ECE 204 - COMBINATIONAL BUILDING BLOCKS - INVEST 16
READ ONLY MEMORIES

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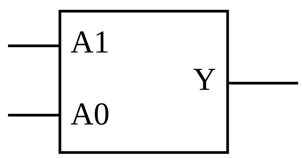
To do "well" on this investigation you must not only get the right answers but must also do neat, complete and concise writeups that make obvious what each problem is, how you're solving the problem and what your answer is. You also need to include drawings of all circuits as well as appropriate graphs and tables.

Programmable logic devices in the form of PALs from the last Investigation are extremely useful combinational circuits used in many applications. One particularly nice feature of PALs is their large number of inputs. But this comes at the price of limiting the number of minterms that can be included in the sums. The objective of this investigation is to introduce another kind of PLD called a ROM. ROMs have fewer inputs than PALs but include all the minterms. The value of every minterm can be specified.

1. In the last investigation we showed how to realize logic equations equal to sums of products with PALs having programmable AND arrays and fixed OR arrays. A **ROM** (**R**ead **O**nly **M**emory) is just like a PAL except that both its AND and OR array are programmed.

   We call the inputs A_1A_0 of a ROM as follows



   the **address** lines of the ROM. And we call the values of the output Y the **contents** of the ROM. ROMs like all combinational circuits are characterized by Truth Tables like the following

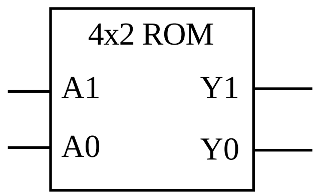
A1	A0	Y
0	0	1
0	1	0
1	0	0
1	1	1

   If the user can change the contents being stored in a ROM then we call the ROM a PROM (Programmable Read Only Memory) or an EPROM (Electronically Programmable Read Only Memory).

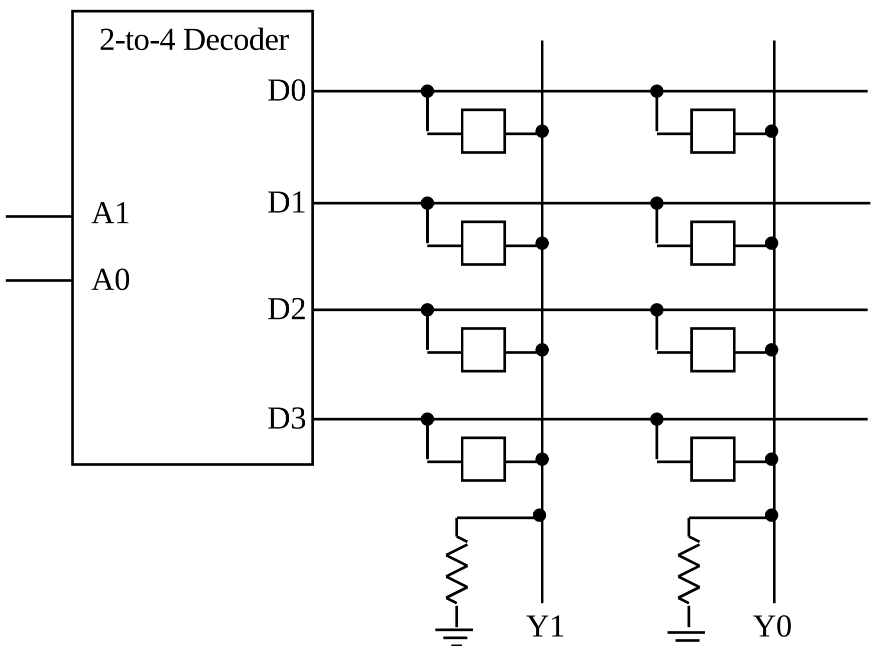
   a. Why do we call the ROM in this problem a 4x1 bit ROM
   b. Why do we say this 4x1 bit ROM stores 4 bits of information
   c. Draw a chip diagram for a 4x2 bit ROM
   d. How many bits of information are stored in a ROM that realizes the following Truth Table with three inputs and two outputs as follows

A2	A1	A0	F1	F0
0	0	0	0	0
0	0	1	1	0
0	1	0	0	1
0	1	1	0	0
1	0	0	1	1
1	0	1	0	0
1	1	0	0	0
1	1	1	0	0

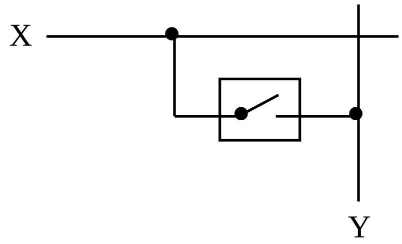
2. If we look inside a ROM like the following 4x2 bit ROM as follows



we'll see something like the following



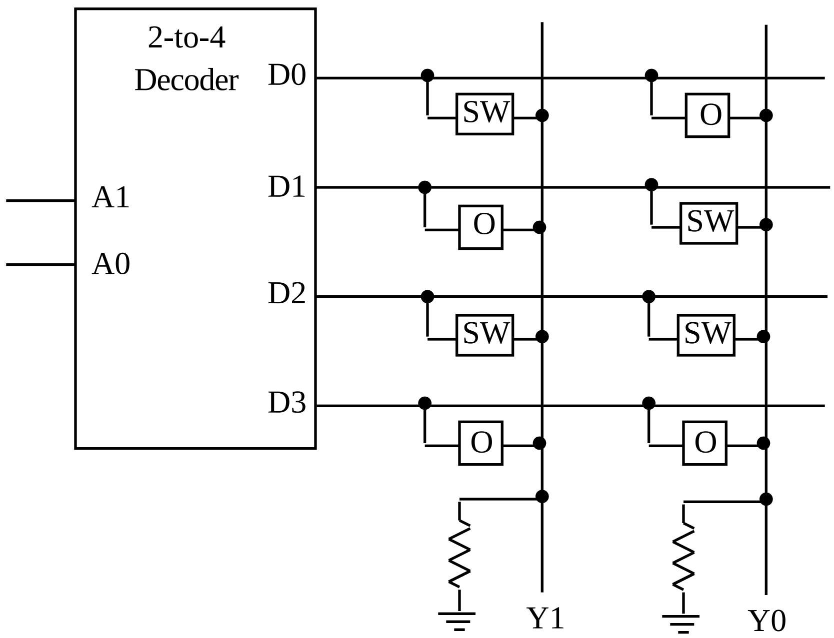
with "little" boxes connected to the crossing wires. Some of the boxes contain circuit elements that are *functionally equivalent* to switches and some contain open circuits. For those boxes containing switches as follows



the switches will be

(1) CLOSED and therefore connecting the two wires together when X=H
(2) OPEN and therefore keeping the two wires apart when X=L

Now for the following ROM



where SW means the box contains a SWITCH and O means it contains an OPEN

a. Find the truth table for this ROM
b. Make use of your truth table to obtain equations for Y1 and Y0 as sums of minterms
c. Why do we need the resistors

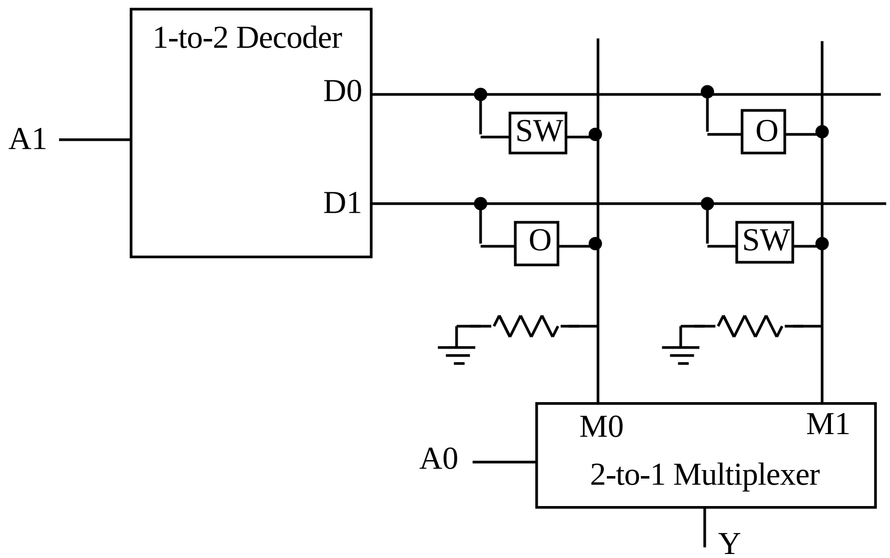
3. Draw a ROM with boxes containing switches and opens like in Problem (2) to realize the following truth table

A1	**A0**	**Y1**	**Y0**
0	0	1	0
0	1	0	0
1	0	0	1
1	1	1	1

4. Each box containing a switch or an open circuit in a ROM like that in Problem (2) is referred to as a **memory cell**. And all the memory cells taken together form what we call a **memory array**. The size of a memory array is the number of rows by the number of columns. The ROM in Problem (2) for example has a 4x2 bit memory array. **Memorize** these definitions. And then make use of them to find

a. How many cells are there in the memory array of a ROM like that of Problem (2) but with 6 address lines and 1 output
b. How many cells are there in the memory array of a ROM like that of Problem (2) but with 6 address lines and 2 outputs

5. The number of wires connecting the decoder to the memory array in a ROM like that in Problem (2) can very quickly get very large as the number of address lines increases. One way to reduce this problem is to rearrange the memory cells into more compact arrangements like the following ROM with a 2x2 bit memory array

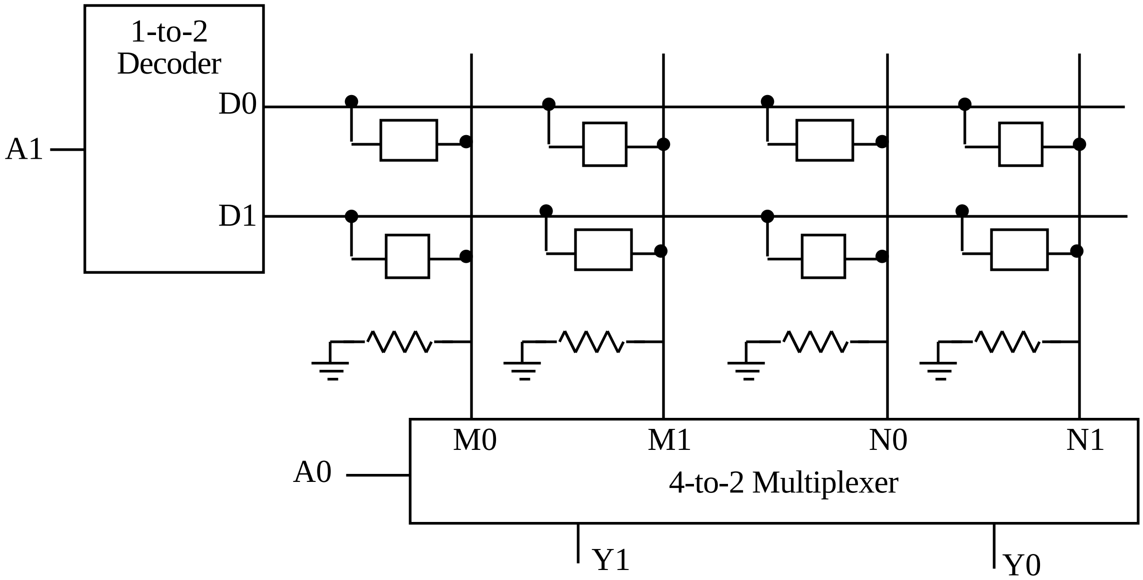


Find the truth table for this ROM and then use it to find the equation for Y

6. Realize the following truth table with a 2x4 bit memory array

A1	**A0**	**Y1**	**Y0**
0	0	1	0
0	1	0	0
1	0	0	1
1	1	1	1

using a 2-input, 2-bit mux as follows



7. Realize the following truth table with a 2x4 bit memory array

A2	**A1**	**A0**	**Y**
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

8. What dimensions would you choose for the memory array of a 1Kx1 bit ROM. Why