

6

ALGEBRA DE BOOLE Y FUNCIONES LÓGICAS

PROBLEMA 5 Simplificar las siguientes FC

• $f_1(w, x, y, z) = \sum m(5, 6, 9, 10)$

a) Mapa de Karnaugh de 4 variables. **MINITERMINOS**

wx \ yz	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

⇒ Todos los mms están disjuntos. No se puede simplificar más.

$$f_1(w, x, y, z) = \bar{w}x\bar{y}z + \bar{w}xy\bar{z} + w\bar{x}\bar{y}z + w\bar{x}y\bar{z}$$

b) **MAXITERMINOS**

wx \ yz	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

se puede simplificar como estos cuatro sumas, de dos literales cada término

$$f_1(w, x, y, z) = (y+z)(\bar{y}+\bar{z})(w+x)(\bar{w}+\bar{x})$$

• $f_z(x, y, z) = \sum m(2, 3, 4, 5, 6, 7)$

a) Tres variables. MINITERMINOS :

		yz			
		00	01	11	10
x	0	0	1	1	1
	1	1	1	1	1

≡ absence de
des littérales
⇒ termes produits
en 1 littéral.

$$f_z(x, y, z) = X + Y$$

b) MAXITERMINOS

		yz			
		00	01	11	10
x	0	0	0		
	1				

⇒ Termes de 2
cases ⇒ absence
de 1 littéral.

$$f_z(x, y, z) = (X + Y)$$

4) $f_3(x, y, z) = \sum m(2, 4, 5, 6)$

a) Tres variables $\Rightarrow 2^3 = 8$ MINITERMINOS (SdP)

	yz			
x \	00	01	11	10
0	0	1	3	2
1	4	5	7	6

= dos grupos de dos
 - Ahora 1 literal -
 - Terminos producto con 2 literales.

$$f_3 = x \cdot \bar{y} + y \bar{z}$$

5) MAXITERMINOS (Productos de Sumas)

	yz			
x \	00	01	11	10
0	0	1	3	2
1	4	5	7	6

- Ahora 1 literal
 → 2 terminos suma de 2 literales

$$f_3(x, y, z) = (x + y) \cdot (\bar{y} + \bar{z})$$

Algebraicamente, se puede demostrar que b) es igual que a)

$$f_3 = (x + y) \cdot (\bar{y} + \bar{z}) = x\bar{y} + x\bar{z} + \cancel{y\bar{y}} + y\bar{z} = y \cdot \bar{z} + \bar{y} \cdot x$$

⇒ Por el "teorema del consenso": $ab + a'c = ab + a'c + bc$

$$y\bar{z} + \bar{y}x = y \cdot \bar{z} + \bar{y}x + \underbrace{\bar{z}x}_{\text{TERMINO EXTRA}}$$

$$f_4(w, x, y, z) = \sum m(3, 6, 7, 11, 12, 14, 15)$$

a) Cuatro variables \Rightarrow mk de 16 celdas. MINITÉRMINOS

	yz			
wx	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

- 1: $wx\bar{z}$
- 2: $y\bar{z}$
- 3: $x\bar{y}$

$$f_4 = wx\bar{z} + y\bar{z} + x\bar{y}$$

b) MAXITÉRMINOS (me's complejo en este caso?) No, resulte con me's sencillo.

	yz			
wx	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

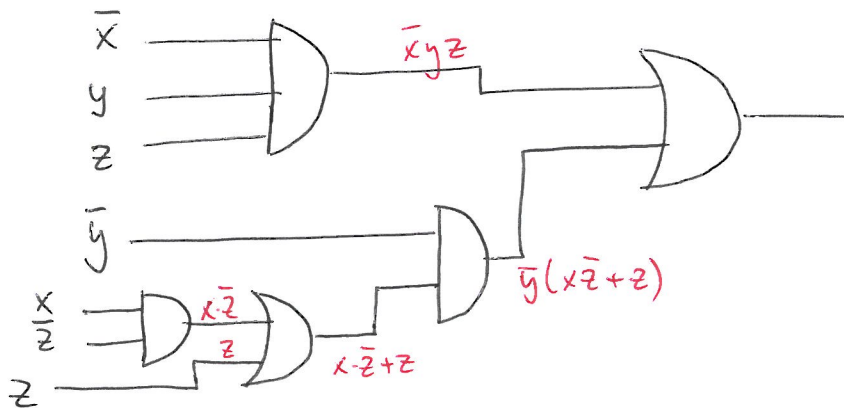
- 1: $(w+y)$
- 2: $(y+\bar{z})$
- 3: $(x+z)$

$$f_4 = (w+y)(y+\bar{z})(x+z)$$

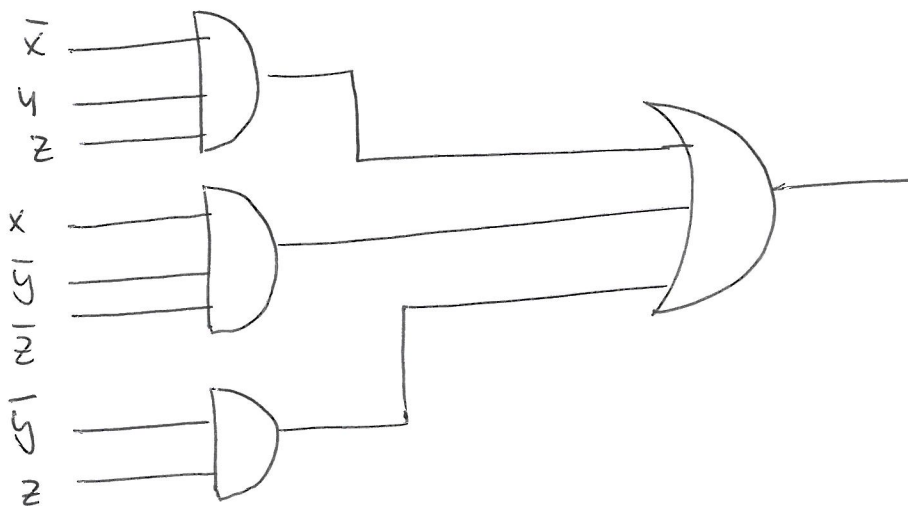
PROBLEMA 6 Dibujar un circuito con puertas AND, OR, NOT que la sintetice.

$$a) F = \bar{x}yz + \bar{y} \cdot (x\bar{z} + z)$$

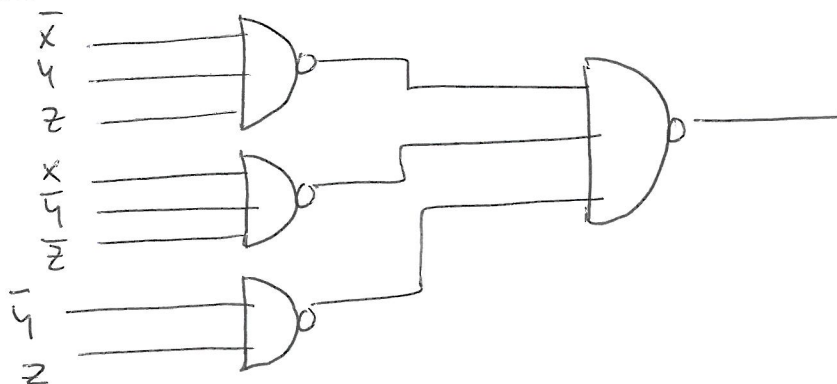
1) Haciéndolo directamente sería.



2) Otra opción está en operar $F = \bar{x}yz + \bar{y}x\bar{z} + \bar{y}z$, necesitando 3 AND y 1 OR.

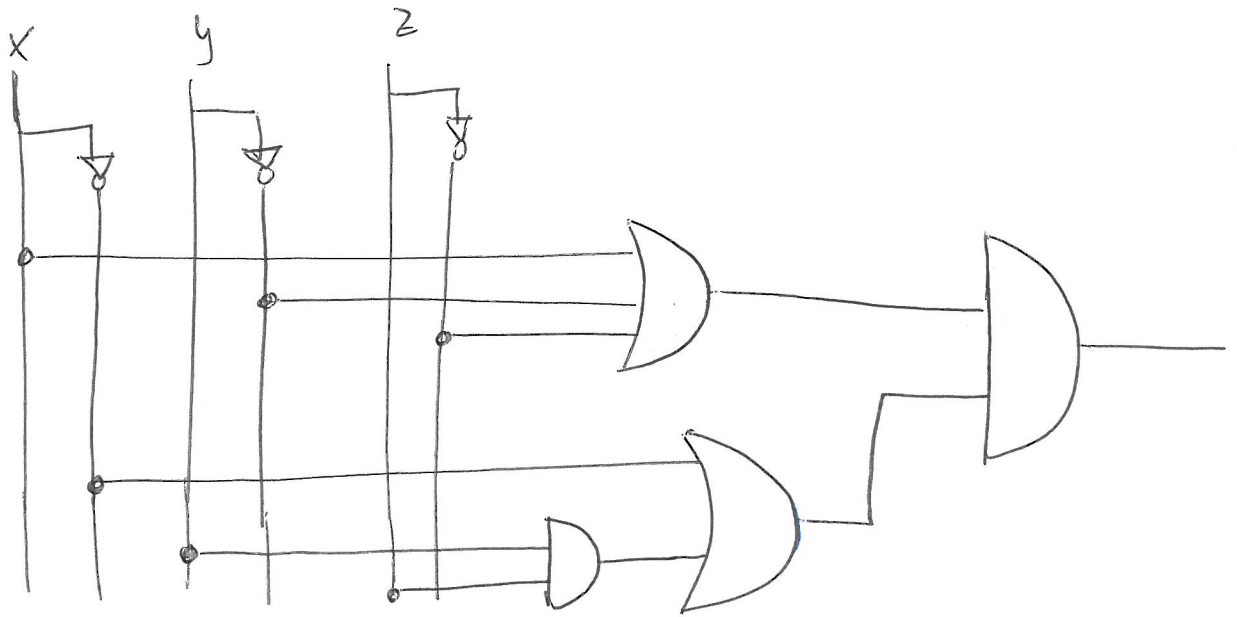


3) Pasar a NAND es trivial:



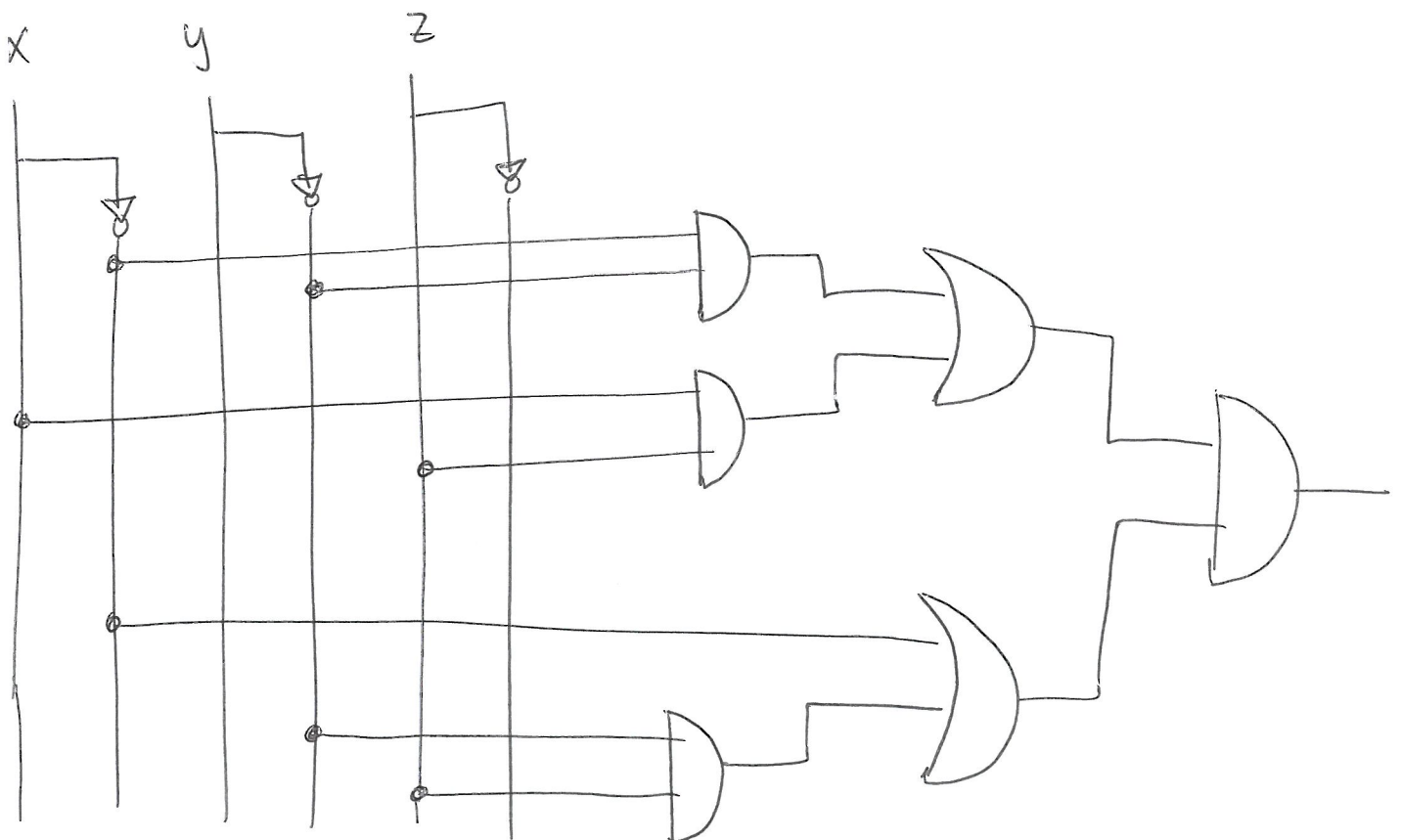
$$b) G = (x + \bar{y} + \bar{z}) \cdot (\bar{x} + yz)$$

Vamos a poner explícitamente las variables y sus complementos



$$c) H = (\bar{x}\bar{y} + xz) (\bar{x} + \bar{y}z)$$

Hacemos lo mismo:



PROBLEMA 7

Proceso químico mezcla

$$-4^{\circ}\text{C} < T < 4^{\circ}\text{C}$$

→ El sensor ofrece la medida en 4 bits, C_2 (1 nibble)

Diseñar un circuito digital tal que se active una alarma cuando estamos entre -4 y 4°C .

a) Recordemos que con 4 bits el rango en C_2 es de:

$$(0111)_{C_2} = +7_{10}$$

$$(1000)_{C_2} = -8_{10}$$



La tabla de verdad del sistema es entonces de $2^4 = 16$ celdas.

• Clave: saber que número decimal está codificado en code C_2

DEC	T_3	T_2	T_1	T_0	LED
0	0	0	0	0	0
1	0	0	0	1	0
2	0	0	1	0	0
3	0	0	1	1	0
4	0	1	0	0	0
5	0	1	0	1	1
6	0	1	1	0	1
7	0	1	1	1	1
-8	1	0	0	0	1
-7	1	0	0	1	1
-6	1	0	1	0	1
-5	1	0	1	1	1
-4	1	1	0	0	0
-3	1	1	0	1	0
-2	1	1	1	0	0
-1	1	1	1	1	0

b) Como SOP (1FC):
$$\text{LED}(T_3, T_2, T_1, T_0) = \sum m(5, 6, 7, 8, 9, 10, 11)$$

$$= m_5 + m_6 + m_7 + m_8 + m_9 + m_{10} + m_{11}$$

c1) Simplificaci3n por m3nsterminos (SDP)

$T_3 T_2$ \ $T_1 T_0$	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

1: $\bar{T}_3 T_2 \bar{T}_0$

2: $\bar{T}_3 T_2 T_1$

3: $T_3 \bar{T}_2$

$$LED = \bar{T}_3 T_2 \bar{T}_0 + \bar{T}_3 T_2 T_1 + T_3 \bar{T}_2$$

c2) Simplificaci3n por maxiterminos (PDS)

$T_3 T_2$ \ $T_1 T_0$	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

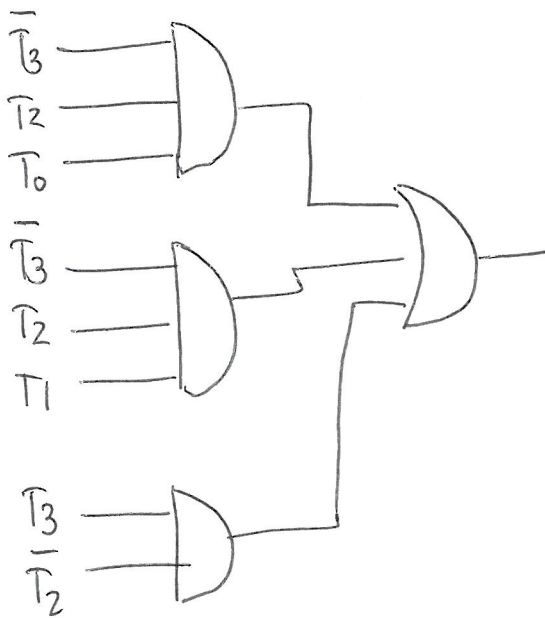
1: $T_3 + T_1 + T_0$

2: $\bar{T}_3 + T_2$

3: $\bar{T}_3 + \bar{T}_2$

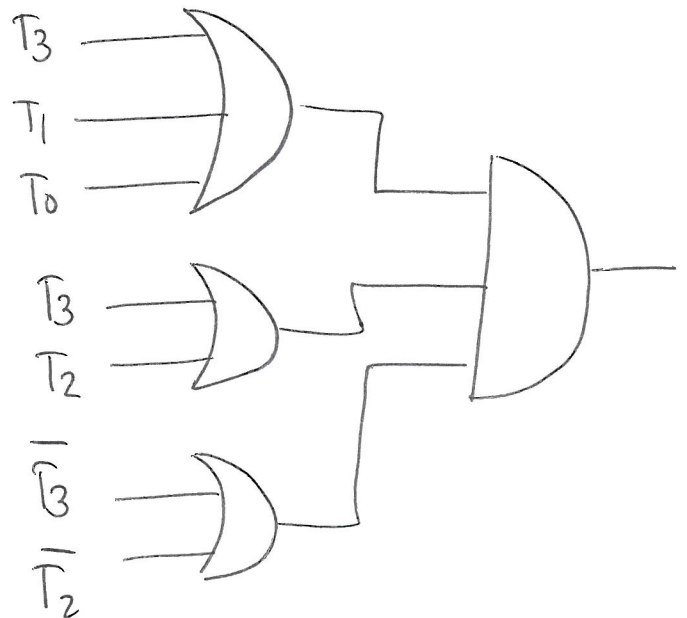
$$LED = (T_3 + T_1 + T_0) (\bar{T}_3 + T_2) (\bar{T}_3 + \bar{T}_2)$$

D) IMPLEMENTAMOS
SPD



PASAR A NAND ES TRIVIAL

PDS



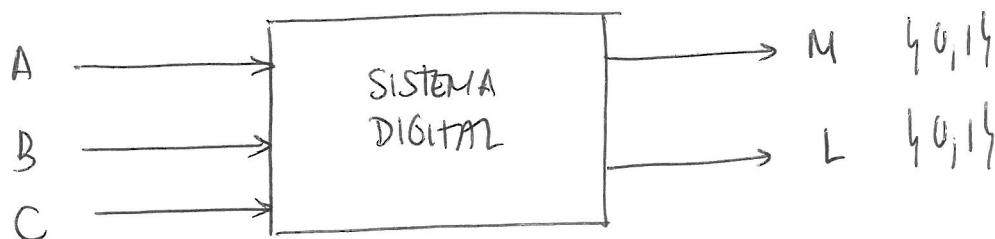
PASAR A NOR ES TRIVIAL.

PROBLEMA 8

MOTOR CONTROLADO POR TRES PULSADORES

$\left. \begin{matrix} A \\ B \\ C \end{matrix} \right\}$

→ Hay un LED que se debe encender sólo cuando se pulsan 1 o 2 pulsadores (no 3 o ninguno)



a) Tabla de verdad $\left\{ \begin{matrix} M(A,B,C) \\ L(A,B,C) \end{matrix} \right. \rightarrow$ dos funciones de conmutación

	A	B	C	M	L	
④	0	0	0	0	0	0
	0	0	1	0	1	1
	0	1	0	0	1	2
	0	1	1	1	1	3
②	1	0	0	0	1	4
②	1	0	1	1	1	5
②	1	1	0	1	1	6
①	1	1	1	1	0	7

Codificamos los 4 casos del enunciado

①: Tres pulsadores $\Rightarrow M=1, L=0$

②: Dos pulsadores cualesquiera $M=1, L=1$

③: 1 pulsador " $M=0, L=1$

④: 0 pulsadores $\Rightarrow M=0, L=0$

b) Expresar como 1FC

$$M = M_3 + M_5 + M_6 + M_7 = \sum m(3, 5, 6, 7)$$

$$L = M_1 + M_2 + M_3 + M_4 + M_5 + M_6 = \sum m(1, 2, 3, 4, 5, 6)$$

Alternativamente (2FC)

$$M = M_0 \cdot M_1 \cdot M_2 \cdot M_4 = \prod M(0, 1, 2, 4)$$

$$L = M_0 \cdot M_7 = \prod M(0, 7)$$

c) Simplificaci3n usando mK.

(A) MOTOR.

A \ BC	00	01	11	10
0	0	1	1	2
1	4	5	7	6

Handwritten annotations: Circles around 1s in cells (1,3), (1,4), (1,6), (1,7), (1,5), (1,2). Numbers 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807, 808, 809, 810, 811, 812, 813, 814, 815, 816, 817, 818, 819, 820, 821, 822, 823, 824, 825, 826, 827, 828, 829, 830, 831, 832, 833, 834, 835, 836, 837, 838, 839, 840, 841, 842, 843, 844, 845, 846, 847, 848, 849, 850, 851, 852, 853, 854, 855, 856, 857, 858, 859, 860, 861, 862, 863, 864, 865, 866, 867, 868, 869, 870, 871, 872, 873, 874, 875, 876, 877, 878, 879, 880, 881, 882, 883, 884, 885, 886, 887, 888, 889, 890, 891, 892, 893, 894, 895, 896, 897, 898, 899, 900, 901, 902, 903, 904, 905, 906, 907, 908, 909, 910, 911, 912, 913, 914, 915, 916, 917, 918, 919, 920, 921, 922, 923, 924, 925, 926, 927, 928, 929, 930, 931, 932, 933, 934, 935, 936, 937, 938, 939, 940, 941, 942, 943, 944, 945, 946, 947, 948, 949, 950, 951, 952, 953, 954, 955, 956, 957, 958, 959, 960, 961, 962, 963, 964, 965, 966, 967, 968, 969, 970, 971, 972, 973, 974, 975, 976, 977, 978, 979, 980, 981, 982, 983, 984, 985, 986, 987, 988, 989, 990, 991, 992, 993, 994, 995, 996, 997, 998, 999, 1000.

- 1: BC
- 2: AC
- 3: AB

$M = AB + AC + BC$

(B) LED

Minimizados

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

Handwritten annotations: Circles around 1s in cells (0,1), (0,2), (0,3), (1,0), (1,1), (1,4). A blue 'XX' is written over cell (0,2).

- 1 = $\bar{A}C$
- 2 = **XX (sobra)**
- 3 = $A\bar{B}$
- 4 = $B\bar{C}$

$L = \bar{A}C + \text{XX} + A\bar{B} + B\bar{C}$

Maximizados
(m3s r3pido)

A \ BC	00	01	11	10
0	0	1	1	2
1	1	1	0	6

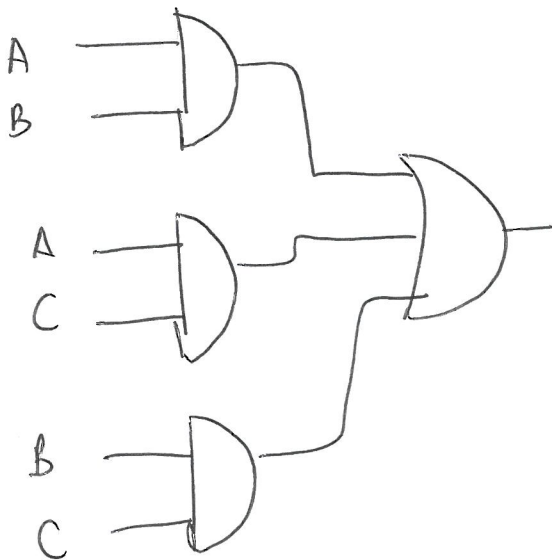
Handwritten annotations: Circles around 0s in cells (0,0), (1,3), (1,6).

- 0 = $A+B+C$
- 1 = $\bar{A} + \bar{B} + \bar{C}$

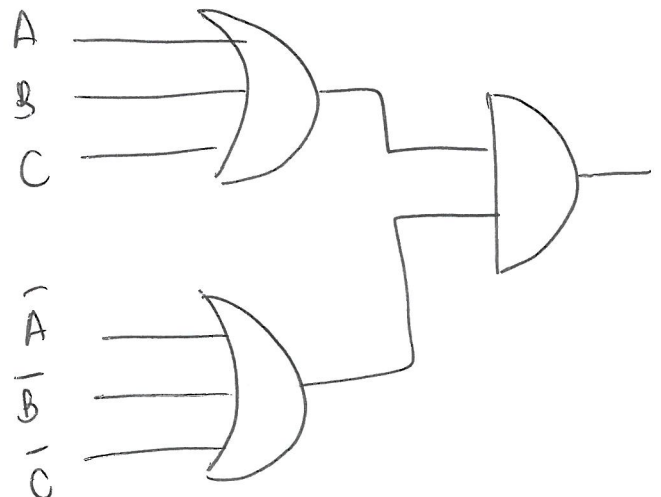
$L = (A+B+C)(\bar{A} + \bar{B} + \bar{C})$

d) Circuitos con puertas l3gicas:

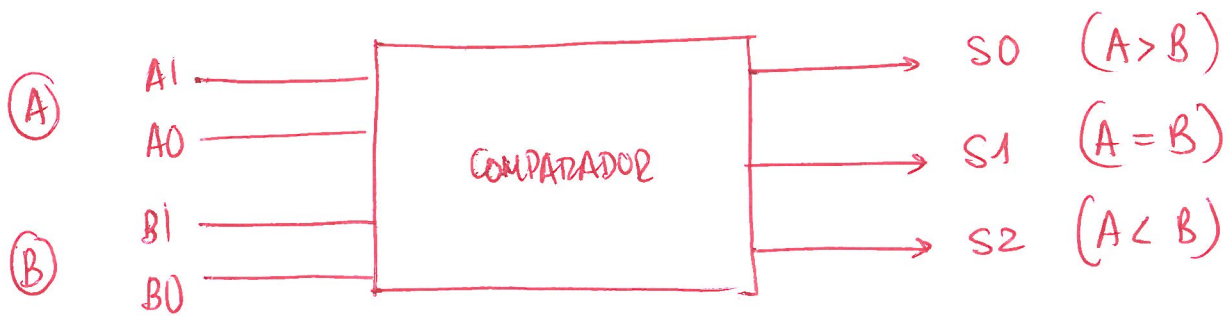
MOTOR



LED



PROBLEMA 9 Comparador binario completo (3 salidas)



a) Table de verdad. 4 entradas \Rightarrow 16 posibles combinaciones

	A_1	A_0	B_1	B_0	S_0	S_1	S_2
0	0	0	0	0		1	
1	0	0	0	1			1
2	0	0	1	0			1
3	0	0	1	1			1
4	0	1	0	0	1		
5	0	1	0	1		1	
6	0	1	1	0			1
7	0	1	1	1			1

	A_1	A_0	B_1	B_0	S_0	S_1	S_2
8	1	0	0	0	1		
9	1	0	0	1	1		
10	1	0	1	0		1	
11	1	0	1	1			1
12	1	1	0	0	1		
13	1	1	0	1	1		
14	1	1	1	0	1		
15	1	1	1	1		1	

- b) Funciones de salida como suma de productos (1FC)
- $S_0 = M_4 + M_8 + M_9 + M_{12} + M_{13} + M_{14} = \sum m(4, 8, 9, 12, 13, 14)$
 - $S_1 = M_0 + M_5 + M_{10} + M_{15} = \sum m(0, 5, 10, 15)$
 - $S_2 = M_1 + M_2 + M_3 + M_6 + M_7 + M_{11} = \sum m(1, 2, 3, 6, 7, 11)$

Adicionalmente (2FC)

- $S_0 = \prod M(0, 1, 2, 3, 5, 6, 7, 10, 11, 15)$
- $S_1 = \prod M(1, 2, 3, 4, 6, 7, 8, 9, 11, 12, 13, 14)$
- $S_2 = \prod M(0, 4, 5, 8, 9, 10, 12, 13, 14, 15)$

c) Simplificarea mediante mK.

$A_1 A_0$ \ $B_1 B_0$	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

Mapa de Karnaugh pentru funcția S0. Valorile 1 sunt marcate în celulele (01,00), (11,00), (11,01), (11,10), (10,00) și (10,01). Grupurile de simplificare sunt: 1. Un grup vertical de două celule în coloana 00 (minterme 4 și 12). 2. Un grup vertical de două celule în coloana 01 (minterme 5 și 13). 3. Un grup orizontal de două celule în rândul 11 (minterme 12 și 13). 4. Un grup orizontal de două celule în rândul 10 (minterme 8 și 9). 5. Un grup diagonal de două celule (minterme 12 și 14).

$$S_0 = \sum m (4, 8, 9, 12, 13, 14)$$

$$1: \overline{A_1} \overline{A_0} \overline{B_0}$$

$$2: A_1 \overline{A_0} B_0$$

$$3: A_1 B_1$$

$$S_0 = \overline{A_1} \overline{A_0} \overline{B_0} + A_1 \overline{A_0} B_0 + A_1 B_1$$

$A_1 A_0$ \ $B_1 B_0$	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

Mapa de Karnaugh pentru funcția S1. Valorile 1 sunt marcate în celulele (00,00), (01,01), (11,11) și (10,10).

$$S_1 = \sum m (0, 5, 10, 15)$$

⇒ nu permite nicio simplificare și
minterme

$$S_1 = \overline{A_1} \overline{A_0} \overline{B_1} \overline{B_0} + \overline{A_1} \overline{A_0} \overline{B_1} B_0 + \overline{A_1} \overline{A_0} B_1 \overline{B_0} + \overline{A_1} \overline{A_0} B_1 B_0$$

$A_1 A_0$ \ $B_1 B_0$	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

Mapa de Karnaugh pentru funcția S2. Valorile 1 sunt marcate în celulele (01,00), (11,00), (11,01), (11,10), (10,00) și (10,01). Grupurile de simplificare sunt: 1. Un grup orizontal de două celule în rândul 00 (minterme 1 și 3). 2. Un grup orizontal de două celule în rândul 01 (minterme 7 și 6). 3. Un grup orizontal de două celule în rândul 10 (minterme 11 și 10).

$$S_2 = \sum m (1, 2, 3, 6, 7, 11)$$

$$1: \overline{A_1} \overline{A_0} B_0$$

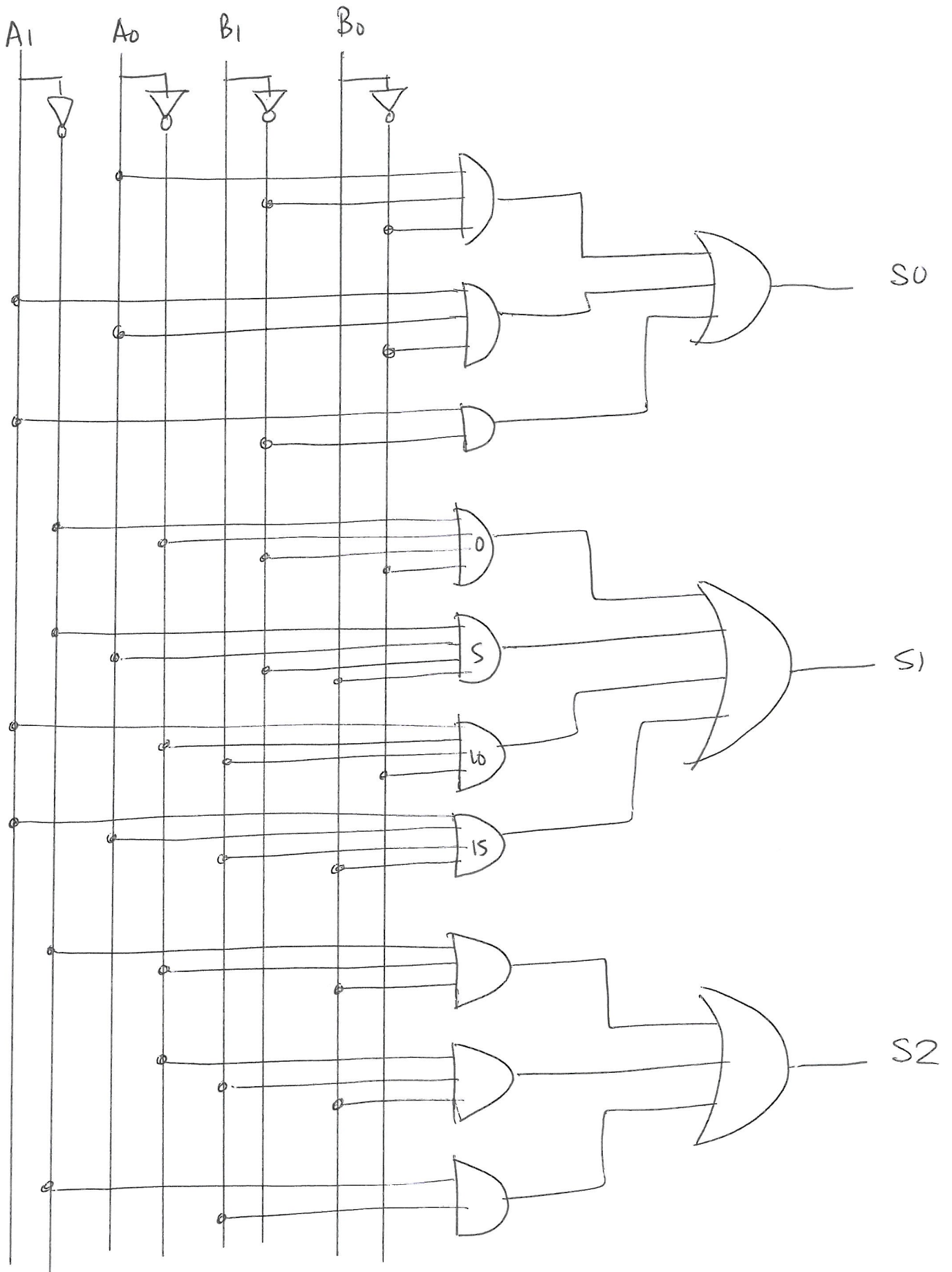
$$2: \overline{A_0} B_1 B_0$$

$$3: \overline{A_1} B_1$$

$$S_2 = \overline{A_1} \overline{A_0} B_0 + \overline{A_0} B_1 B_0 + \overline{A_1} B_1$$

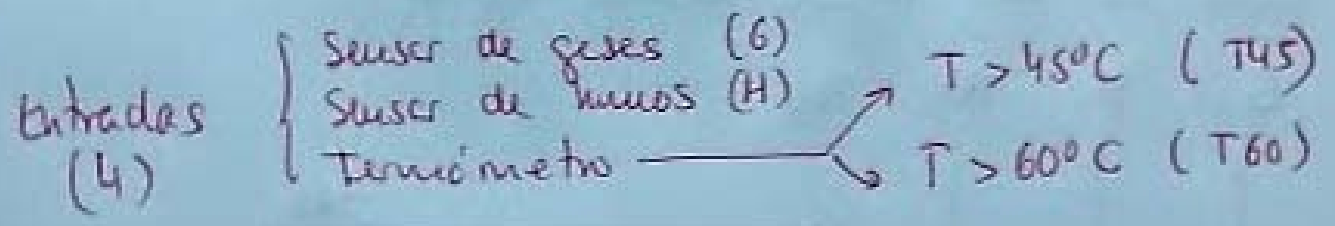
d) Implementación mediante puertas lógicas.

- AND - OR - NOT



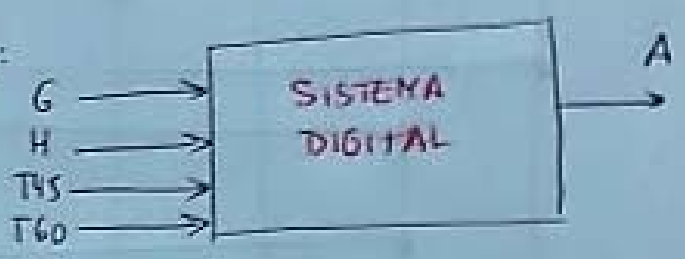
PROBLEMA 10

Circuito para activar la alarma de incendios (A) de un edificio.



a) Tabla de verdad del sistema:

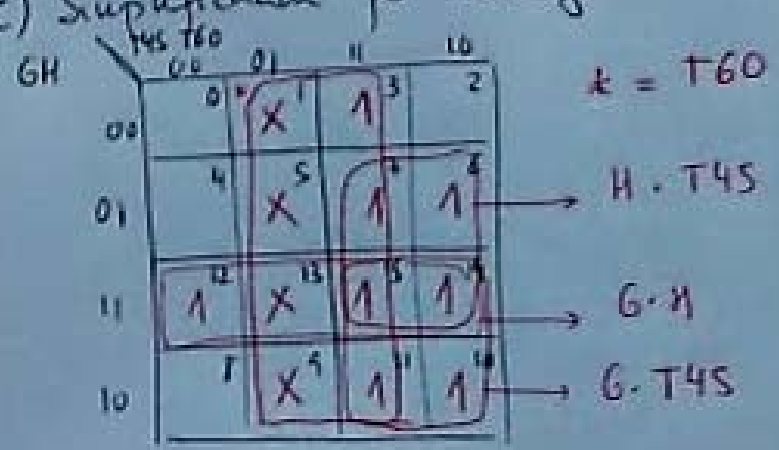
4 entradas $\rightarrow 2^4 = 16$ filas



	G	H	T45	T60	A	
0	0	0	0	0	0	→ Condiciones normales, sin alarmas
1	0	0	0	1	X	→ T no puede ser $> 60^{\circ}$ y $< 45^{\circ}$ a la vez
2	0	0	1	0	0	→ $45 \leq T < 60$ para G=0 y H=0
3	0	0	1	1	1	→ $T > 60^{\circ}$
4	0	1	0	0	0	→ solo humo, no alarma
5	0	1	0	1	X	
6	0	1	1	0	1	→ HUMO + $T > 45^{\circ}$
7	0	1	1	1	1	→ $T > 60^{\circ}$
8	1	0	0	0	0	→ solo GAS, no alarma
9	1	0	0	1	X	
10	1	0	1	0	1	→ GAS + $T > 45^{\circ}$
11	1	0	1	1	1	→ $T > 60^{\circ}$
12	1	1	0	0	1	→ GAS + HUMO con $T \geq 45^{\circ}$ → Alarma
13	1	1	0	1	X	
14	1	1	1	0	1	→ GAS + HUMO + $T > 45^{\circ}$ → Alarma
15	1	1	1	1	1	→ $T > 60^{\circ}$

b) Suma de productos (FC) $\Rightarrow A = \sum m(3, 6, 7, 10, 11, 12, 14, 15) + \sum X(1, 5, 9, 13)$

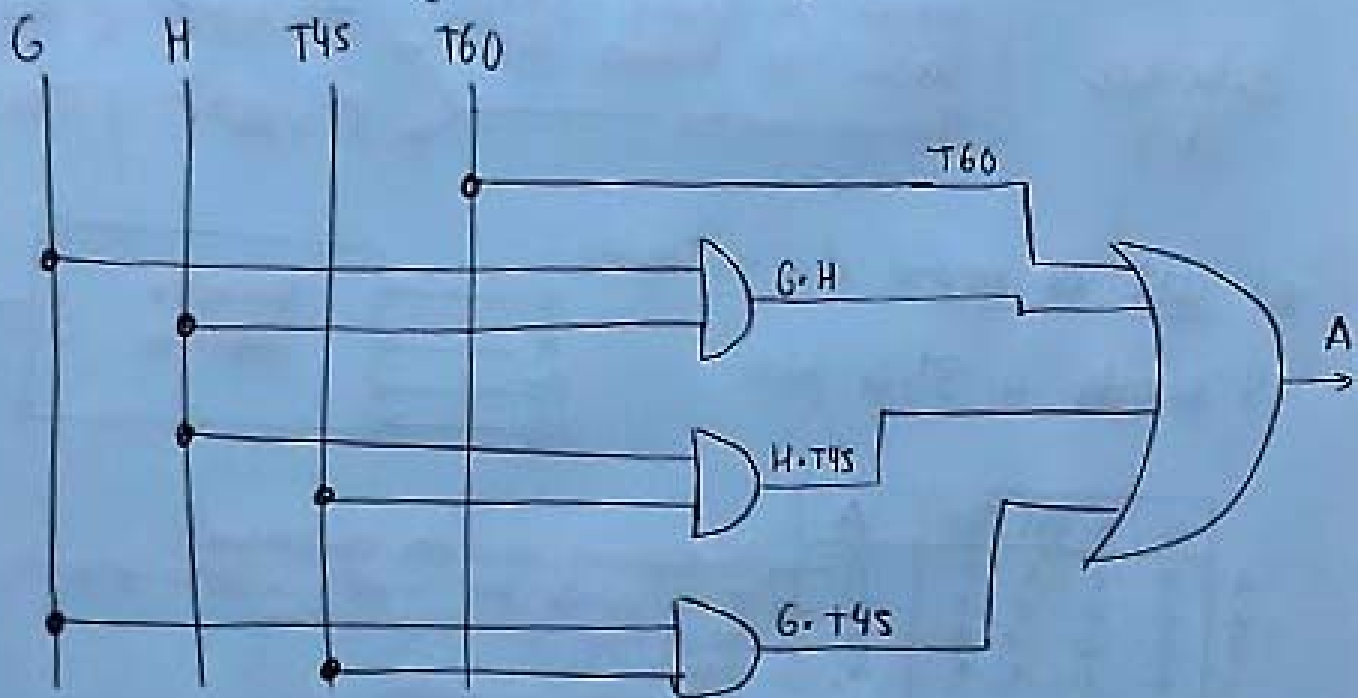
c) Simplificación por Karnaugh:



$$A = G \cdot H + T60 + H \cdot T45 + G \cdot T45$$

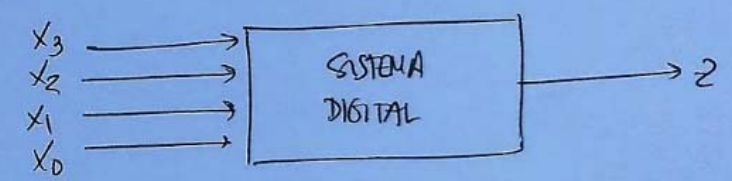
d) Implementaciai vaudo puer-tes ligees:

Cemo no kas mugue vaucdu ufedde:



CASO PRACTICO Sistema digital que acepte números del 1 al 10 codificados en binario, y genere salida = 1 por entradas múltiplos de 2 o igual a 9

a) Table de verdad:
Necesitamos 4 dígitos



DEC	x ₃	x ₂	x ₁	x ₀	z
0	0	0	0	0	X
1	0	0	0	1	0
2	0	0	1	0	1
3	0	0	1	1	0
4	0	1	0	0	1
5	0	1	0	1	0
6	0	1	1	0	1
7	0	1	1	1	0
8	1	0	0	0	1
9	1	0	0	1	1
10	1	0	1	0	1
11	1	0	1	1	X
12	1	1	0	0	X
13	1	1	0	1	X
14	1	1	1	0	X
15	1	1	1	1	X

b) Expresar en la 1ª forma canónica:

$$z = \sum m(2, 4, 6, 8, 10) + \sum X(0, 11, 12, 13, 14, 15)$$

c) Simplificamos:

x ₃ x ₂ \ x ₁ x ₀	00	01	11	10
00	X ⁰	1	3	1 ² ①
01	1 ⁴	5	7	1 ⁶
11	X ¹¹	X ¹³	X ¹⁵	X ¹⁴
10	1 ⁷	1 ⁹	X ¹¹	1 ¹⁰

$$z = \bar{x}_0 + x_3$$

① 8 literales → aborro de 2³ = 3

$$z = \bar{x}_0$$

② 8 literales → aborro de 3

$$z = x_3$$

a)

	x ₃	x ₂	x ₁	x ₀	z	
0	0	0	0	0	X	dentro
1	0	0	0	1	0	
2	0	0	1	0	1	
3	0	0	1	1	0	
4	0	1	0	0	1	dentro
5	0	1	0	1	0	
6	0	1	1	0	1	
7	0	1	1	1	0	
8	1	0	0	0	1	dentro
9	1	0	0	1	1	
10	1	0	1	0	1	
11	1	0	1	1	X	
12	1	1	0	0	X	
13	1	1	0	1	X	
14	1	1	1	0	X	
15	1	1	1	1	X	

d) Implementación con partes lógicas:

