Nombre: José Alejandro Rodríguez Porras Carné: 19131 Sección: 10

Laboratorio 4

Ejercicio 1

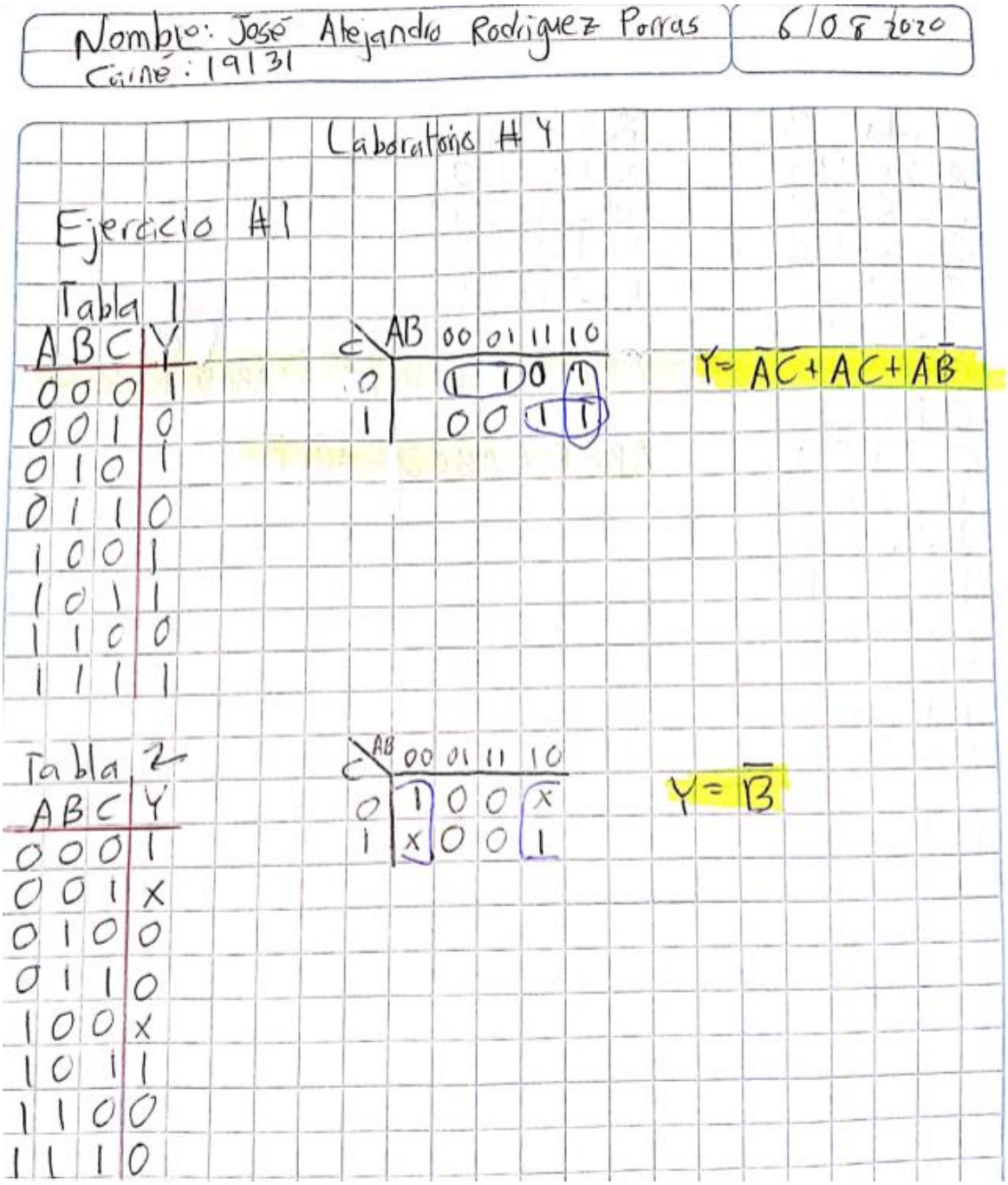


Tabla 3

A	B	C	D	Y
0	0	0	0	1
0	0	0	1	0
0	0	1	0	0
0	0	1	1	1
0	1	0	0	0
0	1	0	1	1
0	1	1	0	1
0	1	1	1	0
1	0	0	0	0
1	0	0	1	1
1	0	1	0	1
1	0	1	1	0
1	1	0	0	1
1	1	0	1	0
1	1	1	0	0
1	1	1	1	1

CD \ AB	00	01	11	10
00	1	0	1	0
01	0	1	0	1
11	1	0	1	0
10	0	1	0	1

$$Y = \bar{A}\bar{B}\bar{C}\bar{D} + \bar{A}\bar{B}\bar{C}D + \bar{A}\bar{B}C\bar{D} + \bar{A}BC\bar{D} + AB\bar{C}\bar{D} + ABC\bar{D} + A\bar{B}\bar{C}D + A\bar{B}C\bar{D} + \bar{A}\bar{B}C\bar{D}$$

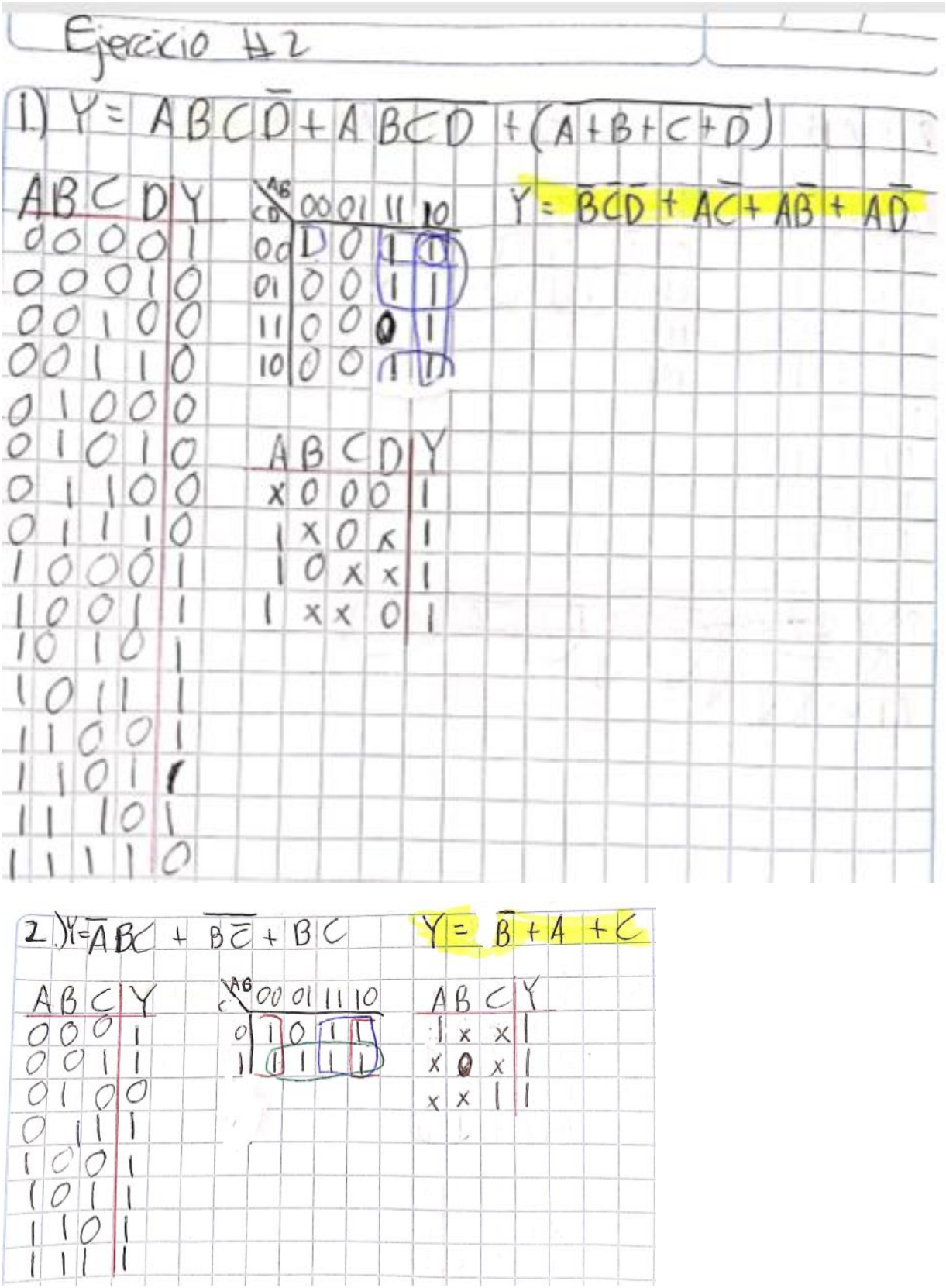
Tabla Y

A	B	C	D	Y
0	0	0	0	x
0	0	0	1	x
0	0	1	0	x
0	0	1	1	0
0	1	0	0	0
0	1	0	1	x
0	1	1	0	0
0	1	1	1	x
1	0	0	0	1
1	0	0	1	0
1	0	1	0	x
1	0	1	1	1
1	1	0	0	1
1	1	0	1	1
1	1	1	0	x
1	1	1	1	1

CD \ AB	00	01	11	10
00	x	0	1	1
01	x	x	1	0
11	0	x	1	1
10	x	0	x	x

$$Y = BD + A\bar{D} + \bar{A}C$$

Ejercicio 2


Ejercicio #2
1.) $Y = ABC\bar{D} + A\bar{B}\bar{C}D + \overline{(A+B+C+D)}$
$Y = B\bar{C}\bar{D} + A\bar{C} + A\bar{B} + A\bar{D}$
2.) $Y = \bar{A}BC + \overline{B\bar{C}} + BC$
$Y = \bar{B} + A + C$

3) $Y=\overline{(A+B+C\,D)}+AD+B$

A	B	C	D	Y
0	0	0	0	0
0	0	0	1	1
0	0	1	0	0
0	0	1	1	0
0	1	0	0	1
0	1	0	1	1
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	1
1	1	0	1	1
1	1	1	0	1
1	1	1	1	1

CD \ AB	00	01	11	10
00	0	1	1	0
01	1	1	1	1
11	0	1	1	1
10	0	1	1	0

$Y=\overline{C}D+B+AD$

A	B	C	D	Y
x	x	0	1	1
x	1	x	x	1
1	x	x	1	1

4) $Y=BC+\overline{A}\,\overline{B}\,\overline{C}+B\overline{C}$ $Y=\overline{A}\,\overline{C}+B$

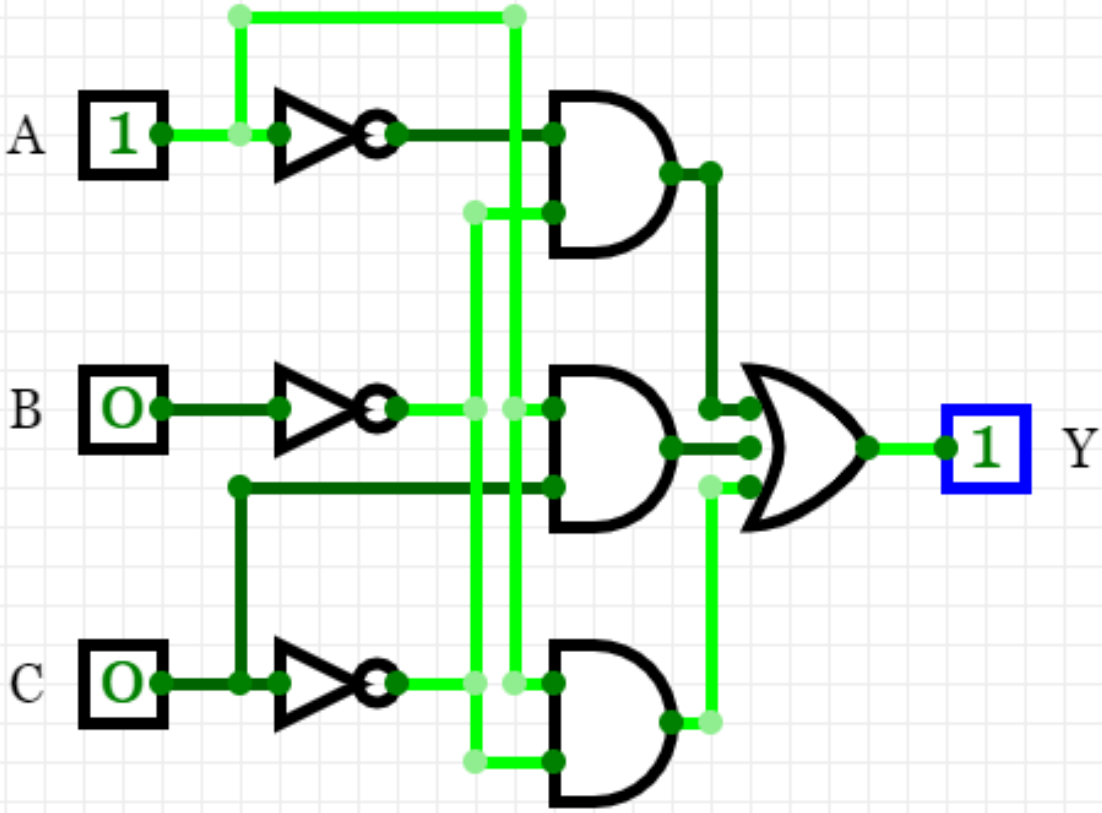
A	B	C	Y
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	1

C \ AB	00	01	11	10
0	1	1	1	1
1	0	1	1	0

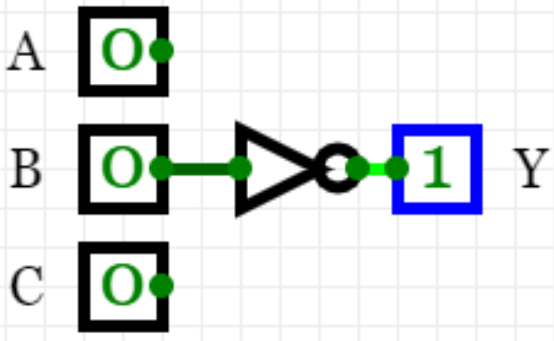
A	B	C	Y
0	x	0	1
x	1	x	1

Ejercicio 3

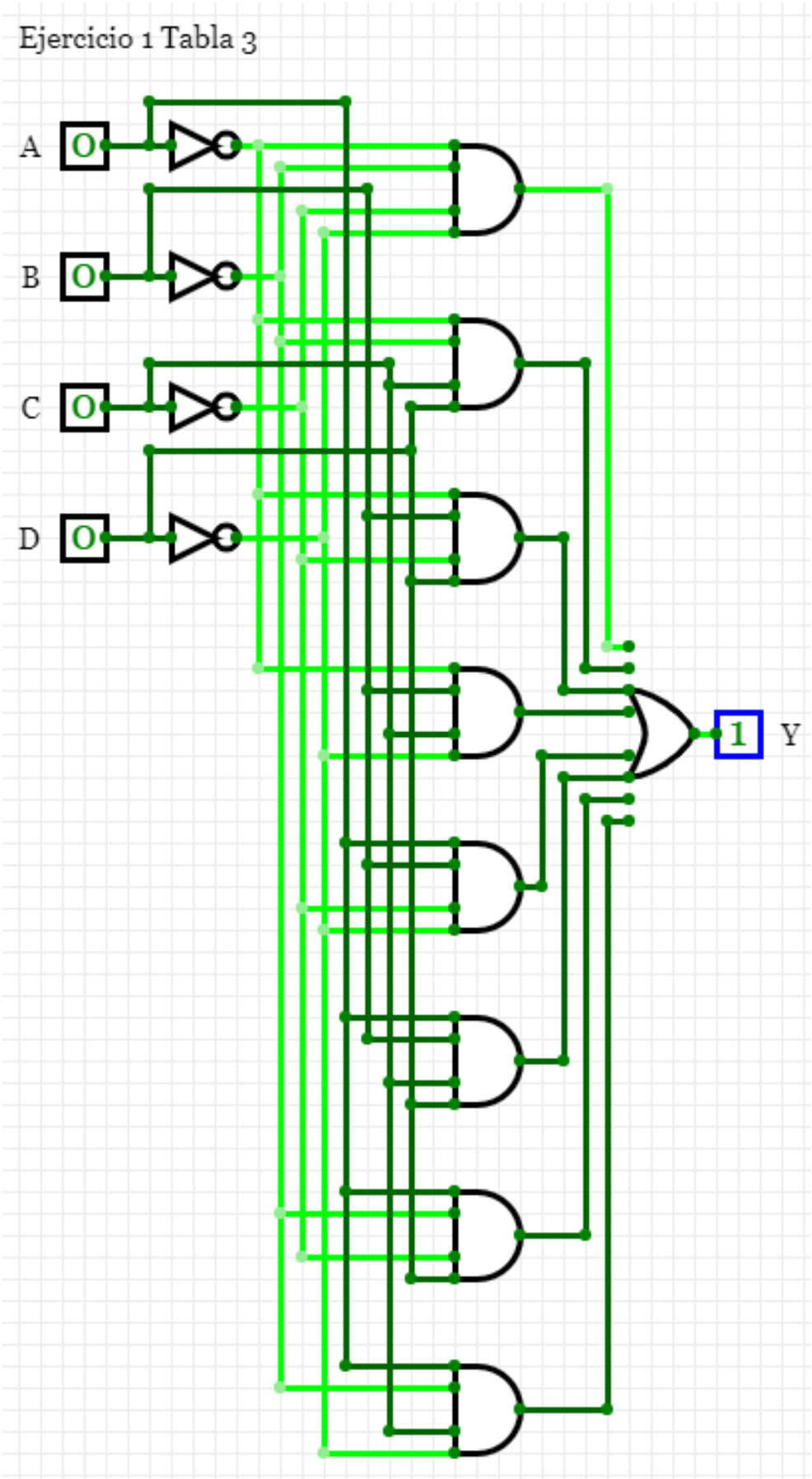
Ejercicio 1 Tabla 1



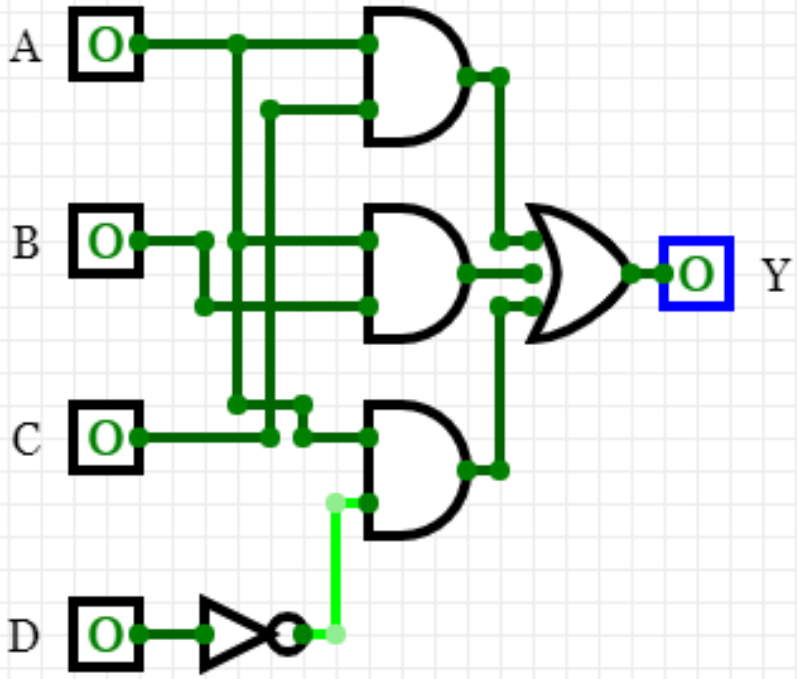
Ejercicio 1 Tabla 2



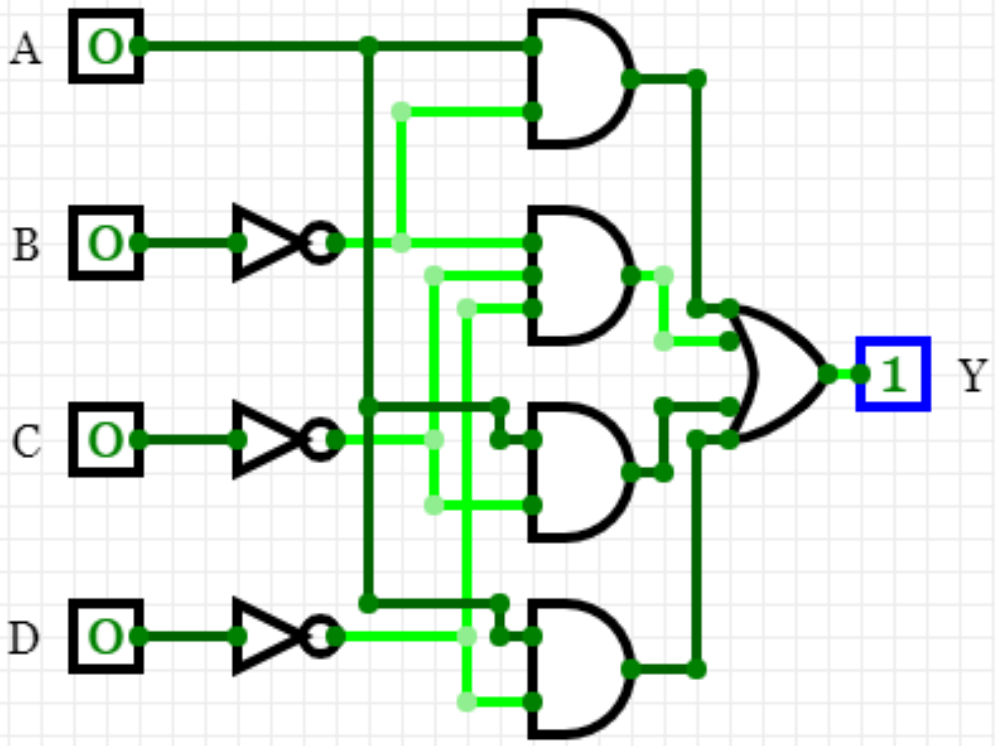
Ejercicio 1 Tabla 3



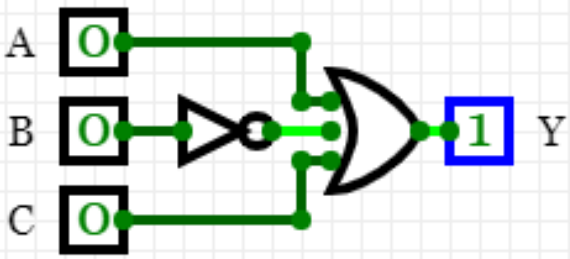
Ejercicio 1 Tabla 4



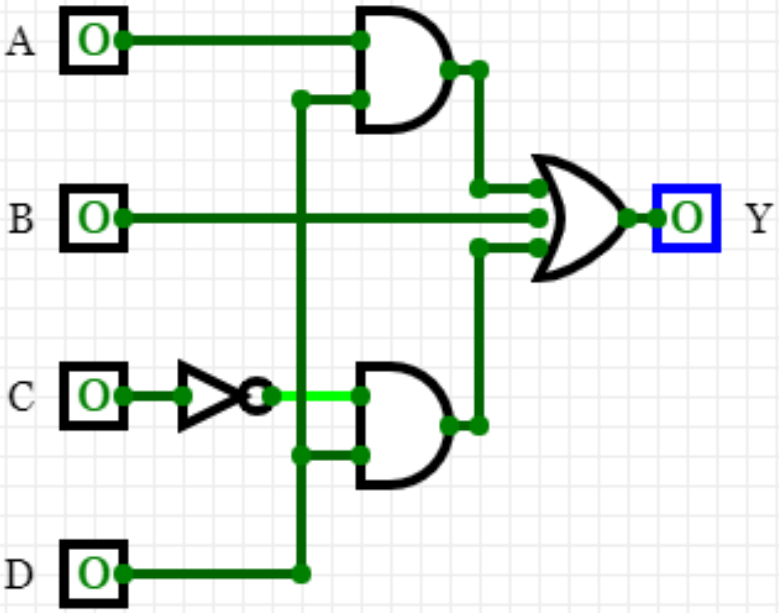
Ejercicio 2 - 1



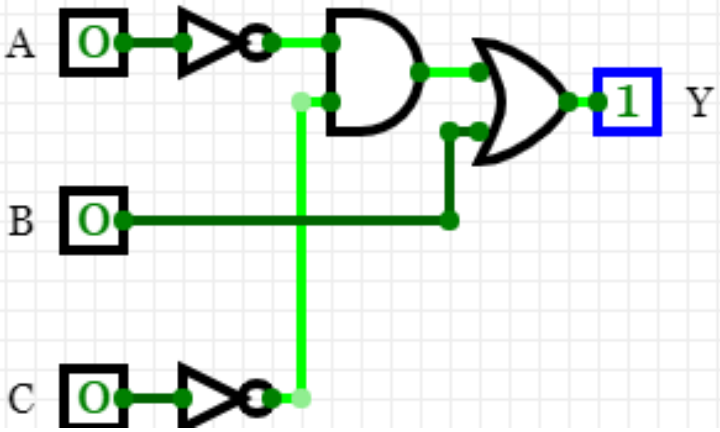
Ejercicio 2 - 2



Ejercicio 2 - 3



Ejercicio 2 - 4



Ejercicio 4

Archivo de módulos del ejercicio04

ejercicio04.v ejercicio04_tb.v

D: > AlejandroDigital > electronica_digital1 > lab04dig > ejercicio04 > ejercicio04.v

```
1   //José Alejandro Rodríguez Porras 19131
2   //Electrónica Digital
3   //Lab 4 Ejercicio 4
4   //Módulos con Gate Level Modelling
5   //Ejercicio 1 Tabla 1 : Y = A'C'+AC+AB'
6   module gle01_1(input wire A, B, C, output wire Y);
7
8       wire na, nb, nc, w1, w2, w3;
9
10      not (na, A);
11      not (nb, B);
12      not (nc, C);
13      and (w1, na, nc);
14      and (w2, A, C);
15      and (w3, A, nb);
16      or (Y, w1, w2, w3);
17
18  endmodule
19
20  //Ejercicio 1 Tabla 2: Y = B'
21  module gle01_2(input wire A, B, C, output wire Y);
22
23      wire nb;
24
25      not (nb, B);
26      or (Y,nb);
27
28  endmodule
```

```
29
30  //Ejercicio 1 Tabla 3: Y=A'B'C'D'+A'B'CD+A'BC'D+A'BCD'+ABC'D'+ABCD+AB'C'D+AB'CD'
31  module gle01_3(input wire A, B, C, D, output wire Y);
32
33      wire na, nb, nc, nd, w1, w2, w3, w4, w5, w6, w7, w8;
34
35      not (na, A);
36      not (nb, B);
37      not (nc, C);
38      not (nd, D);
39      and (w1, na, nb, nc, nd);
40      and (w2, na, nb, C, D);
41      and (w3, na, B, nc, D);
42      and (w4, na, B, C, nd);
43      and (w5, A, B, nc, nd);
44      and (w6, A, B, C, D);
45      and (w7, A, nb, nc, D);
46      and (w8, A, nb, C, nd);
47      or (Y, w1, w2, w3, w4, w5, w6, w7, w8);
48
49  endmodule
50
51  //Ejercicio 1 Tabla 4: Y=BD+AD'+AC
52  module gle01_4(input wire A, B, C, D, output wire Y);
53
54      wire nd, w1, w2, w3;
55
56      not (nd, D);
57      and (w1, B, D);
58      and (w2, A, nd);
59      and (w3, A, C);
60      or (Y, w1, w2, w3);
61
62  endmodule
63
```

```
//Módulos con operadores lógicos
//Ejercicio 2 -1): Y=B'C'D'+AC'+AB'+AD'

module ope02_1(input wire A, B, C, D, output wire Y);

    assign Y = (~B & ~C & ~D) | (A & ~C) | (A & ~B) | (A & ~D);

endmodule

//Ejercicio 2 -2): Y=B'+A+C
module ope02_2(input wire A, B, C, output wire Y);

    assign Y = (~B) | (A) | (C);

endmodule

//Ejercicio 2 -3): Y=C'D+B+AD
module ope02_3(input wire A, B, C, D, output wire Y);

    assign Y = (~C & D) | (B) | (A & D);

endmodule

//Ejercicio 2 -4): Y=A'C'+B
module ope02_4(input wire A, B, C, output wire Y);

    assign Y = (~A & ~C) | (B);

endmodule
```

Archivo de la simulación del testbench ejercicio04_tb

ejercicio04.v ejercicio04_tb.v

D: > AlejandroDigital > electronica_digital1 > lab04dig > ejercicio04 > ejercicio04_tb.v

```
// José Alejandro Rodríguez Porras 19131
//testbench
module testbench();

//definir variables de inputs para cada ecuación
    reg e1A1, e1B1, e1C1, e1A2, e1B2, e1C2, e1A3, e1B3, e1C3, e1D3, e1A4, e1B4, e1C4, e1D4, e2A1, e2B1, e2C1, e2D1, e2A2, e2B2, e2C2,
    e2A3, e2B3, e2C3, e2D3, e2A4, e2B4, e2C4;
    wire e1Y1, e1Y2, e1Y3, e1Y4, e2Y1, e2Y2, e2Y3, e2Y4;

 //asignación de las variables a cada uno de los módulos
 //módulos con gate level modelling
    gle01_1 GE1_1(e1A1, e1B1, e1C1, e1Y1);
    gle01_2 GE1_2(e1A2, e1B2, e1C2, e1Y2);
    gle01_3 GE1_3(e1A3, e1B3, e1C3, e1D3, e1Y3);
    gle01_4 GE1_4(e1A4, e1B4, e1C4, e1D4, e1Y4);
//módulos con operadores lógicos
    ope02_1 OPE2_1(e2A1, e2B1, e2C1, e2D1, e2Y1);
    ope02_2 OPE2_2(e2A2, e2B2, e2C2, e2Y2);
    ope02_3 OPE2_3(e2A3, e2B3, e2C3, e2D3, e2Y3);
    ope02_4 OPE2_4(e2A4, e2B4, e2C4, e2Y4);

//Simulación Ejercicio 1 Ecuación 1
    initial begin
        $display("A B C | Y");
        $display("------|--");
        $monitor("%b %b %b | %b", e1A1, e1B1, e1C1, e1Y1);
        e1A1 = 0; e1B1 = 0; e1C1 = 0;
        #1 e1A1 = 0; e1B1 = 0; e1C1 = 1;
        #1 e1A1 = 0; e1B1 = 1; e1C1 = 0;
        #1 e1A1 = 0; e1B1 = 1; e1C1 = 1;
        #1 e1A1 = 1; e1B1 = 0; e1C1 = 0;
        #1 e1A1 = 1; e1B1 = 0; e1C1 = 1;
        #1 e1A1 = 1; e1B1 = 1; e1C1 = 0;
        #1 e1A1 = 1; e1B1 = 1; e1C1 = 1;
    end

```

```
//Simulación Ejercicio 1 Ecuación 2
    initial begin
        #8
        $display("\n");
        $display("A B C | Y");
        $display("------|--");
        $monitor("%b %b %b | %b", e1A2, e1B2, e1C2, e1Y2);
        e1A2 = 0; e1B2 = 0; e1C2 = 0;
        #1 e1A2 = 0; e1B2 = 0; e1C2 = 1;
        #1 e1A2 = 0; e1B2 = 1; e1C2 = 0;
        #1 e1A2 = 0; e1B2 = 1; e1C2 = 1;
        #1 e1A2 = 1; e1B2 = 0; e1C2 = 0;
        #1 e1A2 = 1; e1B2 = 0; e1C2 = 1;
        #1 e1A2 = 1; e1B2 = 1; e1C2 = 0;
        #1 e1A2 = 1; e1B2 = 1; e1C2 = 1;
    end

```

```
54      //Simulación Ejercicio 1 Ecuación 3
55      initial begin
56          #16
57          $display("\n");
58          $display("A B C D | Y");
59          $display("--------|--");
60          $monitor("%b %b %b %b | %b", e1A3, e1B3, e1C3, e1D3, e1Y3);
61          e1A3 = 0; e1B3 = 0; e1C3 = 0; e1D3 = 0;
62          #1 e1A3 = 0; e1B3 = 0; e1C3 = 0; e1D3 = 1;
63          #1 e1A3 = 0; e1B3 = 0; e1C3 = 1; e1D3 = 0;
64          #1 e1A3 = 0; e1B3 = 0; e1C3 = 1; e1D3 = 1;
65          #1 e1A3 = 0; e1B3 = 1; e1C3 = 0; e1D3 = 0;
66          #1 e1A3 = 0; e1B3 = 1; e1C3 = 0; e1D3 = 1;
67          #1 e1A3 = 0; e1B3 = 1; e1C3 = 1; e1D3 = 0;
68          #1 e1A3 = 0; e1B3 = 1; e1C3 = 1; e1D3 = 1;
69          #1 e1A3 = 1; e1B3 = 0; e1C3 = 0; e1D3 = 0;
70          #1 e1A3 = 1; e1B3 = 0; e1C3 = 0; e1D3 = 1;
71          #1 e1A3 = 1; e1B3 = 0; e1C3 = 1; e1D3 = 0;
72          #1 e1A3 = 1; e1B3 = 0; e1C3 = 1; e1D3 = 1;
73          #1 e1A3 = 1; e1B3 = 1; e1C3 = 0; e1D3 = 0;
74          #1 e1A3 = 1; e1B3 = 1; e1C3 = 0; e1D3 = 1;
75          #1 e1A3 = 1; e1B3 = 1; e1C3 = 1; e1D3 = 0;
76          #1 e1A3 = 1; e1B3 = 1; e1C3 = 1; e1D3 = 1;
77      end
78
```

```
//Simulación Ejercicio 1 Ecuación 4
    initial begin
        #32
        $display("\n");
        $display("A B C D | Y");
        $display("--------|--");
        $monitor("%b %b %b %b | %b", e1A4, e1B4, e1C4, e1D4, e1Y4);
        e1A4 = 0; e1B4 = 0; e1C4 = 0; e1D4 = 0;
        #1 e1A4 = 0; e1B4 = 0; e1C4 = 0; e1D4 = 1;
        #1 e1A4 = 0; e1B4 = 0; e1C4 = 1; e1D4 = 0;
        #1 e1A4 = 0; e1B4 = 0; e1C4 = 1; e1D4 = 1;
        #1 e1A4 = 0; e1B4 = 1; e1C4 = 0; e1D4 = 0;
        #1 e1A4 = 0; e1B4 = 1; e1C4 = 0; e1D4 = 1;
        #1 e1A4 = 0; e1B4 = 1; e1C4 = 1; e1D4 = 0;
        #1 e1A4 = 0; e1B4 = 1; e1C4 = 1; e1D4 = 1;
        #1 e1A4 = 1; e1B4 = 0; e1C4 = 0; e1D4 = 0;
        #1 e1A4 = 1; e1B4 = 0; e1C4 = 0; e1D4 = 1;
        #1 e1A4 = 1; e1B4 = 0; e1C4 = 1; e1D4 = 0;
        #1 e1A4 = 1; e1B4 = 0; e1C4 = 1; e1D4 = 1;
        #1 e1A4 = 1; e1B4 = 1; e1C4 = 0; e1D4 = 0;
        #1 e1A4 = 1; e1B4 = 1; e1C4 = 0; e1D4 = 1;
        #1 e1A4 = 1; e1B4 = 1; e1C4 = 1; e1D4 = 0;
        #1 e1A4 = 1; e1B4 = 1; e1C4 = 1; e1D4 = 1;
    end

```

```
104 //Simulación Ejercicio 2 Ecuación 1
105     initial begin
106         #48
107         $display("\n");
108         $display("A B C D | Y");
109         $display("--------|--");
110         $monitor("%b %b %b %b | %b", e2A1, e2B1, e2C1, e2D1, e2Y1);
111         e2A1 = 0; e2B1 = 0; e2C1 = 0; e2D1 = 0;
112         #1 e2A1 = 0; e2B1 = 0; e2C1 = 0; e2D1 = 1;
113         #1 e2A1 = 0; e2B1 = 0; e2C1 = 1; e2D1 = 0;
114         #1 e2A1 = 0; e2B1 = 0; e2C1 = 1; e2D1 = 1;
115         #1 e2A1 = 0; e2B1 = 1; e2C1 = 0; e2D1 = 0;
116         #1 e2A1 = 0; e2B1 = 1; e2C1 = 0; e2D1 = 1;
117         #1 e2A1 = 0; e2B1 = 1; e2C1 = 1; e2D1 = 0;
118         #1 e2A1 = 0; e2B1 = 1; e2C1 = 1; e2D1 = 1;
119         #1 e2A1 = 1; e2B1 = 0; e2C1 = 0; e2D1 = 0;
120         #1 e2A1 = 1; e2B1 = 0; e2C1 = 0; e2D1 = 1;
121         #1 e2A1 = 1; e2B1 = 0; e2C1 = 1; e2D1 = 0;
122         #1 e2A1 = 1; e2B1 = 0; e2C1 = 1; e2D1 = 1;
123         #1 e2A1 = 1; e2B1 = 1; e2C1 = 0; e2D1 = 0;
124         #1 e2A1 = 1; e2B1 = 1; e2C1 = 0; e2D1 = 1;
125         #1 e2A1 = 1; e2B1 = 1; e2C1 = 1; e2D1 = 0;
126         #1 e2A1 = 1; e2B1 = 1; e2C1 = 1; e2D1 = 1;
127     end
128
```

```
129  //Simulación Ejercicio 2 Ecuación 2
130      initial begin
131          #64
132          $display("\n");
133          $display("A B C | Y");
134          $display("------|--");
135          $monitor("%b %b %b | %b", e2A2, e2B2, e2C2, e2Y2);
136          e2A2 = 0; e2B2 = 0; e2C2 = 0;
137          #1 e2A2 = 0; e2B2 = 0; e2C2 = 1;
138          #1 e2A2 = 0; e2B2 = 1; e2C2 = 0;
139          #1 e2A2 = 0; e2B2 = 1; e2C2 = 1;
140          #1 e2A2 = 1; e2B2 = 0; e2C2 = 0;
141          #1 e2A2 = 1; e2B2 = 0; e2C2 = 1;
142          #1 e2A2 = 1; e2B2 = 1; e2C2 = 0;
143          #1 e2A2 = 1; e2B2 = 1; e2C2 = 1;
144      end
145
```

```
146  //Simulación Ejercicio 2 Ecuación 3
147      initial begin
148          #72
149          $display("\n");
150          $display("A B C D | Y");
151          $display("--------|--");
152          $monitor("%b %b %b %b | %b", e2A3, e2B3, e2C3, e2D3, e2Y3);
153          e2A3 = 0; e2B3 = 0; e2C3 = 0; e2D3 = 0;
154          #1 e2A3 = 0; e2B3 = 0; e2C3 = 0; e2D3 = 1;
155          #1 e2A3 = 0; e2B3 = 0; e2C3 = 1; e2D3 = 0;
156          #1 e2A3 = 0; e2B3 = 0; e2C3 = 1; e2D3 = 1;
157          #1 e2A3 = 0; e2B3 = 1; e2C3 = 0; e2D3 = 0;
158          #1 e2A3 = 0; e2B3 = 1; e2C3 = 0; e2D3 = 1;
159          #1 e2A3 = 0; e2B3 = 1; e2C3 = 1; e2D3 = 0;
160          #1 e2A3 = 0; e2B3 = 1; e2C3 = 1; e2D3 = 1;
161          #1 e2A3 = 1; e2B3 = 0; e2C3 = 0; e2D3 = 0;
162          #1 e2A3 = 1; e2B3 = 0; e2C3 = 0; e2D3 = 1;
163          #1 e2A3 = 1; e2B3 = 0; e2C3 = 1; e2D3 = 0;
164          #1 e2A3 = 1; e2B3 = 0; e2C3 = 1; e2D3 = 1;
165          #1 e2A3 = 1; e2B3 = 1; e2C3 = 0; e2D3 = 0;
166          #1 e2A3 = 1; e2B3 = 1; e2C3 = 0; e2D3 = 1;
167          #1 e2A3 = 1; e2B3 = 1; e2C3 = 1; e2D3 = 0;
168          #1 e2A3 = 1; e2B3 = 1; e2C3 = 1; e2D3 = 1;
169      end
170
```

```
171  //Simulación Ejercicio 2 Ecuación 4
172      initial begin
173          #88
174          $display("\n");
175          $display("A B C | Y");
176          $display("------|--");
177          $monitor("%b %b %b | %b", e2A4, e2B4, e2C4, e2Y4);
178          e2A4 = 0; e2B4 = 0; e2C4 = 0;
179          #1 e2A4 = 0; e2B4 = 0; e2C4 = 1;
180          #1 e2A4 = 0; e2B4 = 1; e2C4 = 0;
181          #1 e2A4 = 0; e2B4 = 1; e2C4 = 1;
182          #1 e2A4 = 1; e2B4 = 0; e2C4 = 0;
183          #1 e2A4 = 1; e2B4 = 0; e2C4 = 1;
184          #1 e2A4 = 1; e2B4 = 1; e2C4 = 0;
185          #1 e2A4 = 1; e2B4 = 1; e2C4 = 1;
186      end
187
188      initial
189      #97 $finish;
190
191    initial begin
192      $dumpfile("ejercicio04_tb.vcd");
193      $dumpvars(0, testbench);
194    end
195
196  endmodule
```

Diagrama de Timing

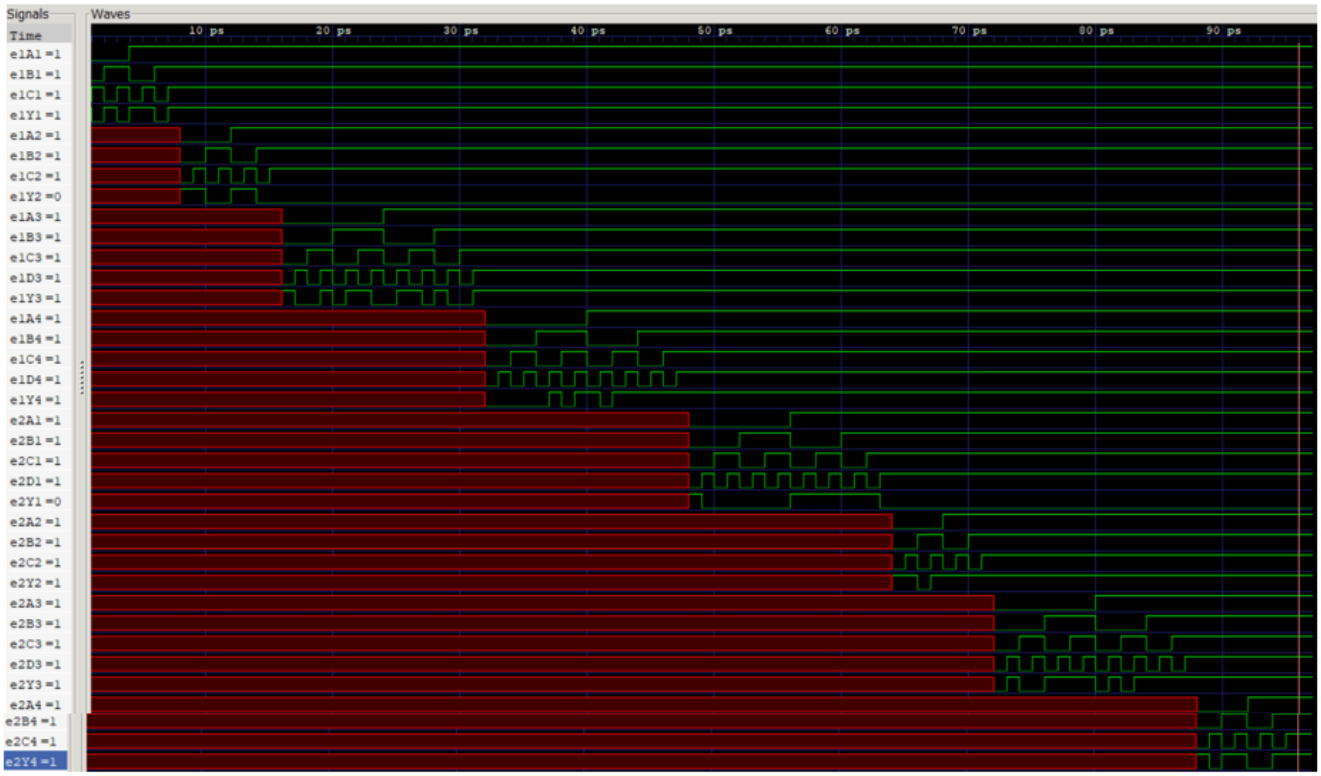
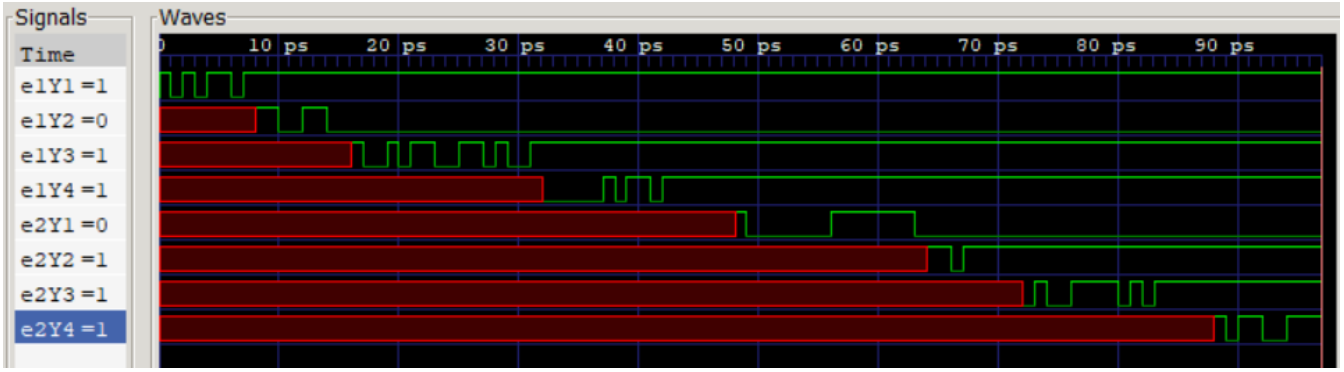


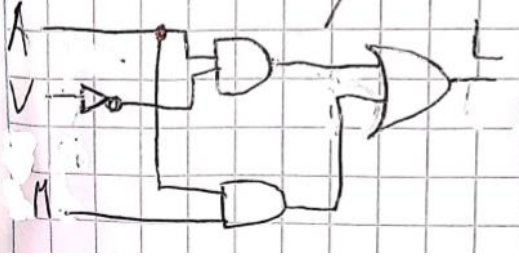
Diagrama de timing de las salidas



Ejercicio 5

Ejercicio 5

Sistema de Alarma: A = 1 = encendido
Sensor de ventana/puerta: V = 1 = sensor OK
Sensor de movimiento: M = 0 = no movimiento
Alarma y Luces encendidas: L = 1 = sistema armado



Ecuación booleana:

$A\bar{V} + AM$

Tabla Ejercicio 5

A	V	M	L	mintem	maxtem		
0	0	0	0	$\bar{A}\bar{V}\bar{M}$	$A+V+M$	m_0	M_0
0	0	1	0	$\bar{A}\bar{V}M$	$A+V+\bar{M}$	m_1	M_1
0	1	0	0	$\bar{A}V\bar{M}$	$A+\bar{V}+M$	m_2	M_2
0	1	1	0	$\bar{A}VM$	$A+V+\bar{M}$	m_3	M_3
1	0	0	1	$A\bar{V}\bar{M}$	$\bar{A}+V+M$	m_4	M_4
1	0	1	1	$A\bar{V}M$	$\bar{A}+V+\bar{M}$	m_5	M_5
1	1	0	0	$AV\bar{M}$	$\bar{A}+\bar{V}+M$	m_6	M_6
1	1	1	1	AVM	$\bar{A}+\bar{V}+\bar{M}$	m_7	M_7

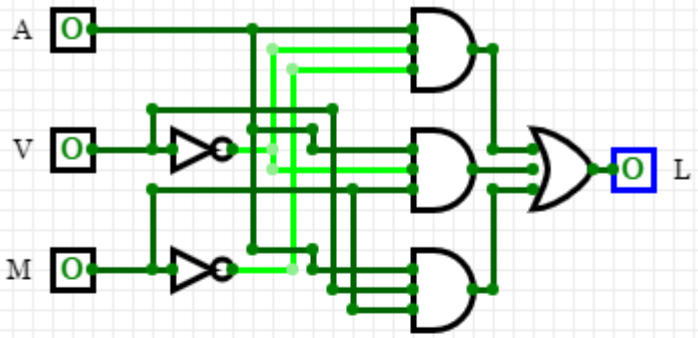
$SOP = A\bar{V}\bar{M} + A\bar{V}M + AVM$

$POS = (A+V+M)\cdot(A+V+\bar{M})\cdot(A+\bar{V}+M)\cdot(A+\bar{V}+\bar{M})\cdot(\bar{A}+\bar{V}+M)$

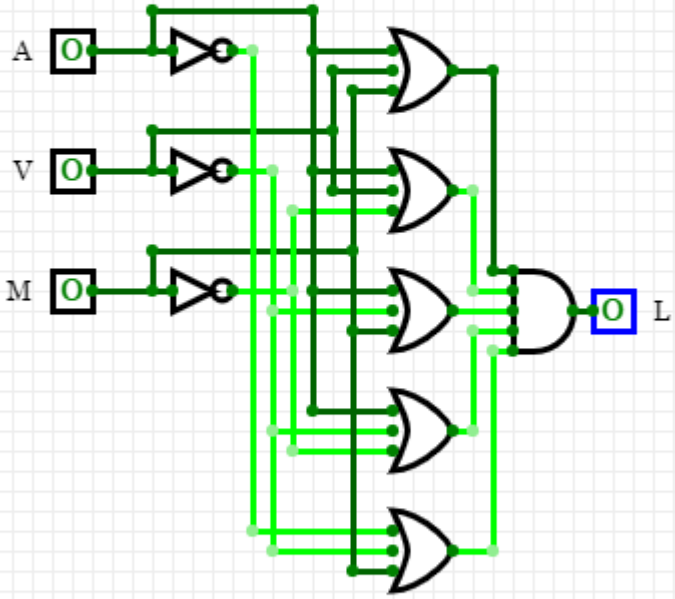
A \ VM	00	01	11	10
0	0	0	0	1
1	0	0	1	1

$L = A\bar{V} + AM$

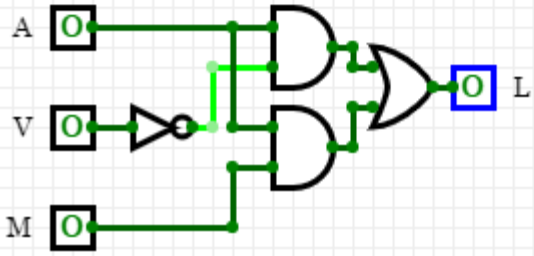
Ejercicio 5 SOP



Ejercicio 5 POS



Ejercicio 5 Solución minimizada



Output del programa en cmd

```
---> WARNING: no PCF file found (.pcf)

iverilog -o ejercicio05_tb.out -D VCD_OUTPUT=ejercicio05_tb C:/Users/AlejandroRodriguez/.apio\packages\toolchain-yosys\share\yosys/ice40/cells_sim.v ejercicio05.v ejercicio05_tb.v
vvp ejercicio05_tb.out
A B C | Y
------|--
VCD info: dumpfile ejercicio05_tb.vcd opened for output.
0 0 0 | 0
0 0 1 | 0
0 1 0 | 0
0 1 1 | 0
1 0 0 | 1
1 0 1 | 1
1 1 0 | 0
1 1 1 | 1


A B C | Y
------|--
0 0 0 | 0
0 0 1 | 0
0 1 0 | 0
0 1 1 | 0
1 0 0 | 1
1 0 1 | 1
1 1 0 | 0
1 1 1 | 1


A B C | Y
------|--
0 0 0 | 0
0 0 1 | 0
0 1 0 | 0
0 1 1 | 0
1 0 0 | 1
1 0 1 | 1
1 1 0 | 0
1 1 1 | 1


A B C | Y
------|--
0 0 0 | 0
0 0 1 | 0
0 1 0 | 0
0 1 1 | 0
1 0 0 | 1
1 0 1 | 1
1 1 0 | 0
1 1 1 | 1


A B C | Y
------|--
0 0 0 | 0
0 0 1 | 0
0 1 0 | 0
0 1 1 | 0
1 0 0 | 1
1 0 1 | 1
1 1 0 | 0
1 1 1 | 1


A B C | Y
------|--
0 0 0 | 0
0 0 1 | 0
0 1 0 | 0
0 1 1 | 0
1 0 0 | 1
1 0 1 | 1
1 1 0 | 0
1 1 1 | 1
gtkwave ejercicio05_tb.vcd ejercicio05_tb.gtkw
```

Código de ejercicio05 (módulos de gate level modelling y behavioral modelling)

ejercicio05_tb.v | ejercicio05.v

D: > AlejandroDigital > electronica_digital1 > lab04dig > ejercicio05 > ejercicio05.v

```
1   //José Alejandro Rodríguez Porras 19131
2   //Electrónica Digital
3   //Lab 4 Ejercicio 5
4   //Variables:
5   //A = Sistema de Alarma : 1 = armado
6   //V = sensor de ventana/puerta : 1 = OK
7   //M = sensor de movimiento : 0 = no movimiento
8   //L = Alarma y luces encendidas : 1 = se enciende
9   //Módulos con Gate Level Modelling
10  //SOP = AV'M'+AV'M+AVM
11  module gsop05(input wire A, V, M, output wire L);
12
13      wire nv, nm, w1, w2, w3;
14
15      not (nv, V);
16      not (nm, M);
17      and (w1, A, nv, nm);
18      and (w2, A, nv, M);
19      and (w3, A, V, M);
20      or (L, w1, w2, w3);
21
22  endmodule
23
24  //POS = (A+V+M)*(A+V+M')*(A+V'+M)*(A+V'+M')*(A'+V'+M)
25  module gpos05(input wire A, V, M, output wire L);
26
27      wire na, nv, nm, w1, w2, w3, w4, w5;
28
29      not (na, A);
30      not (nv, V);
31      not (nm, M);
32      or (w1, A, V, M);
33      or (w2, A, V, nm);
34      or (w3, A, nv, M);
35      or (w4, A, nv, nm);
36      or (w5, na, nv, M);
37      and (L, w1, w2, w3, w4, w5);
38
39  endmodule
40
41  //Ecuación minimizada con mapa de Karnaugh: Y = AV'+AM
42  module g05(input wire A, V, M, output wire L);
43
44      wire nv, w1, w2;
45
46      not (nv, V);
47      and (w1, A, nv);
48      and (w2, A, M);
49      or (L, w1, w2);
50
51  endmodule
```

```
52
53  //Módulos con Behavioral Modelling
54  //SOP = AV'M'+AV'M+AVM
55  module opsop05(input wire A, V, M, output wire L);
56
57      assign L = (A & ~V & ~M) | (A & ~V & M) | (A & V & M);
58
59  endmodule
60
61  //POS = (A+V+M)*(A+V+M')*(A+V'+M)*(A+V'+M')*(A'+V'+M)
62  module oppos05(input wire A, V, M, output wire L);
63
64      assign L = (A | V | M) & (A | V | ~M) & (A | ~V | M) & (A | ~V | ~M) & (~A | ~V | M);
65
66  endmodule
67
68  //Ecuación minimizada con mapa de Karnaugh: Y = AV'+AM
69  module op05(input wire A, V, M, output L);
70
71      assign L = (A & ~V) | (A & M);
72
73  endmodule
```

Código de ejercicio05_tb (test bench con las simulaciones para cada uno de los módulos)

ejercicio05_tb.v ejercicio05.v

D: > AlejandroDigital > electronica_digital1 > lab04dig > ejercicio05 > ejercicio05_tb.v

```
// José Alejandro Rodríguez Porras 19131
//testbench
module testbench();

    //definir variables de inputs para cada ecuación
    reg gsopA, gsopV, gsopM, gposA, gposV, gposM, g5A, g5V, g5M,
    opsopA, opsopV, opsopM, opposA, opposV, opposM, op5A, op5V, op5M;
    wire gsopL, gposL, g5L, opsopL, opposL, op5L;
    //asignación de las variables a cada uno de los módulos
    //módulos con gate level modelling
    gsop05 GS5(gsopA, gsopV, gsopM, gsopL);
    gpos05 GP5(gposA, gposV, gposM, gposL);
    g05 G5(g5A, g5V, g5M, g5L);

    //módulos con operadores lógicos
    opsop05 OPS5(opsopA, opsopV, opsopM, opsopL);
    oppos05 OPP5(opposA, opposV, opposM, opposL);
    op05 OP5(op5A, op5V, op5M, op5L);

    //Simulaciones de los módulos con gate level modelling
    //Simulación sop
    initial begin
        $display("A B C | Y");
        $display("------|--");
        $monitor("%b %b %b | %b", gsopA, gsopV, gsopM, gsopL);
        gsopA = 0; gsopV = 0; gsopM = 0;
        #1 gsopA = 0; gsopV = 0; gsopM = 1;
        #1 gsopA = 0; gsopV = 1; gsopM = 0;
        #1 gsopA = 0; gsopV = 1; gsopM = 1;
        #1 gsopA = 1; gsopV = 0; gsopM = 0;
        #1 gsopA = 1; gsopV = 0; gsopM = 1;
        #1 gsopA = 1; gsopV = 1; gsopM = 0;
        #1 gsopA = 1; gsopV = 1; gsopM = 1;
    end

    //Simulación pos
    initial begin
        #8
        $display("\n");
        $display("A B C | Y");
        $display("------|--");
        $monitor("%b %b %b | %b", gposA, gposV, gposM, gposL);
        gposA = 0; gposV = 0; gposM = 0;
        #1 gposA = 0; gposV = 0; gposM = 1;
        #1 gposA = 0; gposV = 1; gposM = 0;
        #1 gposA = 0; gposV = 1; gposM = 1;
        #1 gposA = 1; gposV = 0; gposM = 0;
        #1 gposA = 1; gposV = 0; gposM = 1;
        #1 gposA = 1; gposV = 1; gposM = 0;
        #1 gposA = 1; gposV = 1; gposM = 1;
    end

```

```
    //Simulación ecuación minimizada
    initial begin
        #16
        $display("\n");
        $display("A B C | Y");
        $display("------|--");
        $monitor("%b %b %b | %b", g5A, g5V, g5M, g5L);
        g5A = 0; g5V = 0; g5M = 0;
        #1 g5A = 0; g5V = 0; g5M = 1;
        #1 g5A = 0; g5V = 1; g5M = 0;
        #1 g5A = 0; g5V = 1; g5M = 1;
        #1 g5A = 1; g5V = 0; g5M = 0;
        #1 g5A = 1; g5V = 0; g5M = 1;
        #1 g5A = 1; g5V = 1; g5M = 0;
        #1 g5A = 1; g5V = 1; g5M = 1;
    end

    //Simulación de los módulos con behavioral modelling
    //Simulación sop
    initial begin
        #24
        $display("\n");
        $display("A B C | Y");
        $display("------|--");
        $monitor("%b %b %b | %b", opsopA, opsopV, opsopM, opsopL);
        opsopA = 0; opsopV = 0; opsopM = 0;
        #1 opsopA = 0; opsopV = 0; opsopM = 1;
        #1 opsopA = 0; opsopV = 1; opsopM = 0;
        #1 opsopA = 0; opsopV = 1; opsopM = 1;
        #1 opsopA = 1; opsopV = 0; opsopM = 0;
        #1 opsopA = 1; opsopV = 0; opsopM = 1;
        #1 opsopA = 1; opsopV = 1; opsopM = 0;
        #1 opsopA = 1; opsopV = 1; opsopM = 1;
    end

    //Simulación pos
    initial begin
        #32
        $display("\n");
        $display("A B C | Y");
        $display("------|--");
        $monitor("%b %b %b | %b", opposA, opposV, opposM, opposL);
        opposA = 0; opposV = 0; opposM = 0;
        #1 opposA = 0; opposV = 0; opposM = 1;
        #1 opposA = 0; opposV = 1; opposM = 0;
        #1 opposA = 0; opposV = 1; opposM = 1;
        #1 opposA = 1; opposV = 0; opposM = 0;
        #1 opposA = 1; opposV = 0; opposM = 1;
        #1 opposA = 1; opposV = 1; opposM = 0;
        #1 opposA = 1; opposV = 1; opposM = 1;
    end

```

```
105     //Simulación ecuación minimizada
106     initial begin
107         #40
108         $display("\n");
109         $display("A B C | Y");
110         $display("------|--");
111         $monitor("%b %b %b | %b", op5A, op5V, op5M, op5L);
112         op5A = 0; op5V = 0; op5M = 0;
113         #1 op5A = 0; op5V = 0; op5M = 1;
114         #1 op5A = 0; op5V = 1; op5M = 0;
115         #1 op5A = 0; op5V = 1; op5M = 1;
116         #1 op5A = 1; op5V = 0; op5M = 0;
117         #1 op5A = 1; op5V = 0; op5M = 1;
118         #1 op5A = 1; op5V = 1; op5M = 0;
119         #1 op5A = 1; op5V = 1; op5M = 1;
120     end
121
122     initial
123     #49 $finish;
124
125 //generación del archivo vcd
126   initial begin
127     $dumpfile("ejercicio05_tb.vcd");
128     $dumpvars(0, testbench);
129   end
130
131 endmodule
```

Diagrama de timing del ejercicio 5

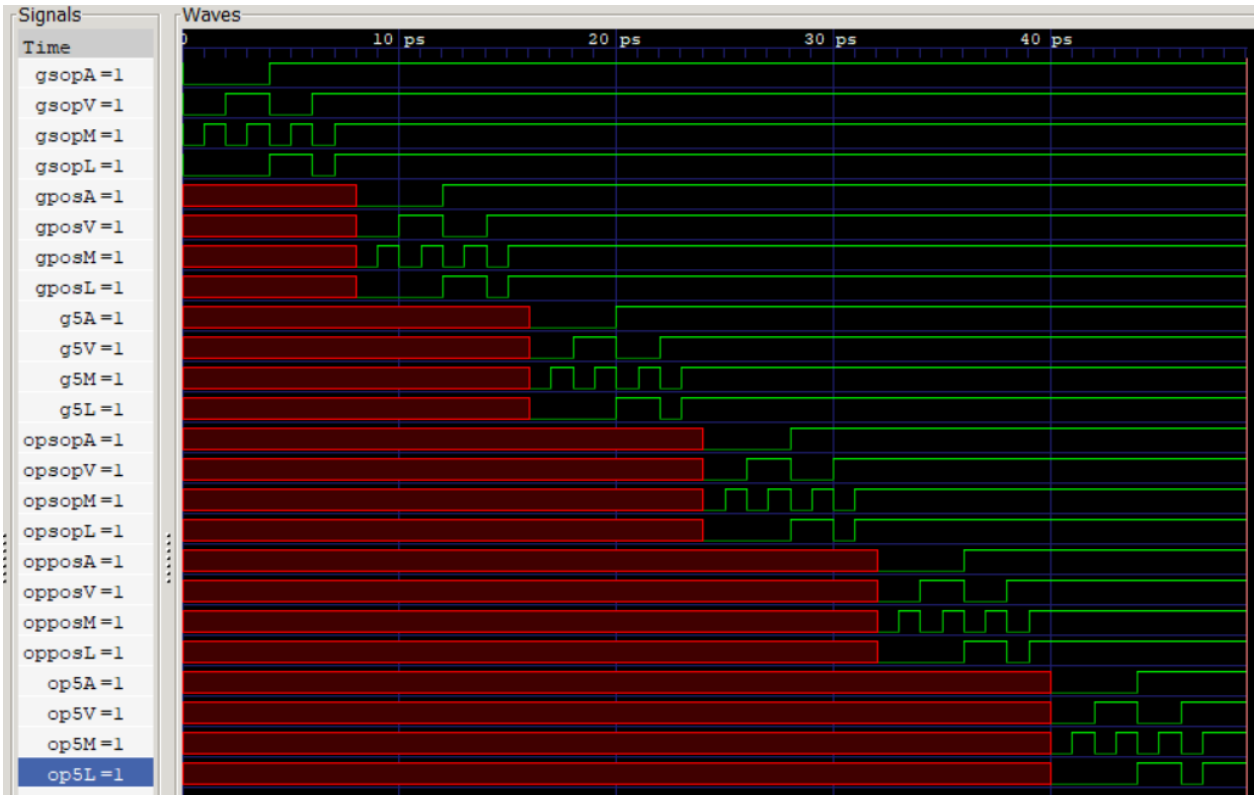
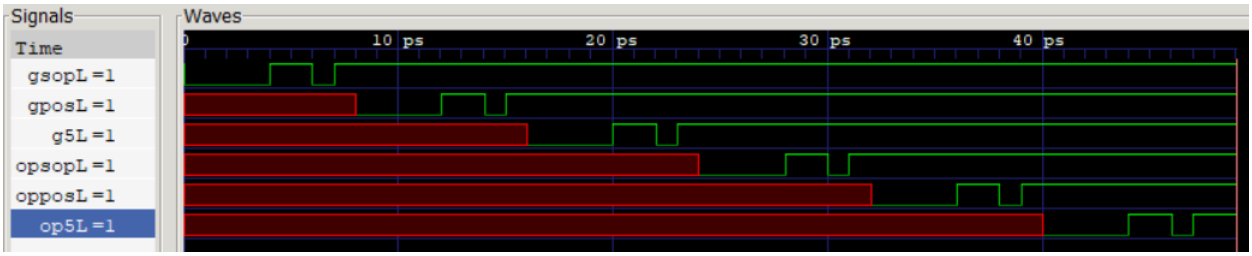


Diagrama de timing de las salidas de las ecuaciones SOP, POS y minimizada con Gate Level Modelling (g) y Behavioral Modelling (op)



Link repositorio: https://github.com/rod19131/electronica_digital1