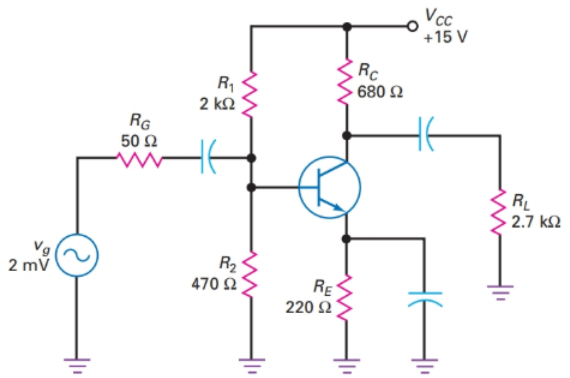
Power Amplifier

Jiwook Kim

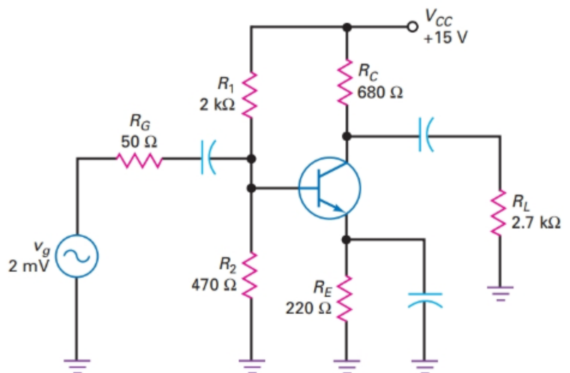
1 What is the DC collector resistance in Fig. 10-38? What is the DC saturation current?



Collector resistance.
R_C = 680Ω

DC saturation current.
I_{Cmax} = V_{CC}/(R_E + R_C) = 15V/(680Ω + 220Ω) = 16.67mA

2 In Fig. 10-38, what is the AC collector resistance? What is the AC saturation current?



AC collector resistance

$R_C||R_l$ = 680Ω||2.7kΩ = 540Ω

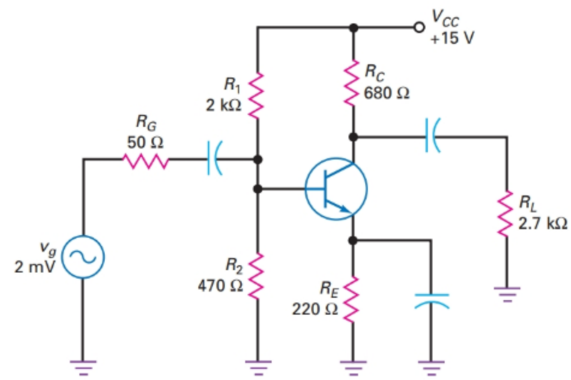
AC saturation current

V_{BB} = V_{CC} * $R2$ / $(R1 + R2)$ = 15V * 470/(2000+470) = 2.85V
V_E = V_{BB}-0.7V = 2.15V
$I_{CQ} \approx I_E$
I_E = V_E/R_E = 9.77mA

V_{CE} = V_{CC}-I_{CQ}*-R_C-V_E = 15V-9.77mA*680Ω-2.15V = 6.2V

$I_{C(sat)}$ = I_{CQ}+V_{CE}/r_c = 9.77mA+6.2V/0.54kΩ = 21.25mA

3 What is the maximum peak-to-peak output in Fig. 10-38?



V_{BB} = V_{CC} * $R2$ / $(R1 + R2)$ = 15V * 470/(2000+470) = 2.85V
V_E = V_{BB} - 0.7V = 2.15V
$I_{CQ} \approx I_E$
I_E = V_E/R_E = 9.77mA

V_{CE} = V_{CC}-I_{CQ}*-R_C-V_E = 15V-9.77mA*680Ω-2.15V = 6.2V

$I_{C(sat)}$ = I_{CQ}+V_{CEQ}/r_c = 9.77mA+6.2V/0.54kΩ = 21.25mA

MPP(maximum peak to peak output) $<$ 15V

I_{CQ}*r_c = 9.77mA * 0.54kΩ = 5.3V

V_{EQ} = 6.2V

MPP(maximum peak to peak output voltage) = 2*5.3V = 10.6V

4 An amplifier has an input power of 4mW and output power of 2 W. What is the power gain?

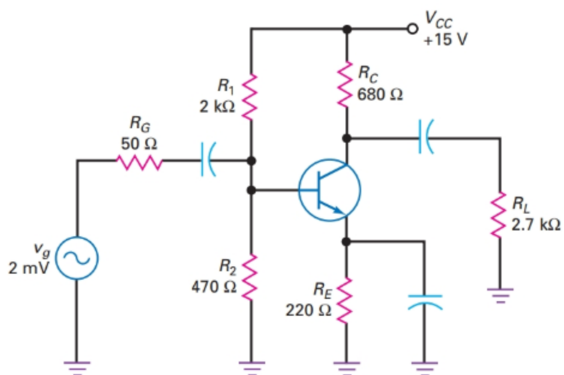
A_P = p_{out}/p_{in} = 2W / 4mW = 500

5 If an amplifier has a peak-to-peak output voltage of 15V across a load resistance of 1 kΩ, what is the power gain if the input power is 400 W?

P_{out} = V^2/(8R_l)
$(15V)^2$/(8*1kΩ) = 28.125mW

A_P = P_{out}/P_{in} = 28.125mW/400μW =70.3
The power gain of the amplifier is 70.3

6 What is the current drain in Fig. 10-38.



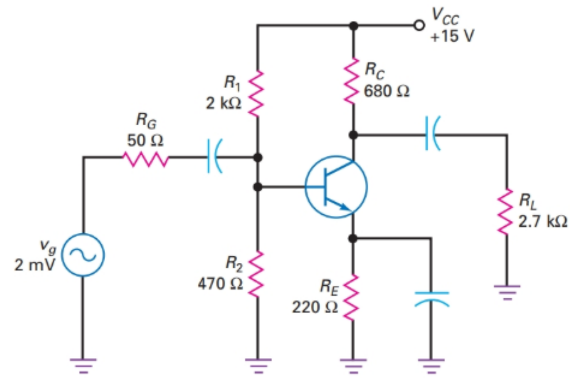
V_{BB} =470Ω/(2kΩ+470Ω)*15 = 2.85V
V_{EE} = 2.85V - 0.7V = 2.15V
I_{EE} = V_{EE}/R_{EE} = 2.15V/220Ω = 9.77mA

I_{Bias} = V_{CC}/($R_1 + R_2$) = 15V/2470Ω = 6.07mA

The drain current is

I_{DC} = I_{Bias} + I_{CQ} = 6.07mA + 9.77mA = 15.84mA

7 What is the DC power supplied to the amplifier of Fig. 10-38?



V_B = R_2/(R_2 + R_1) 15V = 470/2470 *15V = 2.85V

V_E = V_B - 0.7V = 2.15V

I_E = V_E/R_E = 2.15V/220Ω = 9.77mA

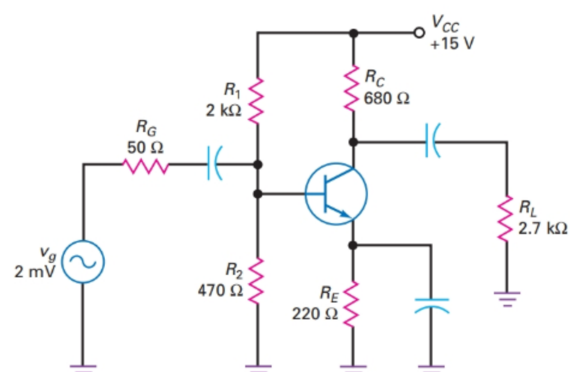
I_{CQ} ≈I_E = 9.77mA

I_{bias} = V_{CC}/($R_1 + R_2$)
I_{bias} = 15V/(2kΩ + 470Ω) = 6.07mA

I_{dc} = I_{bias} + I_{CQ} = 6.07mA + 9.77mA = 15.84mA

P_{DC} = V_{CC}*I_{DC} = 15V * 15.84mA = 237.6mW

8 The input signal of Fig. 10-38 is increased until maximum peak-to-peak output voltage is across the load resistor. What is the efficiency?



V_B = (470Ω)/(2kΩ + 470Ω)*15V = 2.85V

V_E = V_B - 0.7V = 2.85V - 0.7V = 2.15V
I_E = V_E/R_E = 2.15V/220Ω = 9.77mA
= 15V - 9.77mA*680Ω= 8.36V

V_C = V_{CC} - I_{CQ}*R_C
= 15V - 9.77mA*680Ω = 8.36V

V_{CEQ} = V_C - V_E = 8.36V - 2.15V = 6.21V

r_c = R_C|| R_L = 680Ω|| 2.7kΩ = 543Ω

MPP(maximum peak to peak output voltage) $<$15V

MP(maximum peak output voltage) $= I_{CQ} * R_C$ = 9.77mA * 543Ω = 5.3V

or

V_{CEQ} = 6.21V

MPP = 2*(MP) = 2*5.3V = 10.6V

I_{bias} = V_{cc}/(R_1+R_2) = 15V/(2kΩ+ 470Ω) = 6.07mA

I_{DC} = I_{bias} + I_{CQ} = 6.07mA + 9.77mA = 15.84mA

P_{DC} = V_{cc}*I_{dc} = 15V*15.84mA = 237.6mW

$P_{out(Max)}$ = $(MPP)^2$/8R_l = $(10.6V)^2$/8(2.7kΩ) = 0.520 mW

μ = P_{out}/P_{in} = 0.520 mW/237.6mW = 0.022 = 2.2%

9 What is the quiescent power dissipation in Fig. 10-3

V_B = 470Ω/2470Ω*15V = 2.85V

V_E = V_B - 0.7V = 2.15V

I_E = V_E/R_E = 9.77mA

I_{CQ} ≈I_E = 9.77mA

V_C = V_{CC} - I_{CQ}*R_C = 15V - 6.64V = 8.36V

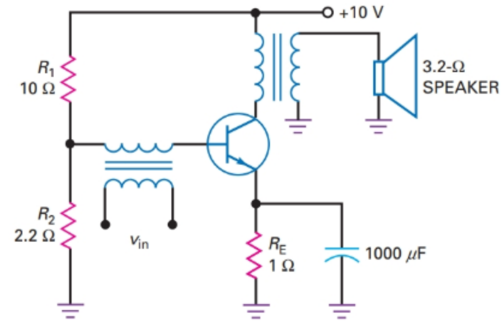
V_{CEQ} = V_C - V_E = 8.36V -2.15V = 6.21V

P_{DQ} = V_{CEQ}*I_{CQ} = 6.21V * 9.77mA = 60.67mW

Quiescent power dissipation is 60.67mW

10 If V_{BE} = 0.7 V in Fig. 10-40, what is the dc emitter current

Figure 10-40



V_B = 2.2Ω/12.2Ω*15V = 1.8V

V_E = V_B - 0.7V = 1.1V

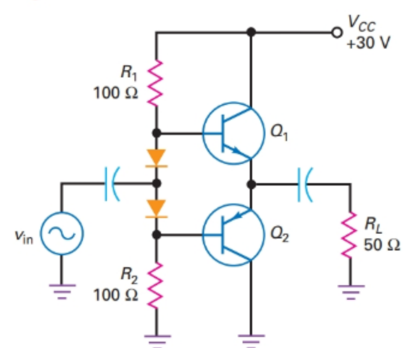
I_E = V_E/R_E = 1.1A

I_{CQ} ≈I_E = 1.1A

dc emitter current 1.1A

11 What is the quiescent collector current in Fig. 10-42?

Figure 10-42



I_{bias} = (V_{CC} - 2*V_{BE})/(2R) = (30V - 2*0.7V) / (200Ω) = 143 mA

quiescent collector current = 143mA

12 In Fig. 10-42, what is the maximum efficiency of the amplifier?

I_{bias} = (V_{CC} - 2*V_{BE})/(2R) = (30V - 2*0.7V) / (200Ω) = 143 mA

quiescent collector current = 143mA

$I_{c(sat)}$ = V_{CEQ}/R_l = (30V/2)/50Ω = 0.3A

$I_{c(average)}$ = $I_{c(sat)}$/π = 95.5mA

The total current drain
I_{dc} = I_{bias} + $I_{average}$ = 143 mA + 95.5mA = 238.5mA

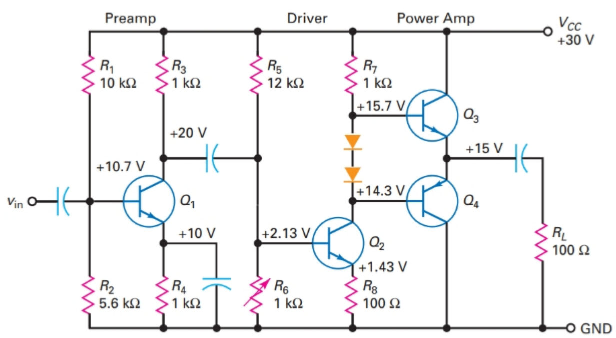
P_{dc} = (V_{CC})*(I_{DC}) = 30V *238.5mA = 7.155 W

The maximum ac output power is
P_{outmax} = $(MPP)^2$/($8R_l$) = 30^2/(8*50Ω) = 2.25W

The efficiency of the amplifier

μ = P_{outmax}/P_{in} * 100% = 2.25W/7.155W * 100% = 31.5%

13 What is the overall voltage gain for the three-stage amplifier in Fig. 10-43?



V_B = 10.7V
Thus, V_E = 10V
I_E = V_E / R_E = 10V/1kΩ = 10 mA

r'_e = 25mV/I_E = 2.5Ω

V_{B2} = 2.13V
Thus, V_{E2} = 1.43V
I_{E2} = V_{E2}/R_E = 1.43V/100Ω = 14.3mA

$r'_{e(driver}$ = 25mV/I_E = 1.75Ω

$Z_{in2(base)}$ = β * $r'_{e(driver}$ = 200*1.75 = 350Ω

$Z_{in(driver)}$ = $Z_{in2(base)}||R_5||R_6$ = $350\Omega||12k\Omega||1k\Omega$ = 254Ω.

Voltage gain of the first stage
A_{v1} = ($R_3||Z_{in(driver)}$)/r'_e = ($1k\Omega||250\Omega$)/2.5Ω = 81

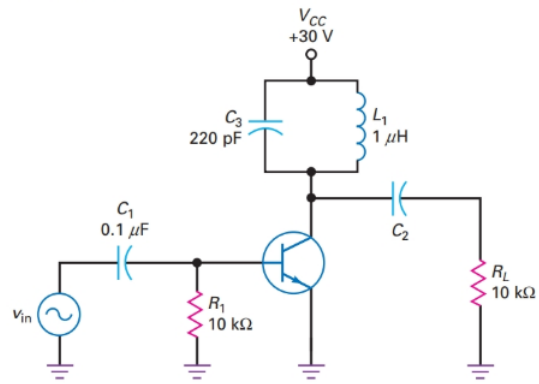
Voltage gain of a directly coupled amplifier
and the voltage gain of second stage.
A_{v2} = R_7/R_8 = 1kΩ/100Ω = 10

Third stage is push-pull amplifier stage, with a negative feedback. The voltage gain of push pull amplifier is 1.

A_v = A_{v1} * A_{v2} * A_{v3} = 81 * 10 * 1 = 810

The total voltage gain is 810

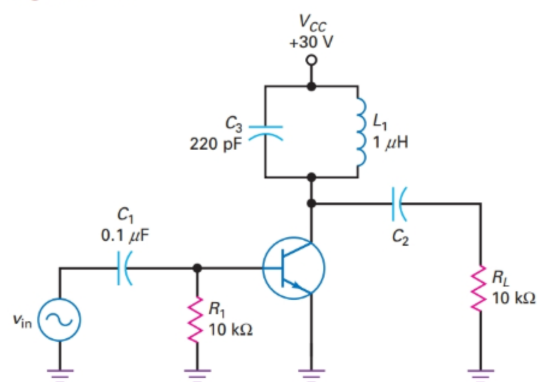
14 What is the resonant frequency in Fig. 10-44.



Resonant frequency

L= $1\mu H$
C = 220pF
f_r = 1/$(2pi*(L*C)^{1/2})$ = 1/$(2pi*(1\mu H*220pF)^{1/2})$
= 10.73Mhz

15 What is the efficiency of Fig. 10-44 if the current drain is 0.4mA and the output voltage is 30V pp.



I_{DC} = 0.4 mA
The output peak to peak voltage is 30V

P_{DC} = I_{DC} * V_{CC} = 30V * 0.4 mA = 12mW

The ac output power
P_{out} = $(MPP)^2$/(8*R_l) = 30V^2 /(8*10kΩ) = 11.25 mW

Efficiency
μ = P_{out}/P_{in} * 100% = 11.25mW/12mW * 100% = 93.75%