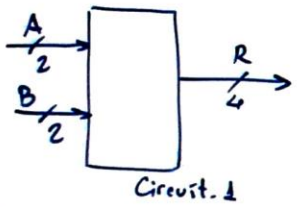
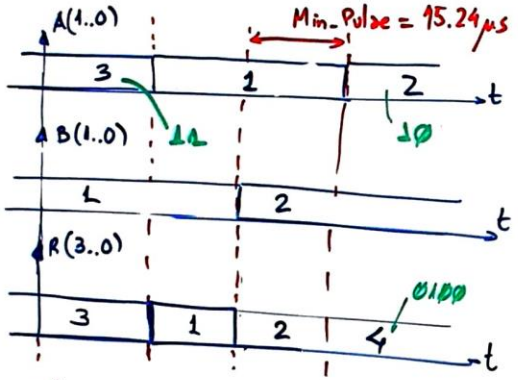
Problem 1

①



$R_i = f(B_1, B_0, A_1, A_0)$



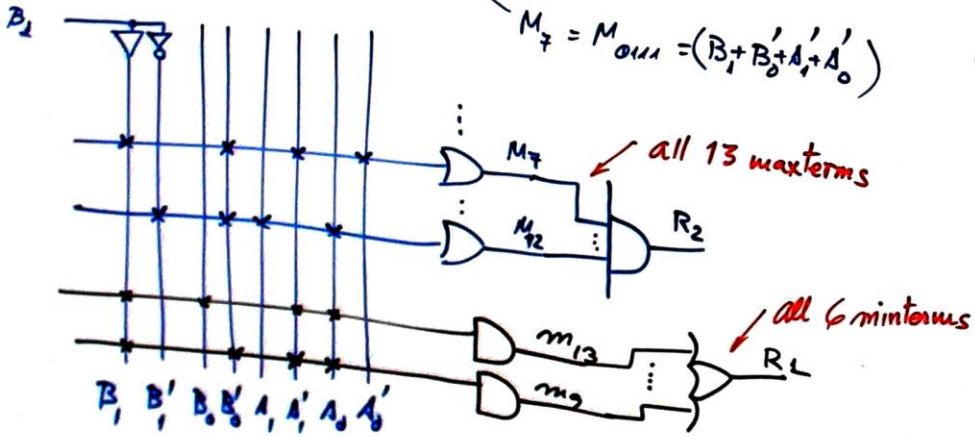
To test all combinations → $2^4 \cdot \text{Min\_Pulse} = 243.84\ \mu s$

The circuit is working as a 2-bit multiplier

② $R_2 = \prod M(0,1,2,3,4,5,6,\textcircled{7},8,9,\textcircled{12},13,15)$

$M_{12} = M_{1100} = (B_1' + B_0' + A_1 + A_0)$

$M_7 = M_{0111} = (B_1 + B_0' + A_1' + A_0')$



$R_1 = \sum m(6,7,\textcircled{9},11,\textcircled{13},14)$

$m_{13} = m_{1101} = B_1 \cdot B_0' \cdot A_1 \cdot A_0$

$m_9 = m_{1001} = B_1 \cdot B_0' \cdot A_1' \cdot A_0$

③ $R_0 = m_5 + m_7 + m_{13} + m_{15}$

$= B_1' \cdot B_0 \cdot A_1' \cdot A_0 + B_1' \cdot B_0 \cdot A_1 \cdot A_0 + B_1 \cdot B_0 \cdot A_1' \cdot A_0 + B_1 \cdot B_0 \cdot A_1 \cdot A_0$

0 1 0 1 0 1 1 1 1 1 0 1 1 1 1 1

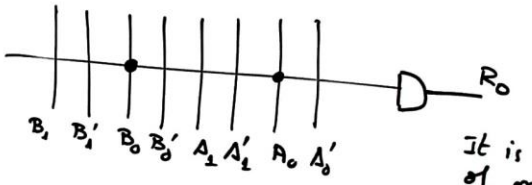
$= B_1' \cdot B_0 \cdot A_0 (A_1' + A_1) + B_1 B_0 A_0 (A_1' + A_1)$

$(A_1' + A_1) = 1$, $(A_1' + A_1) = 1$

$= B_1' \cdot B_0 \cdot A_0 + B_1 \cdot B_0 \cdot A_0 = B_0 \cdot A_0 (B_1' + B_1)$

$(B_1' + B_1) = 1$

$R_0 = B_0 \cdot A_0$



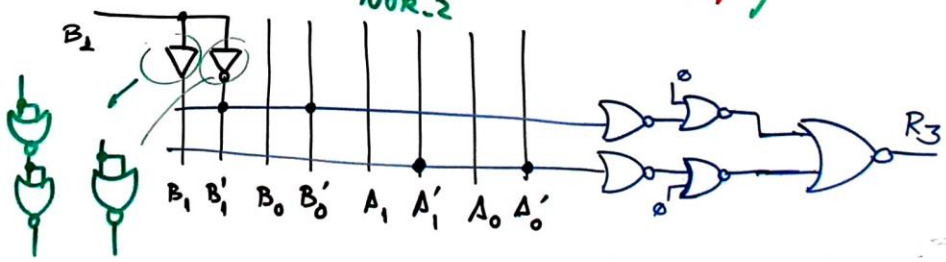
It is a simple product of only two literals

④ $R_3 = m_{15} = (B_1 \cdot B_0 \cdot A_1 \cdot A_0)'' = (B_1' + B_0' + A_1 + A_0')'$

NOR of 4 inputs

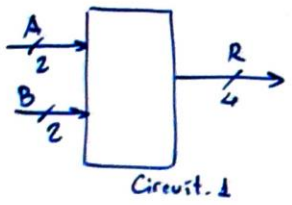
$(((B_1' + B_0')')' + ((A_1' + A_0')')')'$

NOR_2



Problem 1

⑤



$R_i = f(B_1, B_0, A_1, A_0)$

$R_3 \rightarrow$ 4 levels of gates
$R_2 \rightarrow$ 3 levels
$R_1 \rightarrow$ 3 levels
$R_0 \rightarrow$ 2 levels

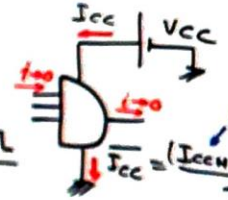
$\Rightarrow t_{p\ Circuit\_1} = 44\,ns$ worst-case scenario

$t_{p\ max\ one\ gate} = 11\,ns$

Input switch →
output switches after t_p →

$\Rightarrow$ 22,7 Millions of operations per second

⑥



state power consumption approximation

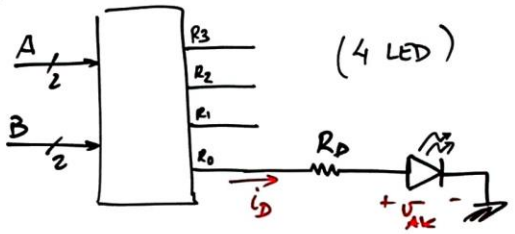
$\overline{I_{cc}} = \frac{(I_{CCH} + I_{CCL})}{2} = \frac{1.8\,mA + 4.2\,mA}{2} = 2.65\,mA$

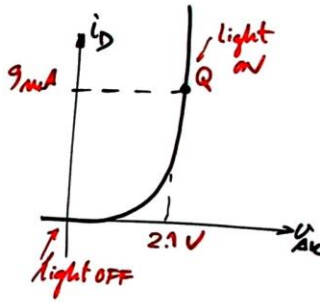
$R_3 \rightarrow 5$ gates
$R_2 \rightarrow 14$ gates
$R_1 \rightarrow 7$ gates
$R_0 \rightarrow 1$ gate
+ 8 gates (NOT, Buffer)

35 gates $\Rightarrow P_s = V_{cc} \cdot I_{cc}\left(\frac{Number}{of\ gates}\right) = 5V \cdot 2.65\,mA \cdot 35$

$P_s = 463.75\,mW$

⑦





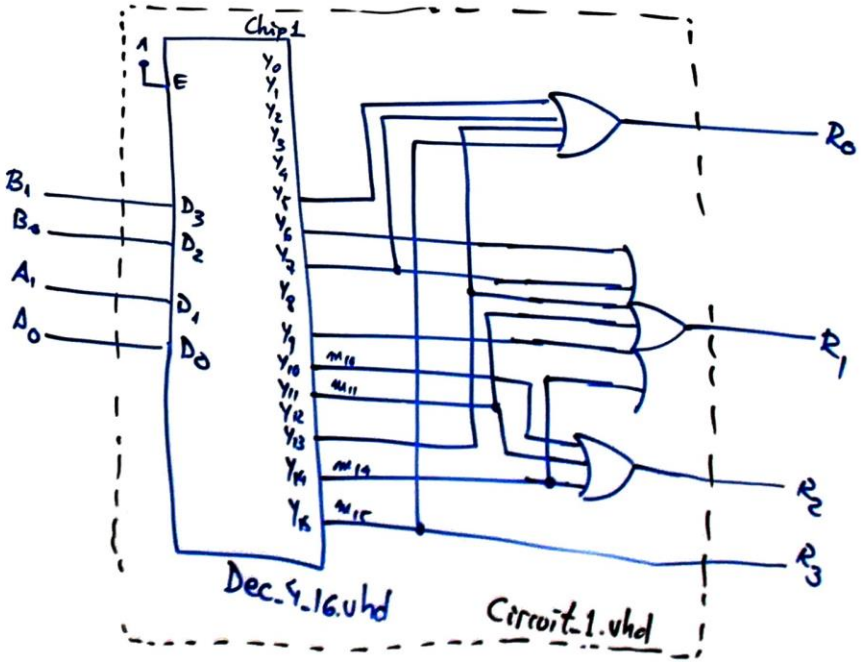
output equation:

$V_O = R_D \cdot i_D + V_{AK}$

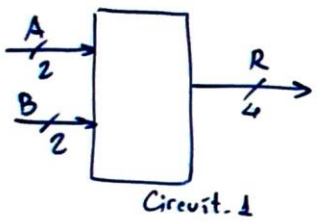
When '1' → Light ON → $V_{OH_{min}} = R_D I_{DQ} + V_{AKQ}$

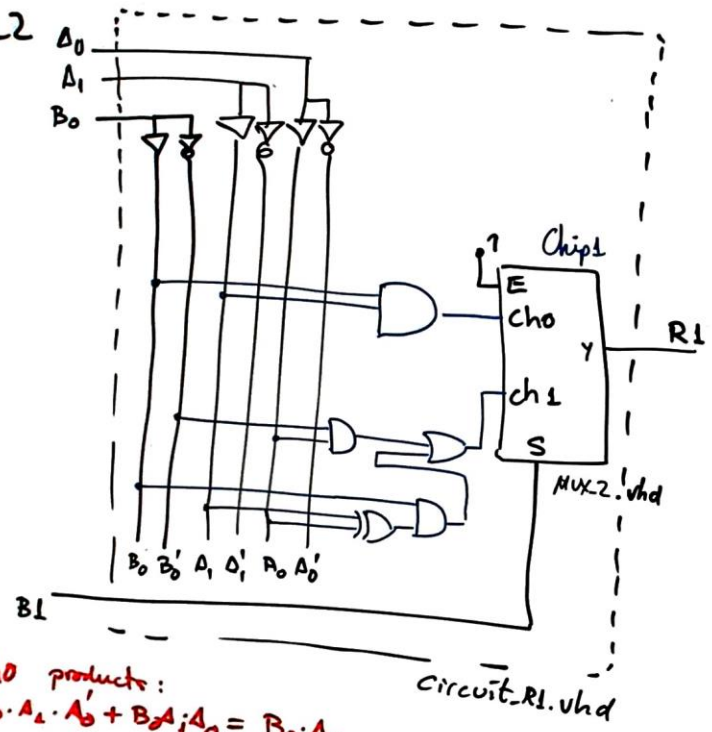
$R_D = \frac{V_{OHmin} - V_{AKQ}}{I_{DQ}} = \frac{3V - 2.1V}{9\,mA} = 100\,\Omega$

⑧ MoD



(9) M o M using MUX_2





S

B_1	B_0	A_1	A_0	R_1
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	0
0	1	0	0	0
0	1	0	1	0
0	1	1	0	1
0	1	1	1	1
1	0	0	0	0
1	0	0	1	1
1	0	1	0	0
1	0	1	1	1
1	1	0	0	0
1	1	0	1	1
1	1	1	0	1
1	1	1	1	0

Ch0 products:

$B_0 \cdot A_1 \cdot A_0' + B_0 A_1 A_0 = B_0 \cdot A_1$

Ch1 products

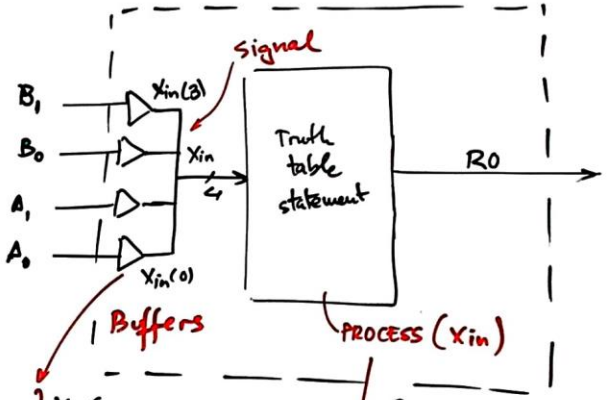
$B_0' \cdot A_1' \cdot A_0 + B_0' \cdot A_1 \cdot A_0 + B_0 A_1' A_0 + B_0 \cdot A_1 \cdot A_0'$

$B_0' \cdot A_0$

$B_0 (A_1 \oplus A_0)$

Ch1

(10) $R_0 = f(B_1, B_0, A_1, A_0)$




```
CASE Xin
  when "0000" => R0 <= '0';
        ⋮
     Truth table
  when "1110" => R0 <= '0';
  when others => R0 <= '1';
END CASE
```