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EEEB273 - Quiz 3 [Question Set 1]
SEMESTER 2, ACADEMIC YEAR 2012/2013
Date: 19 December 2012 **--- Pop Quiz ---**

Question:

Study the output stage circuit shown in **Figure 1** carefully. Let R_L **= 1 kΩ,** V_{BB} **= 1.42 V** and the reverse saturation current for the transistors, I_S **= 2 x 10^{-15} A**. **Assume** β **>> 1**. For the case of the output voltage v_O **= -3.8 V**:

(a) **Determine** i_L, i_{Cp}, and i_{Cn}. [6 marks]

(b) **Calculate** the power dissipated in transistor Q_n and Q_p. [4 marks]

Write your answer **using pen,** in 4 decimal points, with **proper Units** for the parameters.

Answer:

(a)

$v_O = -3.8\text{ V} = i_L R_L$ [0.5]

➔ $i_L = v_O/R_L = (-3.8\text{V})/(1\text{k}\Omega) = -3.8\text{ mA}$ [1]

Therefore, Q_p is conducting and Q_n is OFF.

Approximate value

$|i_L| \approx i_{Cp} = I_S \exp(V_{EBP}/V_T) = 3.8\text{ mA}$ [0.5]

$V_{EBP} = V_T \ln(i_{Cp}/I_S)$

$= (26\text{m}) \ln(3.8\text{m}/2\text{x}10^{-15}) = 0.73509\text{ V}$ [0.5]

$V_{BEN} = V_{BB} - V_{EBP} = 1.42 - 0.73509 = 0.68491\text{ V}$ [0.5]

➔ $i_{Cn} = I_S \exp(V_{BEN}/V_T)$

$= (2\text{x}10^{-15}) \exp(0.68491/0.026) = \mathbf{0.55136\text{ mA}}$ [1]

$i_{Cn} = i_{Cp} + i_L$ [0.5]

Actual value of

$i_{Cp} = i_{Cn} - i_L = 0.55136\text{m} - (-3.8\text{m})$ [1]

➔ $i_{Cp} = \mathbf{4.35136\text{ mA}}$ [0.5]

2nd iteration

$V_{EBP} = 0.73862\text{ V}$

$V_{BEN} = 0.68138\text{ V}$

$i_{Cn} = \mathbf{0.48150\text{ mA}}$

$i_{Cp} = \mathbf{4.28150\text{ mA}}$

(b) Power dissipation:

$P_{Qn} = i_{Cn} V_{CEn}$ [1]

$V_{CEn} = +V_{CC} - v_O = +6 - (-3.8) = 9.8\text{ V}$ [0.5]

➔ $P_{Qn} = \mathbf{(0.55136\text{ mA})(9.8\text{ V}) = 5.40334\text{ mW}}$ [0.5]

Or $P_{Qn} = \mathbf{(0.48150\text{ mA})(9.8\text{ V}) = 4.71869\text{ mW}}$

$P_{Qp} = i_{Cp} V_{ECp}$ [1]

$V_{ECp} = v_O - (-V_{CC}) = -3.8 - (-6) = 2.2\text{ V}$ [0.5]

➔ $P_{Qp} = \mathbf{(4.35136\text{ mA})(2.2\text{ V}) = 9.5730\text{ mW}}$ [0.5]

Or $P_{Qp} = \mathbf{(4.28150\text{ mA})(2.2\text{ V}) = 9.4193\text{ mW}}$

Note: Answer in red can be accepted.

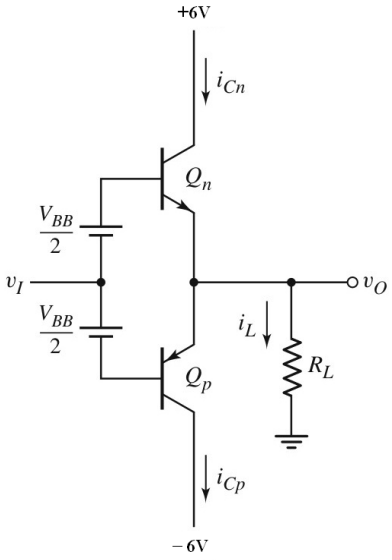

Figure 1

VT (V)	0.026

Pop Quiz 3	QS1	QS2	QS3	QS4
Vcc (V)	6	6	6	6
-Vcc (V)	-6	-6	-6	-6
Vbb (V)	1.420	1.420	1.380	1.380
Is (x10^-15 A)	2.000	2.000	2.000	2.000
Vo (V)	-3.8	-3.6	-3.8	-3.6
RL (kΩ)	1	1	1	1

IL = Vo/RL	IL (mA)	**-3.80000**	**-3.60000**	**-3.80000**	**-3.60000**
iCp ≈ IL	iCp (mA)	3.80000	3.60000	3.80000	3.60000
VEBp = VTln(iCp/Is)	VEBp (V)	0.73509	0.73369	0.73509	0.73369
VBEn = Vbb - VEBp	VBEn (V)	0.68491	0.68631	0.64491	0.64631
iCn1 = Is exp(VBEn/VT)	iCn1 (mA)	**0.55136**	**0.58199**	**0.11838**	**0.12496**
iCp1 = iCn1 - IL	iCp1 (mA)	**4.35136**	**4.18199**	**3.91838**	**3.72496**
VEBp1 = VTln(iCp1/Is)	VEBp1 (V)	0.73862	0.73759	0.73589	0.73458
VBEn1 = Vbb - VEBp1	VBEn1 (V)	0.68138	0.68241	0.64411	0.64542
iCn2 = Is exp(VBEn1/VT)	iCn2 (mA)	**0.48150**	**0.50100**	**0.11481**	**0.12077**
iCp2 = iCn2 - IL	iCp2 (mA)	**4.28150**	**4.10100**	**3.91481**	**3.72077**
VCEn = Vcc - Vo	VCEn (V)	9.80	9.60	9.80	9.60
PQn1 = VCEn * iCn1	PQn1 (mW)	**5.40334**	**5.58713**	**1.16016**	**1.19962**
PQn2 = VCEn * iCn2	PQn2 (mW)	**4.71869**	**4.80959**	**1.12511**	**1.15938**
VECp = Vo - (-Vcc)	VECp (V)	2.20	2.40	2.20	2.40
PQp1 = VECp * iCp1	PQp1 (mW)	**9.57300**	**10.03678**	**8.62044**	**8.93990**
PQp2 = VECp * iCp2	PQp2 (mW)	**9.41930**	**9.84240**	**8.61258**	**8.92984**