit to find overall gain, midband gain, input resistance, and output resistan
7. Determine ω_L and ω_H or f_L and f_H.

Example 1

Use: **ignore r_o, $|V_{BE}|=0.7$, $\beta=50$**
$V_{sig} = 20+0.001\sin(20t)$
For DC analysis, assume that the capacitors are open

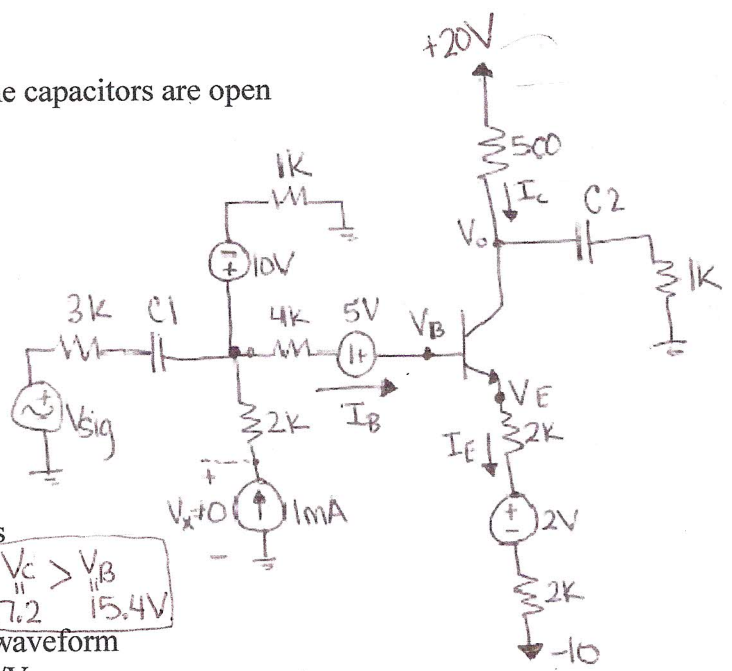
(a) Solve for the DC currents:
   a. $I_B = 111\mu A$
   b. $I_E = 5.7mA$
   c. $I_C = 5.6mA$

(b) Solve for the DC voltages:
   a. $V_B = 15.4V$
   b. $V_E = 14.7V$
   c. $V_o = 17.2V$

(c) What region of operation is this transistor acting? ACTIVE, $V_C > V_B$ ($17.2 > 15.4V$)

(d) Sketch the total instantaneous waveform observed for Vo if V_o/V_{sig}=5V/V.

$V_{o\,total} = 17.2 + 5m\sin(20t)$



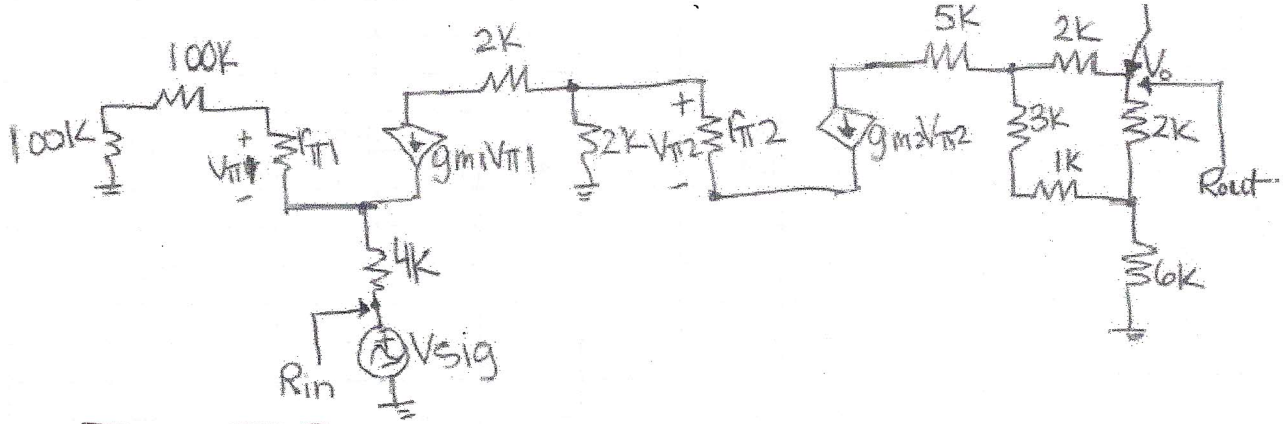
Example 2

Use: **ignore r_o and r_x, $|V_{BE}|=0.7$, $\beta=100$, $V_T=25mV$**
$V_I = 10+0.002\sin(20t)$

$r_{\pi 1}=50k\Omega$, $g_{m2}=50mA/V$

For the following hybrid-π equivalent circuit below, find the following values:

(a) R_{in} (input resistance –ignore only the input source, Vsig and include **all** resistors at the emitter)
(b) R_{out} (output resistance-include **all** resistors at the collector{no load is connected})
(c) midband gain, $\frac{Vo}{Vsig}$



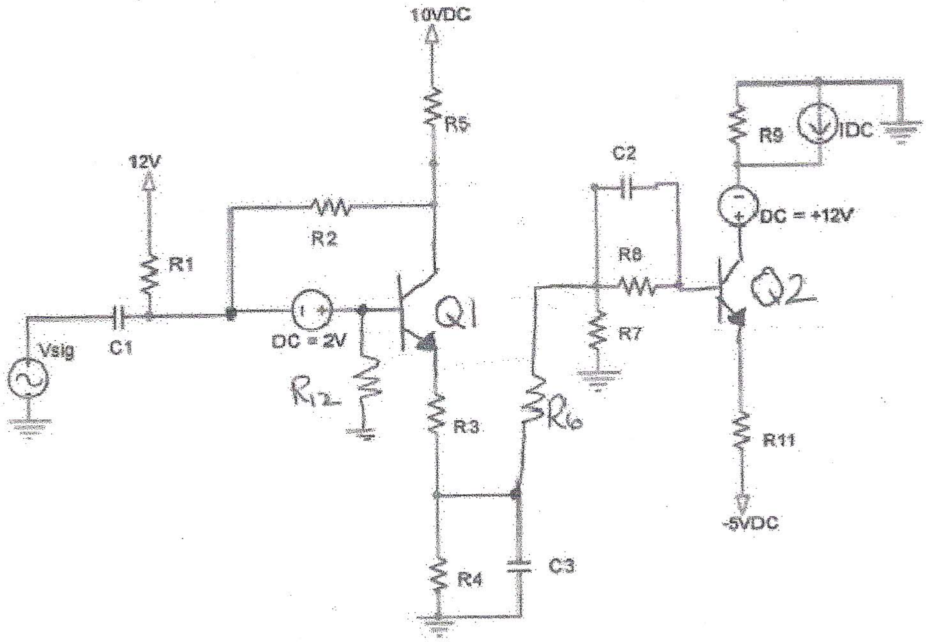
$R_{in} = 8.9K$

$R_{out} = 7.5K$

$\frac{V_o}{V_{sig}} = -26\,V/V$

Example 3

For the circuit shown below, **draw** the AC small-signal equivalent circuit(use hybrid-π or model T). Make sure that everything is labeled in terms of the transistor number. (e.g. g_{m1}, $v_{\pi 2}$, etc.). **Include r_o for all transistors.** v_{sig}=0.001sin(10t) AC. Assume that the capacitors act as a short.



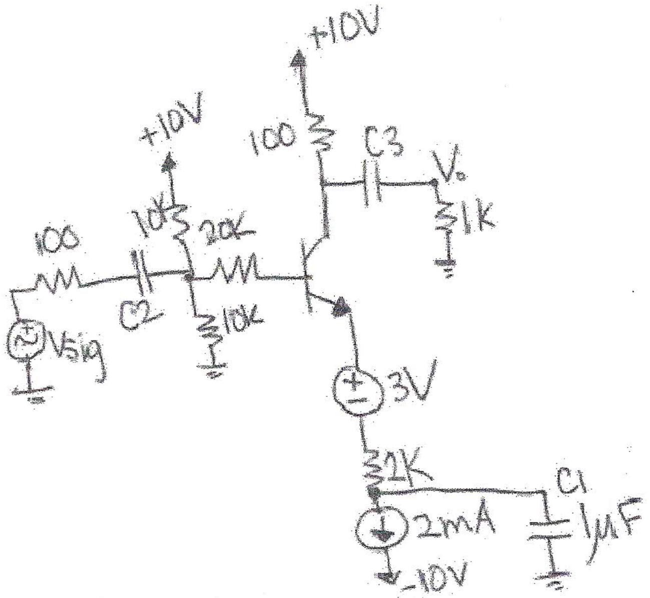
Example 4

Use: g_m=80mA/V, V_T=25mV, β=100, ignore r_o and use r_x=20Ω. Use the attached datasheet for all other values: (Assume C1 yields the highest pole value.)

(a) What frequency pole value does C1 create? (express the answer in rad/sec.) 47.8 rad/sec

(b) What is the frequency range for this circuit(Hint: Find the high frequency value)?

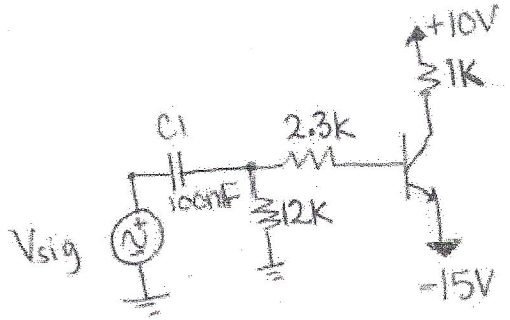
7.5Hz to 459kHz



Example 5

$|V_{BE}|=0.7$, $\beta=100$, $V_T=25mV$, ignore r_o, and r_x, $v_{sig}=\{2+0.1\sin(\omega t)\}$Volts. Assume that the capacitor acts as an open for DC operation and short for AC operation. Does this circuit operate as a **linear** AC amplifier? If so, what is the gain, $\frac{Vo}{Vsig}$, of the following circuit? **If not, explain why**. Assume output is taken at collector of transistor. If in saturation, use the datasheet values to determine $\beta_{\mathbf{forced}}$.

$\beta_{forced} = 24.8$



NPN General Purpose Amplifier
(continued)

2N3904 / MMBT3904 / PZT3904

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter	Test Conditions	Min	Max	Units
OFF CHARACTERISTICS					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	I_C = 1.0 mA, I_B = 0			V
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	I_C = 10 μA, I_E = 0			V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	I_E = 10 μA, I_C = 0			V
I_{BL}	Base Cutoff Current	V_{CE} = 30 V, V_{EB} = 3V			nA
I_{CEX}	Collector Cutoff Current	V_{CE} = 30 V, V_{EB} = 3V			nA
ON CHARACTERISTICS*					
h_{FE}	DC Current Gain	I_C = 0.1 mA, V_{CE} = 1.0 V I_C = 1.0 mA, V_{CE} = 1.0 V I_C = 10 mA, V_{CE} = 1.0 V I_C = 50 mA, V_{CE} = 1.0 V I_C = 100 mA, V_{CE} = 1.0 V	 30		
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_C = 10 mA, I_B = 1.0 mA I_C = 50 mA, I_B = 5.0 mA		0.2 0.3	V V
$V_{BE(sat)}$	Base-Emitter Saturation Voltage	I_C = 10 mA, I_B = 1.0 mA I_C = 50 mA, I_B = 5.0 mA	0.65	0.85 0.95	V V
SMALL SIGNAL CHARACTERISTICS					
f_T	Current Gain - Bandwidth Product	I_C = 10 mA, V_{CE} = 20 V, f = 100 MHz	300		MHz
C_{obo}	Output Capacitance	V_{CB} = 5.0 V, I_E = 0, f = 1.0 MHz		4.0	pF
C_{ibo}	Input Capacitance	V_{EB} = 0.5 V, I_C = 0, f = 1.0 MHz		8.0	pF
NF	Noise Figure	I_C = 100 μA, V_{CE} = 5.0 V, R_S = 1.0kΩ, f=10 Hz to 15.7kHz		5.0	dB