ID: ……………… Name ……………………………………………………….

Part I (20 minutes, 10 points)

1) Each statement is either **true (T)** or **false (F)**: **T** **F**

a) A **resistor** can used as a **source of EM radiation** ◯ ◯

b) A **diode** can be used as a **source of EM radiation** ◯ ◯

c) **BJTs** are **linear devices** ◯ ◯

d) **OpAmps** are linear **devices** ◯ ◯

e) **Drain and source** of a **MOSFET** are interchangeable ◯ ◯

2) The current across a **forward-biased pn junction** is controlled by what process?

[ ]

3) The **dc model** of the **input port of a MOSFET** (gate to source) is modeled as what?

[ ]

4) If the voltage across a pn junction diode increases by **10 mV**, the current changes by

[**%**] (assume $\mathbf{nV_T=30\ mV}$)

5) Which of the following statements apply to a **common-drain MOSFET amplifier**?

A) High voltage gain ◯

B) No voltage gain ◯

C) High output resistance ◯

D) Low input resistance ◯

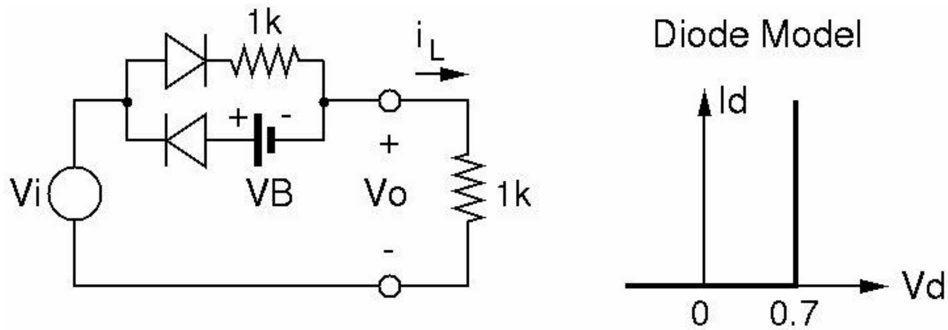
6) If $\mathbf{(V_{GS}-V_t)}$ of a **MOSFET** in saturation **doubles**, the current increases by

[**%**]

ID: ……………. Name ………………………………………………………..

Part II (150 minutes, 40 points)

1) Diode Circuit



Vi = 5V sin(ωt) and V_B=1 V dc

a) What is the **minimum** value of **Vo** under the given operating conditions?

b) Find the **maximum** value of **Vo** for the given operating conditions.

c) Derive a **value** for the **load current I_L** if the **input Vi=0**.

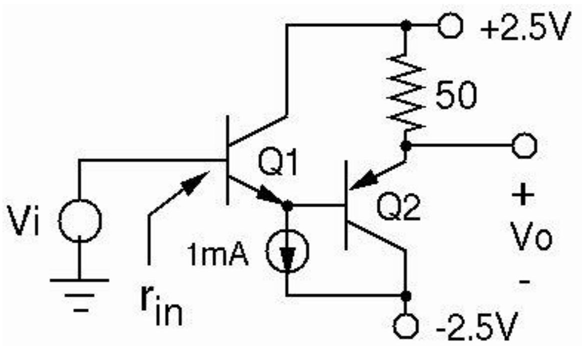
Answers

a) Vo_{min} = ………………..

b) Vo_{max} = ……………..

c) I_L = ………………

2) BJT Amplifier



Transistor Parameters

$\beta_1 = \beta_2 = 100$
$V_{A1} = V_{A1} = \infty$
$V_{BEQ1} = 0.6$ V
$V_{BEQ2} = -0.7$ V
$nV_T = 30$ mV

a) Find the values of the two transistor **bias currents I_{C1} and I_{C2}**, respectfully, if you know that **Vi** is an **ideal ac source** with **a zero dc component**.

b) Sketch the **small signal equivalent circuit** and determine the values of the two **equivalent base-emitter resistors, r_{be1} and r_{be2}**, respectfully.

c) Find **expressions** and a numerical **values** for the **input resistance r_{in} and the small signal voltage gain A_V=vo/vi**.

Answers

a) **I_{C1} = ………….......**

I_{C2} = ………………

b) **r_{be1} = ……………..**

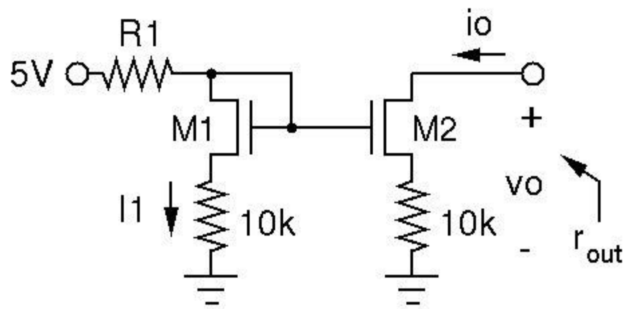
r_{be2} = ……………..

Draw **small signal** equivalent circuit here

c) **r_{in} = ………………**

A_V = ………………

3) MOSFET Current Source



Transistor Parameters

$V_{t1} = V_{t2} = 0.5$ V
$\lambda_1 = \lambda_2 = 0.04\ V^{-1}$
$\mu C_{ox}W/L_1 = 400\ \mu A/V^2$
$\mu C_{ox}W/L_2 = 400\ \mu A/V^2$

a) Find a value for $\mathbf{R_1}$ such that $\mathbf{I_1=50\ \mu A}$.

b) Sketch the **small signal equivalent circuit** of this current source and indicate the value of the **output resistance** $\mathbf{r_{o2}}$ of M_2 if I_1 remains at **50 μA**.

c) Derive an **expression** and find a **value** for the current source **output resistance** $\mathbf{r_{out}}$.

Answers

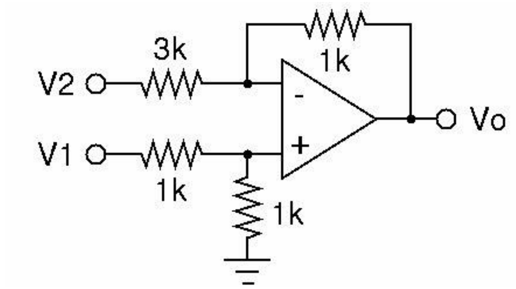
a) $\mathbf{R_1}$ **= ………………**

b) $\mathbf{r_{o2}}$ **= …………………**

Draw **small signal** equivalent circuit here

c) $\mathbf{r_{out}}$ **= …………………**

4) Differential Amplifier with OpAmp



For questions a) – c) you can assume that the **OpAm**p is **ideal**

a) Find a value for the voltage gain $\mathbf{A_{V1}=V_O/V_1}$ under the condition $\mathbf{V_2=0}$.

b) Derive a value for the voltage gain $\mathbf{A_{V2}=V_O/V_2}$ if $\mathbf{V_1=0.}$

c) Find the **peak output voltage** $\mathbf{Vo_{peak}}$ **if** $\mathbf{V_1=2}$ **V dc** while$\mathbf{V_2}$ is a sinusoidal voltage with an **amplitude of 1 V.**

Bonus Question (3 extra points)

If the Opamp features an **open-loop gain** of **200,000** and a constant **20 dB/decade** roll-off starting at **50 Hz,** find the **3 dB corner** of the voltage gain function $\mathbf{A_{V2}(f)}$**.**

Answers

d) $\mathbf{A_{V1}}$ **= ………………**

e) $\mathbf{A_{V2}}$ **= …………………**

f) $\mathbf{Vo_{peak}}$ **= …………………**

Bonus: $\mathbf{f_{3dB}}$ **= ………………..**