# DSL EXPERIMENT 2

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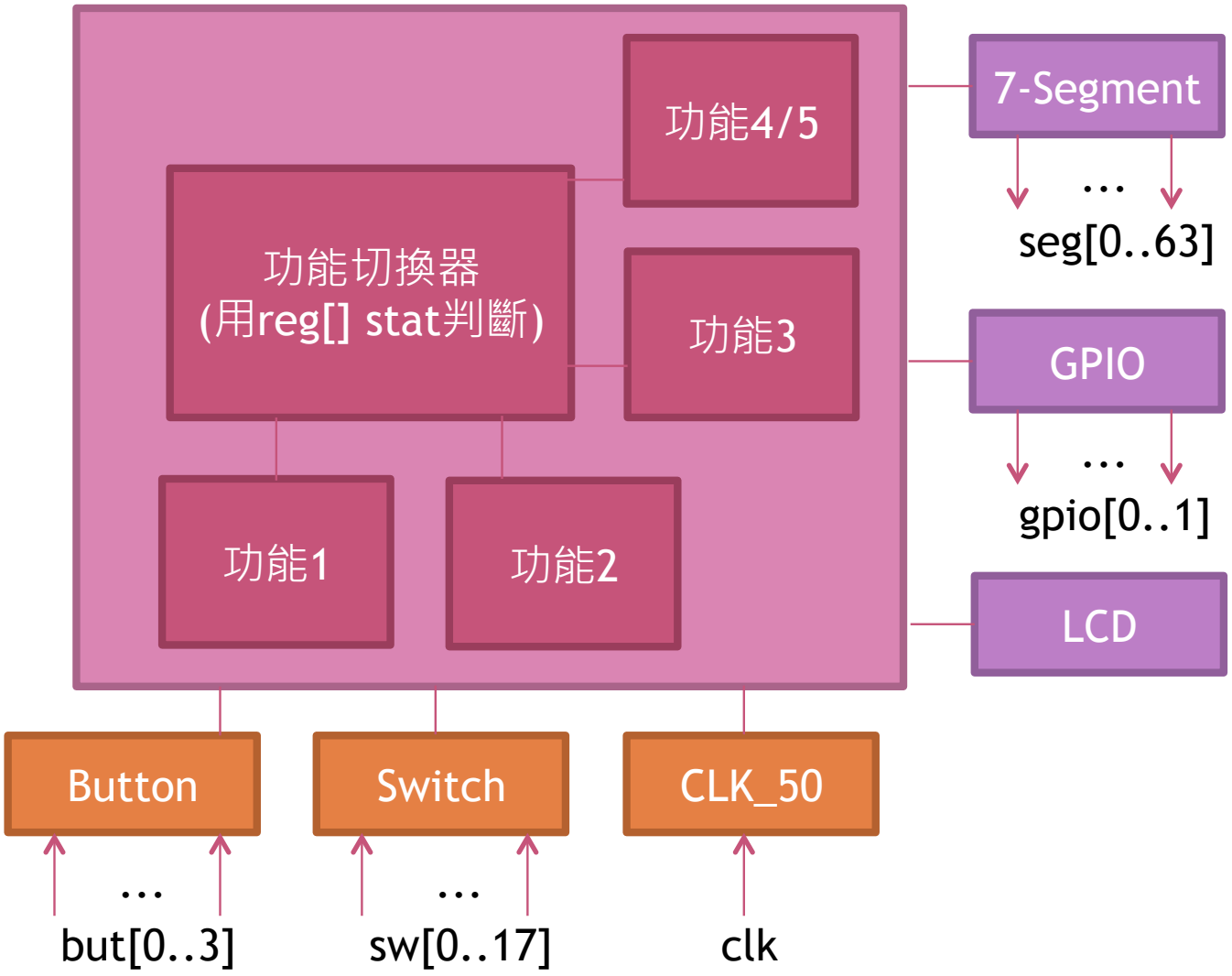
# HARDWARE BLOCK DIAGRAM



# PORT NAMING

| Signal | Naming |
|---|---|
| *INPUT | |
| Seven Segment Digit | seg[63:0] |
| GPIO | gpio[1:0] |
| CLK_50 | clk |
| Pushdown Switch | sw[17:0] |
| *OUTPUT | |
| Button | but[3:0] |
| LCD Data | lcdd[7:0] |
| LCD RW/EN/RS | lcdc[2:0] |

# PIN MAPPING DESCRIPTION(1/9)

| To | Direction | Location | I/O Bank | VREF Group | I/O Standard | Reserved |
|---|---|---|---|---|---|---|
| but[3] | Input | PIN_U29 | 6 | B6_N0 | | |
| but[2] | Input | PIN_U30 | 6 | B6_N0 | | |
| but[1] | Input | PIN_T28 | 6 | B6_N0 | | |
| but[0] | Input | PIN_T29 | 6 | B6_N0 | | |
| clk | Input | PIN_AD15 | 7 | B7_N3 | | |
| gpio[1] | Output | PIN_G27 | 5 | B5_N1 | | |
| gpio[0] | Output | PIN_C30 | 5 | B5_N0 | | |
| lcdc[2] | Output | PIN_F3 | 2 | B2_N0 | | |
| lcdc[1] | Output | PIN_E2 | 2 | B2_N1 | | |
| lcdc[0] | Output | PIN_F2 | 2 | B2_N2 | | |
| lcdd[7] | Output | PIN_B2 | 2 | B2_N0 | | |
| lcdd[6] | Output | PIN_C3 | 2 | B2_N0 | | |

# PIN MAPPING DESCRIPTION(2/9)

| To | Direction | Location | I/O Bank | VREF Group | I/O Standard | Reserved |
|---|---|---|---|---|---|---|
| lcdd[5] | Output | PIN_C2 | 2 | B2_N0 | | |
| lcdd[4] | Output | PIN_C1 | 2 | B2_N0 | | |
| lcdd[3] | Output | PIN_D3 | 2 | B2_N1 | | |
| lcdd[2] | Output | PIN_D2 | 2 | B2_N1 | | |
| lcdd[1] | Output | PIN_E3 | 2 | B2_N0 | | |
| lcdd[0] | Output | PIN_E1 | 2 | B2_N1 | | |
| seg[63] | Output | PIN_AF12 | 8 | B8_N1 | | |
| seg[62] | Output | PIN_AD12 | 8 | B8_N1 | | |
| seg[61] | Output | PIN_AD11 | 8 | B8_N2 | | |
| seg[60] | Output | PIN_AF10 | 8 | B8_N2 | | |
| seg[59] | Output | PIN_AD10 | 8 | B8_N2 | | |
| seg[58] | Output | PIN_AH9 | 8 | B8_N1 | | |

# PIN MAPPING DESCRIPTION(3/9)

| To | Direction | Location | I/O Bank | VREF Group | I/O Standard | Reserved |
|---|---|---|---|---|---|---|
| seg[57] | Output | PIN_AF9 | 8 | B8_N2 | | |
| seg[56] | Output | PIN_AE8 | 8 | B8_N3 | | |
| seg[55] | Output | PIN_AC17 | 7 | B7_N2 | | |
| seg[54] | Output | PIN_AD17 | 7 | B7_N2 | | |
| seg[53] | Output | PIN_AF17 | 7 | B7_N2 | | |
| seg[52] | Output | PIN_AE17 | 7 | B7_N3 | | |
| seg[51] | Output | PIN_AG16 | 7 | B7_N3 | | |
| seg[50] | Output | PIN_AF16 | 7 | B7_N3 | | |
| seg[49] | Output | PIN_AE16 | 7 | B7_N3 | | |
| seg[48] | Output | PIN_AG13 | 8 | B8_N0 | | |
| seg[47] | Output | PIN_AC19 | 7 | B7_N1 | | |
| seg[46] | Output | PIN_AE19 | 7 | B7_N1 | | |

# PIN MAPPING DESCRIPTION(4/9)

| To | Direction | Location | I/O Bank | VREF Group | I/O Standard | Reserved |
|---|---|---|---|---|---|---|
| seg[45] | Output | PIN_AB19 | 7 | B7_N1 | | |
| seg[44] | Output | PIN_AB18 | 7 | B7_N1 | | |
| seg[43] | Output | PIN_AG4 | 8 | B8_N3 | | |
| seg[42] | Output | PIN_AH5 | 8 | B8_N3 | | |
| seg[41] | Output | PIN_AF7 | 8 | B8_N3 | | |
| seg[40] | Output | PIN_AE7 | 8 | B8_N3 | | |
| seg[39] | Output | PIN_M4 | 2 | B2_N3 | | |
| seg[38] | Output | PIN_M6 | 2 | B2_N2 | | |
| seg[37] | Output | PIN_M7 | 2 | B2_N2 | | |
| seg[36] | Output | PIN_M8 | 2 | B2_N1 | | |
| seg[35] | Output | PIN_N7 | 2 | B2_N2 | | |
| seg[34] | Output | PIN_N10 | 2 | B2_N2 | | |

# PIN MAPPING DESCRIPTION(5/9)

| To | Direction | Location | I/O Bank | VREF Group | I/O Standard | Reserved |
|---|---|---|---|---|---|---|
| seg[33] | Output | PIN_P4 | 2 | B2_N3 | | |
| seg[32] | Output | PIN_P6 | 2 | B2_N3 | | |
| seg[31] | Output | PIN_L6 | 2 | B2_N1 | | |
| seg[30] | Output | PIN_M2 | 2 | B2_N3 | | |
| seg[29] | Output | PIN_M1 | 2 | B2_N3 | | |
| seg[28] | Output | PIN_N3 | 2 | B2_N3 | | |
| seg[27] | Output | PIN_N2 | 2 | B2_N3 | | |
| seg[26] | Output | PIN_P3 | 2 | B2_N3 | | |
| seg[25] | Output | PIN_P2 | 2 | B2_N3 | | |
| seg[24] | Output | PIN_P1 | 2 | B2_N3 | | |
| seg[23] | Output | PIN_K6 | 2 | B2_N1 | | |
| seg[22] | Output | PIN_K5 | 2 | B2_N1 | | |

# PIN MAPPING DESCRIPTION(6/9)

| To | Direction | Location | I/O Bank | VREF Group | I/O Standard | Reserved |
|---|---|---|---|---|---|---|
| seg[21] | Output | PIN_K4 | 2 | B2_N2 | | |
| seg[20] | Output | PIN_K1 | 2 | B2_N2 | | |
| seg[19] | Output | PIN_L3 | 2 | B2_N2 | | |
| seg[18] | Output | PIN_L2 | 2 | B2_N3 | | |
| seg[17] | Output | PIN_L1 | 2 | B2_N3 | | |
| seg[16] | Output | PIN_M3 | 2 | B2_N3 | | |
| seg[15] | Output | PIN_K2 | 2 | B2_N2 | | |
| seg[14] | Output | PIN_E4 | 2 | B2_N0 | | |
| seg[13] | Output | PIN_F4 | 2 | B2_N0 | | |
| seg[12] | Output | PIN_G4 | 2 | B2_N0 | | |
| seg[11] | Output | PIN_H8 | 2 | B2_N0 | | |
| seg[10] | Output | PIN_H7 | 2 | B2_N0 | | |

# PIN MAPPING DESCRIPTION(7/9)

| To | Direction | Location | I/O Bank | VREF Group | I/O Standard | Reserved |
|---|---|---|---|---|---|---|
| seg[9] | Output | PIN_H4 | 2 | B2_N1 | | |
| seg[8] | Output | PIN_H6 | 2 | B2_N0 | | |
| seg[7] | Output | PIN_G2 | 2 | B2_N2 | | |
| seg[6] | Output | PIN_G1 | 2 | B2_N2 | | |
| seg[5] | Output | PIN_H3 | 2 | B2_N1 | | |
| seg[4] | Output | PIN_H2 | 2 | B2_N2 | | |
| seg[3] | Output | PIN_H1 | 2 | B2_N2 | | |
| seg[2] | Output | PIN_J2 | 2 | B2_N2 | | |
| seg[1] | Output | PIN_J1 | 2 | B2_N2 | | |
| seg[0] | Output | PIN_K3 | 2 | B2_N2 | | |
| sw[17] | Input | PIN_L8 | 2 | B2_N1 | | |
| sw[16] | Input | PIN_L7 | 2 | B2_N1 | | |

# PIN MAPPING DESCRIPTION(8/9)

| To | Direction | Location | I/O Bank | VREF Group | I/O Standard | Reserved |
|---|---|---|---|---|---|---|
| sw[15] | Input | PIN_L4 | 2 | B2_N2 | | |
| sw[14] | Input | PIN_L5 | 2 | B2_N1 | | |
| sw[13] | Input | PIN_T9 | 1 | B1_N0 | | |
| sw[12] | Input | PIN_U9 | 1 | B1_N0 | | |
| sw[11] | Input | PIN_V10 | 1 | B1_N1 | | |
| sw[10] | Input | PIN_W5 | 1 | B1_N1 | | |
| sw[9] | Input | PIN_AE27 | 6 | B6_N2 | | |
| sw[8] | Input | PIN_AD24 | 6 | B6_N3 | | |
| sw[7] | Input | PIN_AD25 | 6 | B6_N3 | | |
| sw[6] | Input | PIN_AC23 | 6 | B6_N3 | | |
| sw[5] | Input | PIN_AC24 | 6 | B6_N3 | | |
| sw[4] | Input | PIN_AC26 | 6 | B6_N3 | | |

# PIN MAPPING DESCRIPTION(9/9)

| To | Direction | Location | I/O Bank | VREF Group | I/O Standard | Reserved |
|---|---|---|---|---|---|---|
| sw[3] | Input | PIN_AC27 | 6 | B6_N2 | | |
| sw[2] | Input | PIN_AB25 | 6 | B6_N2 | | |
| sw[1] | Input | PIN_AB26 | 6 | B6_N2 | | |
| sw[0] | Input | PIN_AA23 | 6 | B6_N2 | | |

# TIPS TO REDUCE RESOURCE UTILIZATION(1/3)

- Tip1:
  - 盡量少用除法
  - 例如功能1中，計數器是用兩個4-bit-register紀錄，如此顯示時完全不會應用到除法
  - 證明: 除法是個非常複雜的操作，需要使用到相當大的resource數目，當我們把功能1中的除法器改成兩個4-bit-register，整個resource數目減少了約莫1000。

# TIPS TO REDUCE RESOURCE UTILIZATION(2/3)

- Tip2:
  - 不要把太複雜的東西用For迴圈
  - 例如說在功能3中，LCD顯示的延遲便是直接把Code展開，而不是用迴圈進行
  - 證明: 因為For迴圈需要把整個Block包起來，若For內的東西過於複雜可能會造成許多resource的浪費；另外編譯器也可能會把For迴圈展開，如此和直接條列並無差別

# TIPS TO REDUCE RESOURCE UTILIZATION(3/3)

- Tip3:
  - 減少給硬體做的計算量
  - 例如說在功能4/5中，要計算active的duration，本可以用頻率/100*(duty cycle)，但是選擇直接使用8個if來進行判斷
  - 證明: 給硬體做計算是很複雜的，例如說上面要用到一個除法器跟一個乘法器，雖然if看起來很多但實際上resource少很多。