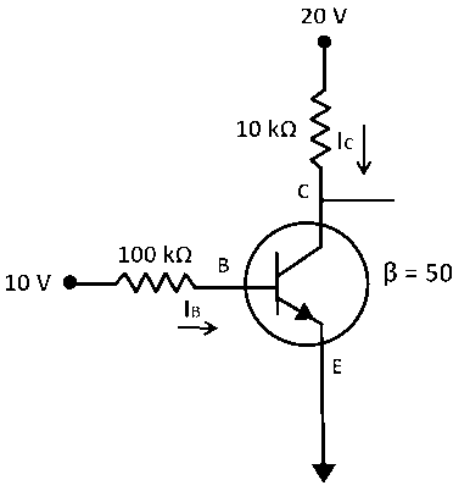
BJT Basics

Review Exercise 1



If the given BJT is in forward active mode-

a) Find I_B.
b) Find I_C.
c) Find V_C.
d) What verifies that the BJT is in forward active mode?

$Ans: a)\ 0.093\ mA$
$b)\ 4.65\ mA$
$c)\ -26.5\ V$
$d)\ V_E > V_C$ or $V_{CE} < 0$

Review Practice Problem 1

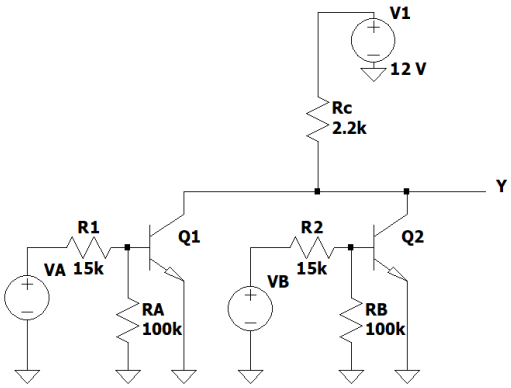
If the BJT in **Review Exercise 1** is in saturation mode-

a) Find I_B.
b) Find I_C.
c) Find I_E.

$Ans: a)\ 0.092\ mA$
$b)\ 1.98\ mA$
$c)\ 2.072\ mA$

Basic Operation

Exercise 1



For the RTL NOR gate-

a) Determine the output voltage V_Y for all logic cases & make a table. Verify your operating mode assumptions.
b) What is the high & low threshold for output voltage?
c) If R_B is doubled, find the new base current of Q_2. Will it still satisfy saturation mode conditions for Q_2 for the cases (1,1) & (0,1)?

[Assume 0.2 V as low input voltage, $\beta_F = 30$]

$Ans: a)\ 12\ V, 0.2\ V, 0.2\ V, 0.2\ V$

$b)\ 12\ V, 0.2\ V$

$c)\ 0.742\ mA, Yes$

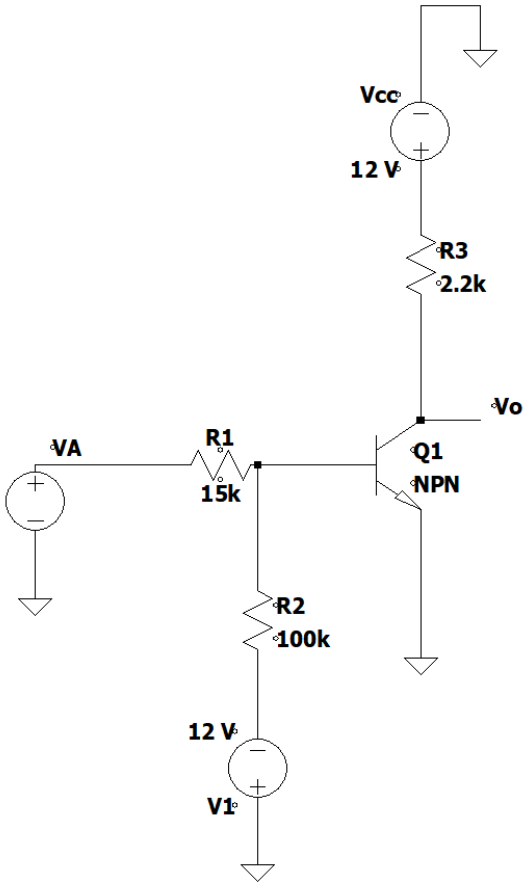
Practice Problem 1:

For the RTL NOR gate in **Exercise 1**, using the value or R_B in (d), find the base voltage of Q_2 and verify whether it meets the condition for cutoff for (0,0) & (1,0).

$Ans: V_b = 0.18\ V < 0.5\ V, satisfies$

Power Dissipation

Exercise 2



For the RTL inverter, find the maximum & average power dissipation.

[High input = 12 V, Low input = 0.2 V]

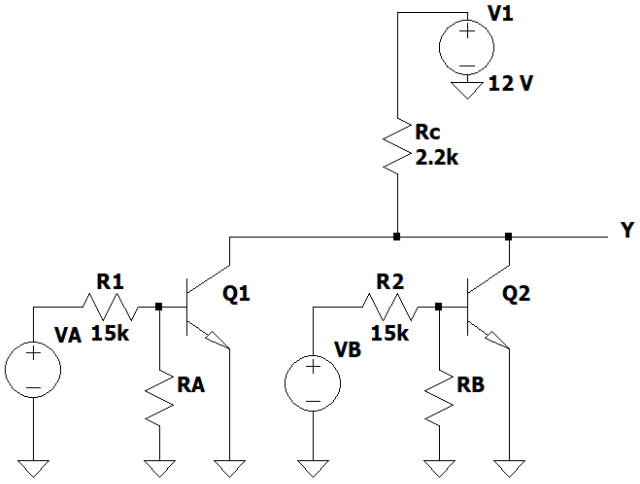
Ans: 74.856 mW, 38.0746 mW

Practice Problem 2:

For the RTL inverter in **Exercise 2**, find the ratio of maximum & minimum power dissipation, **if $V_1(-12\ V)$ was missing.**

Ans: 21249 4.7: 1

Exercise 3



For the RTL NOR gate shown-

a) If, $R_A = R_B$, and the power dissipation for logic case (0,0) is $0.25\ \mu W$, find the value of the resistances.

[$V_{BE}(saturation) = 0.8\ V, V_{CE}(saturation) = 0.2\ V$]
Assume a low input voltage of 0.2 V

Ans: 145 kΩ

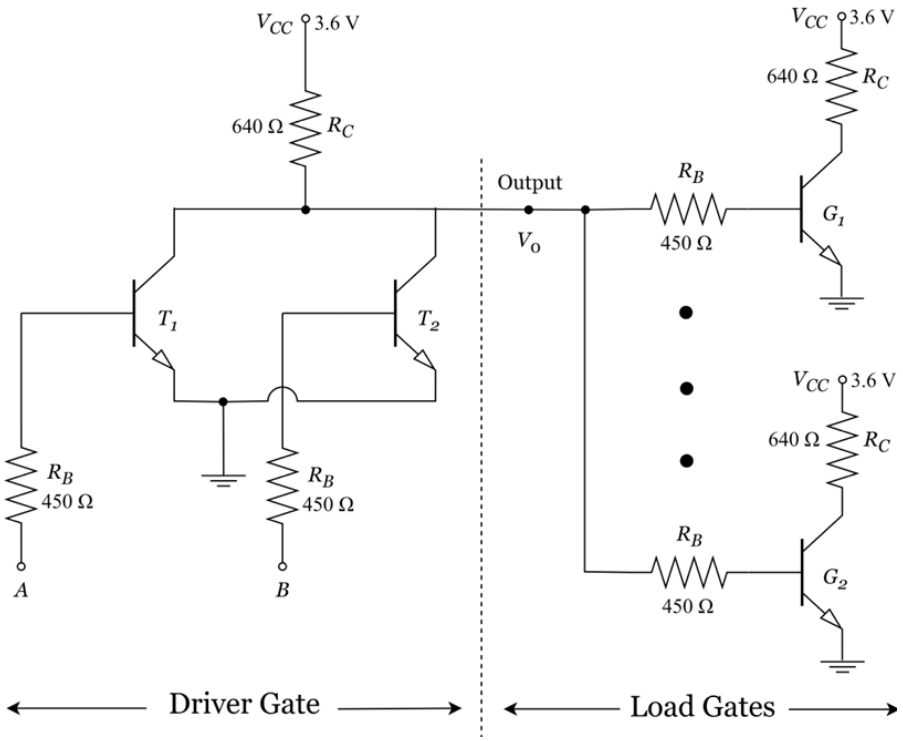
Practice Problem 3:

In the circuit of Exercise **3**, find a new value of R_c required to double the maximum power dissipation in the circuit.

Ans: 0.966 kΩ

Noise Margin

Exercise 4



For the RTL NOR driver & RTL NOT loads, find the noise margin.

Assume
$V_{OH} = 3.5\ V$
$V_{IL} = 0.2\ V$
$\beta_F = 30$

Ans: 0.3 V

Practice Problem 4:

In the circuit of **Exercise 4**, what value of R_B will make $N_H = N_L$?

Ans: 13.55 kΩ

Fanout

Exercise 5

For the RTL NOR driver in **Exercise 4** if $V_{OH} = 1.3\ V$-

a) Find maximum fanout.
b) Find the value of V_o if fanout (N) = 5, and both inputs are low.
c) Find $(\beta_F)_{min}$ (for the loads) the power dissipation of the loads only for conditions in (b).
d) Find the power dissipation in the driver only when both inputs are high.
e) If N=1, what logic function does the driver-load combination implement?

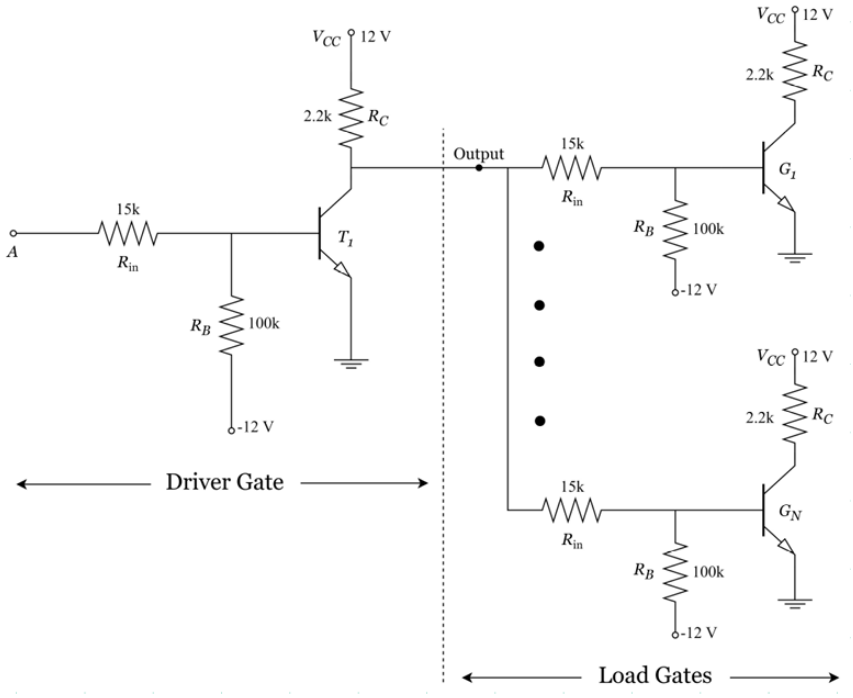
Practice Problem 5:

What value of V_{OH} would reduce the maximum fanout of the RTL NOR gate to 2 in **Exercise 5**?

$Ans: 2.18\ V$

Mixed

Exercise 6

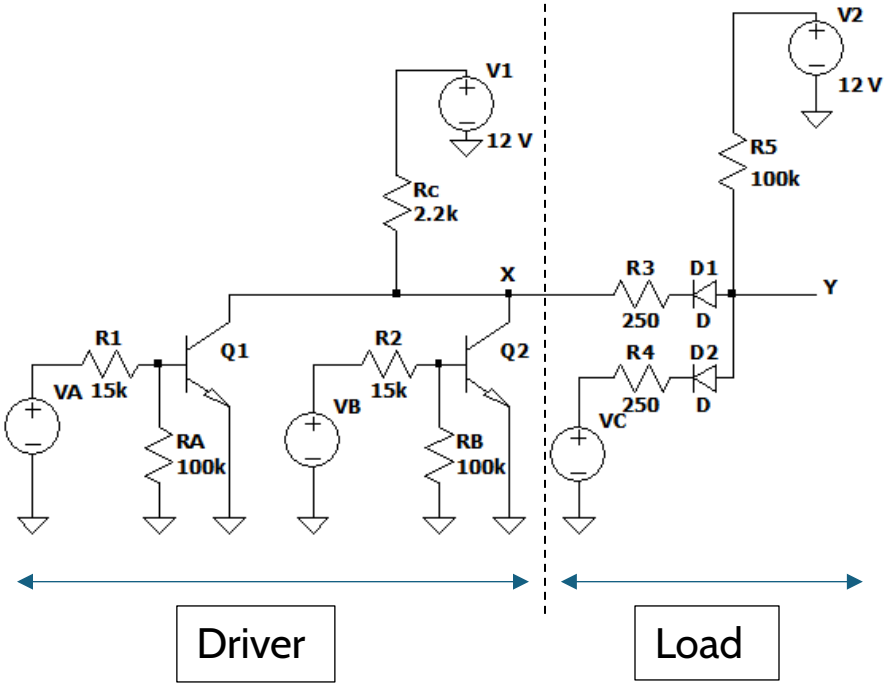


For the given RTL inverters,
$V_{OH} = 10\ V, V_{OL} = 0.2\ V$
$\beta_F = 30$

a) Find maximum fanout.
b) Find V_o for N=2 loads, and the input of the driver is low.
c) If V_{in} is high, find the power dissipation of the driver circuit.
d) If V_{in} is low and fanout=2, find the power dissipation of the total circuit (driver + loads).
e) Find the noise margin.

$Ans: a)\ 1$
$b)\ 9.46\ V$
$c)\ 74.86\ mW$
$d)\ 146.95\ mW$
$e)\ 2.175\ V$

Exercise 7



For the circuit given-

a) What logic function does it implement?
b) Find maximum fanout.
c) Find the max power dissipation of the circuit.

Assume
$V_{OH} = 11.5\ V$
$V_{OL} = 0.2\ V, \beta_F = 25$

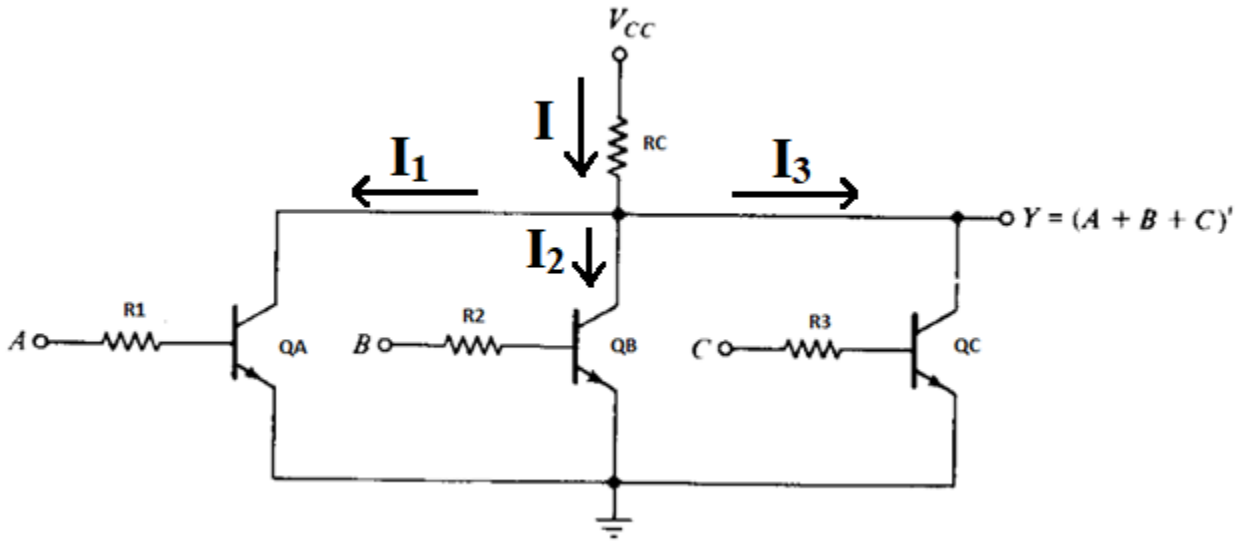
Ans:

a) $Y = \overline{A + B}.C$

b) 13

c) $65.7\ mW$

Exercise 8



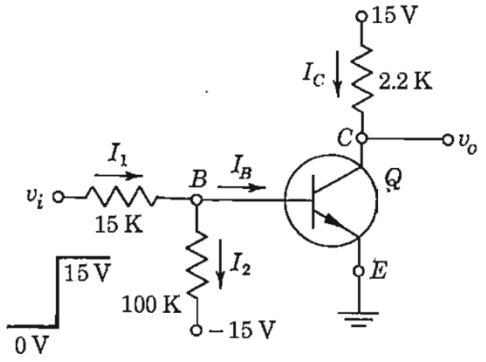
In this circuit $R_1 = R_2 = R_3 = 100\ k\Omega$, $R_C = 10\ k\Omega$, $V_{CC} = 20\ V$.

Now if the input voltages are $V_A = 0\ V, V_B = 10\ V, V_C = 10\ V$.

a) Find out the output voltage.
b) Find out the value of I.
c) Find out the value of I_2.
d) Find out the value of I_3.

Ans: a) 0.2 V
b) 1.98 mA
c) 0.99 mA
d) 0.99 mA

Exercise 9



For the RTL NOT gate shown,

When input is high-

a) Find the output voltage.
b) Find the value of I_C.
c) Find the value of I_1.
d) Find the value of I_2.
e) Find the value of I_B.

$Ans: a)\ 0.2\ V$

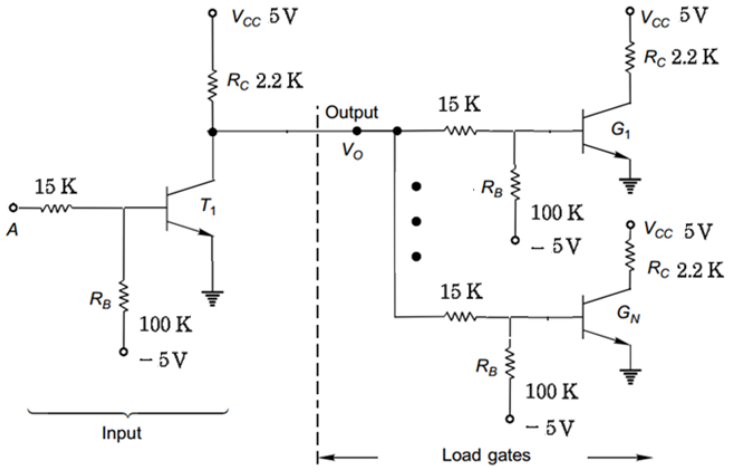
$b)\ 6.7272\ mA$

$c)\ 0.94667\ mA$

$d)\ 0.158\ mA$

$e)\ 0.78867\ mA$

Exercise 10



For the above RTL inverter driver & loads, assume

$V_{OH} = 4\ V, V_{OL} = 0.2\ V, \beta_F = 30$

a) Find the value of V_{IL}.
b) Find the value of V_{IH}.
c) Calculate the noise margin.
d) Find the maximum number of FANOUT for this circuit.

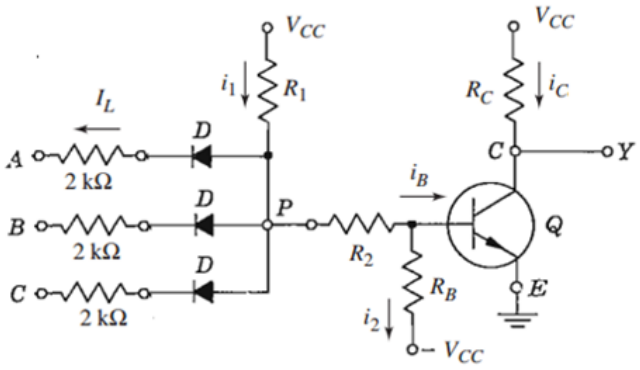
$Ans: a)\ 1.325\ V$

$b)\ 2.761\ V$

$c)\ 1.125\ V$

$d)\ 2$

Exercise 11



For the given circuit, $\beta_F = 30, V_{CC} = 12\ V$,
$R_1 = R_2 = 15\ k\Omega, \mathrm{R_C} = 2.2\ \mathrm{k\Omega}, \mathrm{R_B} = 100\ \mathrm{k\Omega}$
Assume $V_A = 0.1\ V, V_B = V_C = 12\ V$
For this part assume inputs of the load devices are not connected to the driver device.

a) Find I_L.
b) Find i_1.
c) Find i_2.
d) Find I_B.
e) Find I_C.
f) Find the power dissipated in this case.

Ans: a) $0.5521\ mA$
b) $0.673\ mA$
c) $0.121\ mA$
d) $0\ mA$
e) $0\ mA$
f) $9.474\ mW$

Exercise 12

For the circuit in Exercise 11, assume $V_A = V_B = V_C = 12\ V$

For this part assume inputs of the load devices are not connected to driver device.

a) Find I_L.
b) Find i_1.
c) Find i_2.
d) Find I_B.
e) Find I_C.
f) Find the power dissipated in this case.
g) Find the value of β_{min}.

Ans: a) 0
b) $0.37334\ mA$
c) $0.128\ mA$
d) $0.245334\ mA$
e) $5.41\ mA$
f) $70.936\ mW$
g) 22.051