數位系統技術

Keyboard

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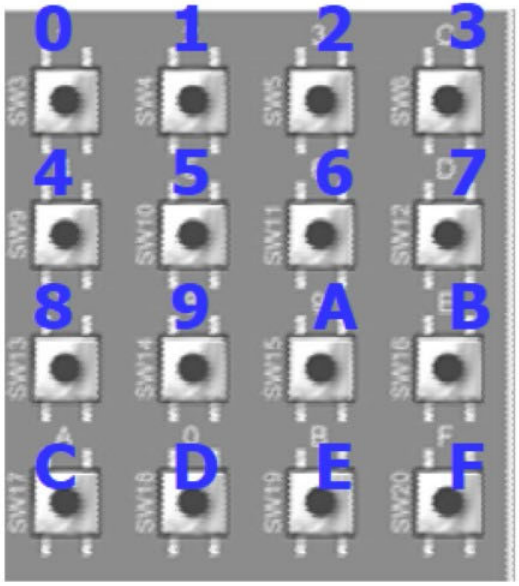
實驗內容 (1/2)

- 設計一個資料儲存電路buffer[23:0]以存放6個數字，每個數字4位元，且這6個數字可同時會顯示在Seg7中。
- 按下keyboard的其中一個16進位數字0~F鍵時，該數字會存入buffer[3:0]位置，原先在buffer[19:0]的數字則會左移。

buffer[23:0]

SEG5 SEG4 SEG3 SEG2 SEG1 SEG0

Seg7



Keyboard

實驗內容 (2/2)

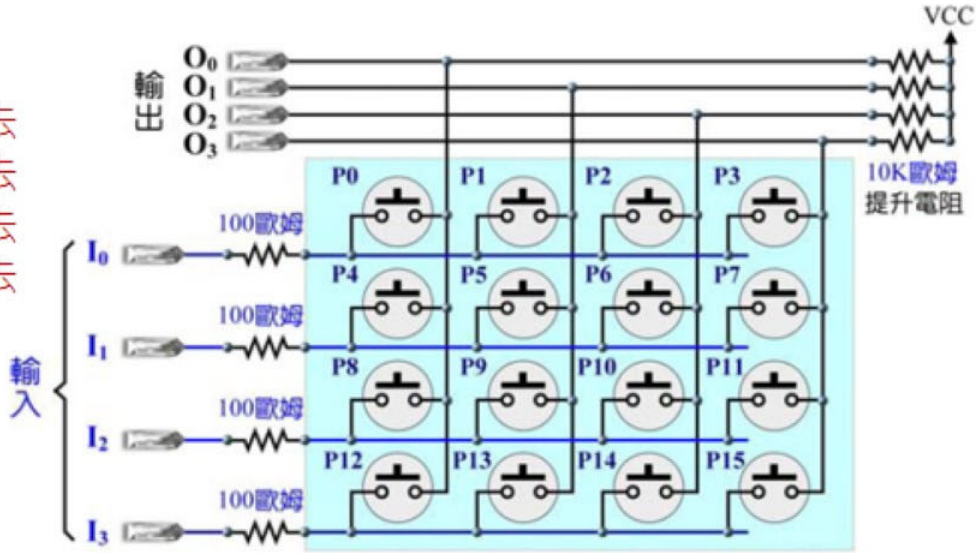
- 當keyboard有按鍵按下時(press=1)，Led9會亮燈表示，同時Led3~Led0會顯示所按之鍵的二進位值(scan_code[3:0])，亮燈表示1，不亮表示0。

Example

- 按下**3**，buffer = _____3
- 按下**4**，buffer = ____34
- 按下**1**，buffer = ___341
- 按下**A**，buffer = __341A
- 按下**5**，buffer = _341A5
- 按下**F**，buffer = 341A5F
- 按下**7**，buffer = 41A5F7
- 按下**8**，buffer = 1A5F78

Keyboard 工作原理

Ex: 給定 I=1101
1. 若偵測到O=1110，表示P4按下去
2. 若偵測到O=1101，表示P5按下去
3. 若偵測到O=1011，表示P6按下去
4. 若偵測到O=0111，表示P7按下去

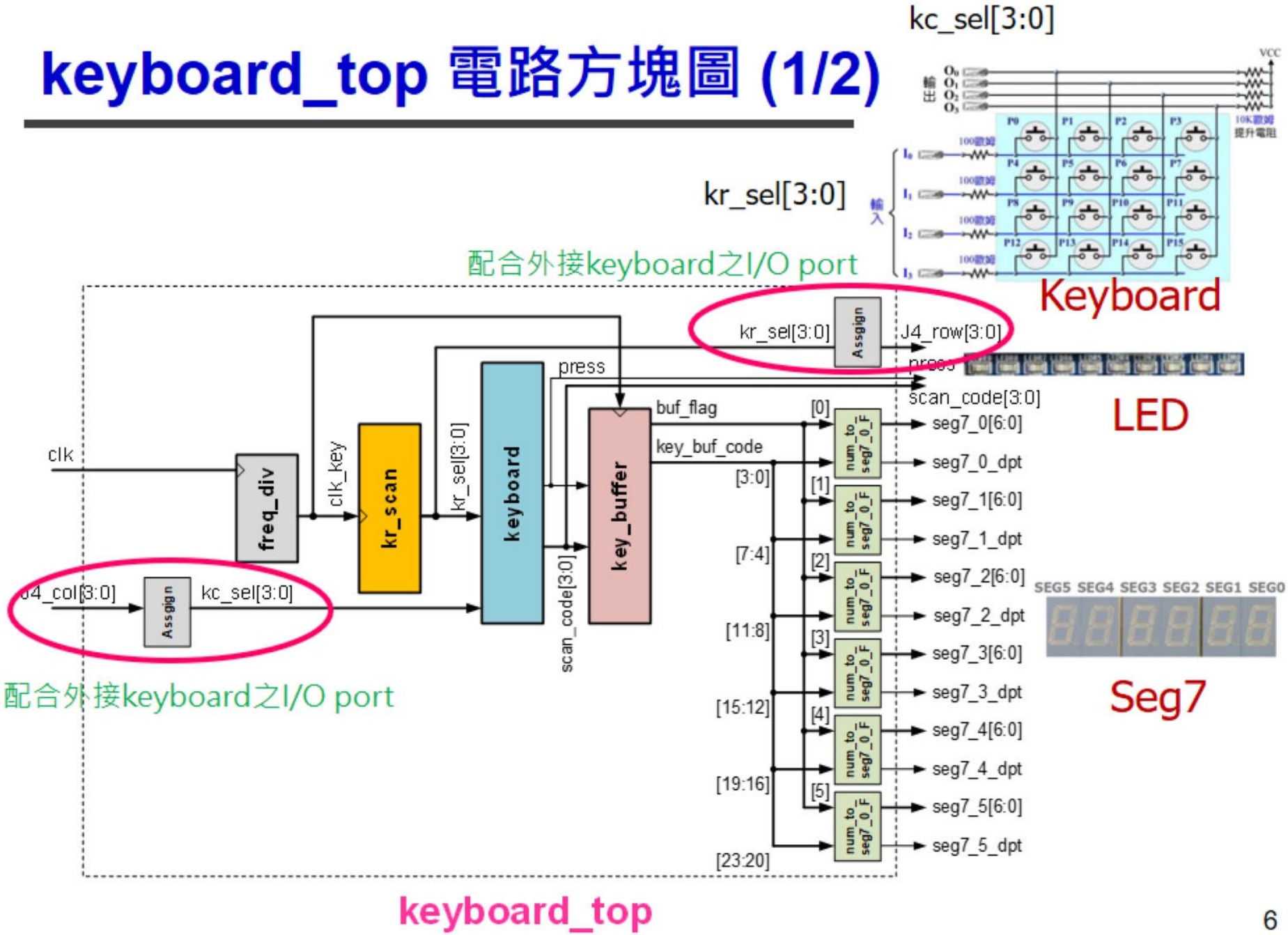


掃描輸入　　偵測輸出

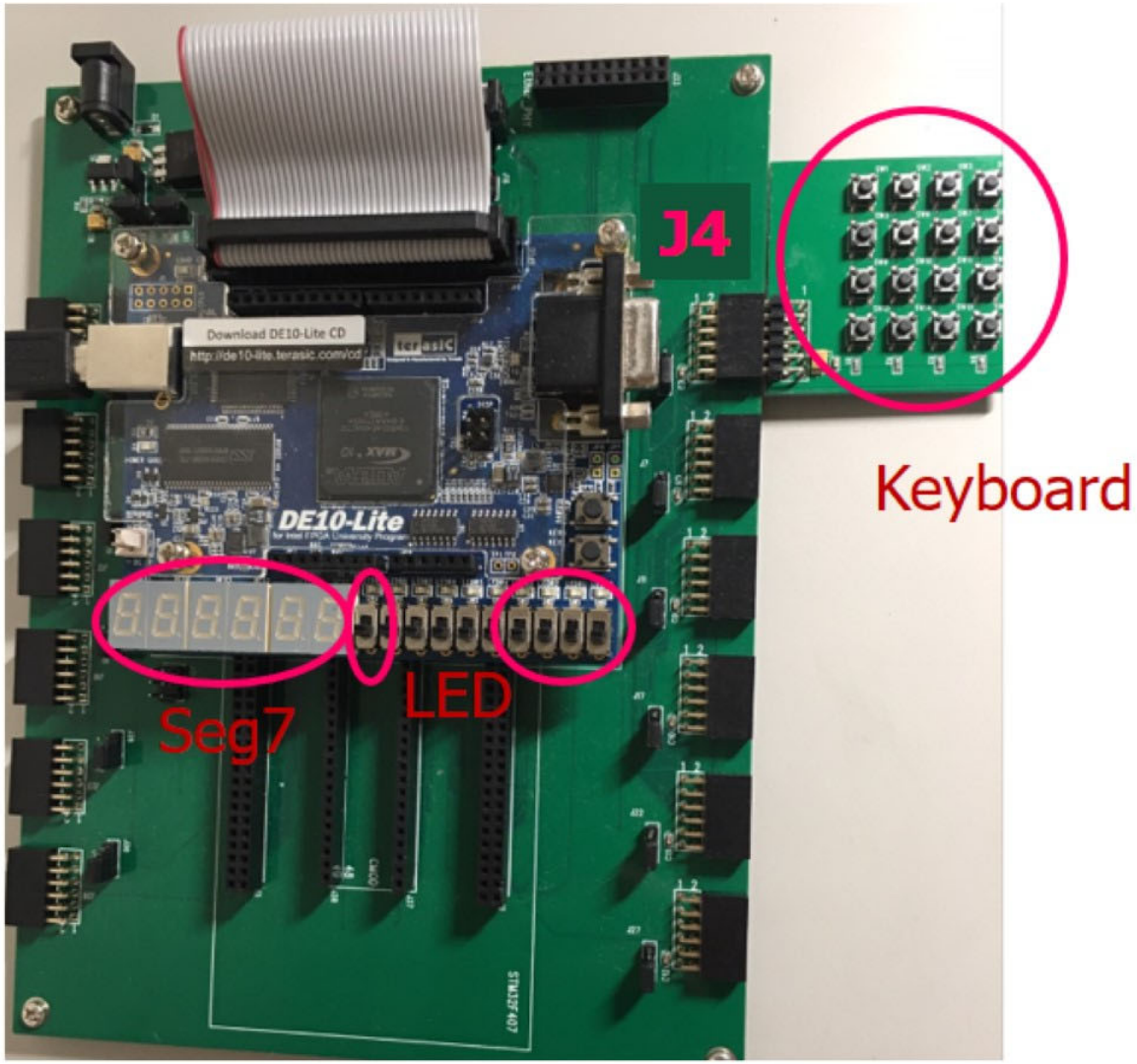
順序	對應鍵	$I_3I_2I_1I_0$	$O_3O_2O_1O_0$	$O_3O_2O_1O_0$	$O_3O_2O_1O_0$	$O_3O_2O_1O_0$
0	$P_3P_2P_1P_0$	1110	按 P_0:1110	按 P_1:1101	按 P_2:1011	按 P_3:0111
1	$P_7P_6P_5P_4$	1101	按 P_4:1110	按 P_5:1101	按 P_6:1011	按 P_7:0111
2	$P_{11}P_{10}P_9P_8$	1011	按 P_8:1110	按 P_9:1101	按 P_{10}:1011	按 P_{11}:0111
3	$P_{15}P_{14}P_{13}P_{12}$	0111	按 P_{12}:1110	按 P_{13}:1101	按 P_{14}:1011	按 P_{15}:0111

4×4 鍵盤掃瞄原理(無按鍵時 $O_3O_2O_1O_0$=1111)

keyboard_top 電路方塊圖 (1/2)



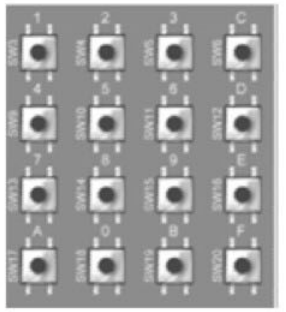
keyboard_top 電路方塊圖 (2/2)



Design 1: kr_scan

- 設計keyboard之row掃描電路kr_scan.v，由上至下掃描keyboard。

1110
1101
1011
0111



```
module kr_scan(clk, rst, kr_out);
    input clk, rst;
    output reg [3:0] kr_out;

    always@(posedge clk or posedge rst) begin
        if (rst)
            kr_out =          // top row
        else // left circular shift
            kr_out =
            // 1110 -> 1101 -> 1011 -> 0111
            // select row from up to down
    end
endmodule
```

Design 2: keyboard (1/6)

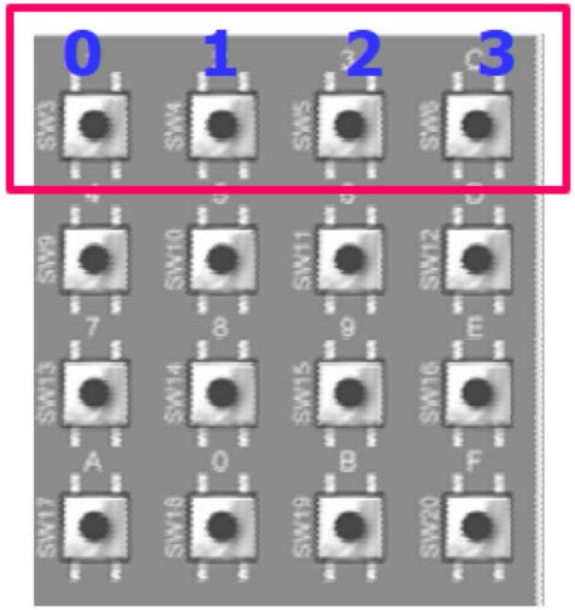
- 設計keyboard偵測電路keyboard.v，判斷keyboard是否有按鍵按下，並產生按鍵之二進位編碼。

```
module keyboard(kr, kc, press, scan_code);
    input [3:0] kr;
    input [3:0] kc;
    output reg press;
    output reg [3:0] scan_code;

    always@(kr or kc) begin
        case(kr)
```

1. kr[3:0]為keyboard的row掃描輸入
2. kc[3:0]為keyboard的column偵測輸出
3. 若keyboard偵測到有任何鍵按下去，press之值為1
4. scan_code[3:0]為所按之鍵的二進位編碼

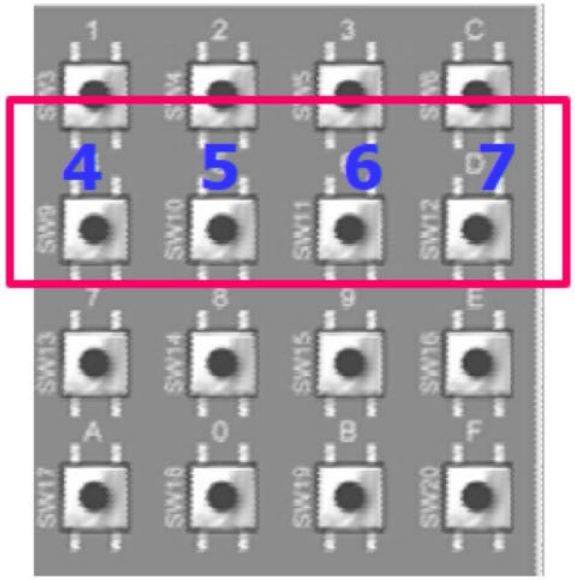
Design 2: keyboard (2/6)

```
4'b1110: // 1st row
    case(kc)
        4'b1110: begin  press =1'b1;
                        scan_code = 4'h0;
                 end // 0
        4'b1101: begin  press =1'b1;
                        scan_code = 4'h1;
                 end // 1
        4'b1011: begin  press =1'b1;
                        scan_code = 4'h2;
                 end // 2
        4'b0111: begin  press =1'b1;
                        scan_code = 4'h3;
                 end // 3
        default: begin  press =1'b0;
                        scan_code = 4'h0;
                 end // default
    endcase
```



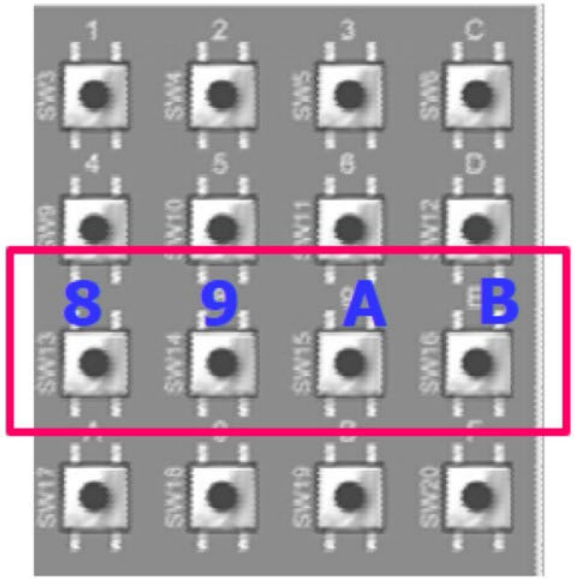
Design 2: keyboard (3/6)

```
4'b1101: // 2nd row
    case(kc)
        4'b1110: begin

                 end //
        4'b1101: begin

                 end //
        4'b1011: begin

                 end //
        4'b0111: begin

                 end //
        default: begin

                 end //
    endcase
```



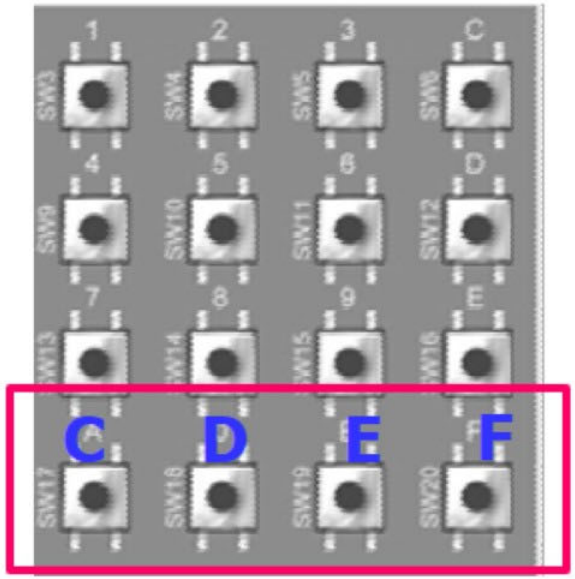
Design 2: keyboard (4/6)

```
4'b1011: // 3rd row
    case(kc)
        4'b1110: begin

                 end //
        4'b1101: begin

                 end //
        4'b1011: begin

                 end //
        4'b0111: begin

                 end //
        default: begin

                 end //
    endcase
```



Design 2: keyboard (5/6)

```
4'b0111: // 4th row
    case(kc)
        4'b1110: begin

                 end //
        4'b1101: begin

                 end //
        4'b1011: begin

                 end //
        4'b0111: begin

                 end //
        default: begin

                 end //
    endcase
```



Design 2: keyboard (6/6)

```
            default: begin   press = 1'b0;
                             scan_code = 4'h0;
                     end
        endcase
    end
endmodule
```

Design 3: key_buffer (1/2)

- 設計一個可存放6個數字之buffer電路key_buffer.v，每個數字4個位元。

```
module key_buffer(clk, rst, press, scan_code,
buf_flag, key_buf_code);

    input   clk, rst, press;
    input   [3:0] scan_code;
    output  [5:0] buf_flag;
    output  [23:0] key_buf_code;

    reg     [5:0] buf_flag;
    reg     [23:0] key_buf_code;
```

1. press為1時表示keyboard有按鍵被按下
2. scan_code[3:0]為所按下之鍵的二進位編碼
3. buf_flag[5:0]為記錄buffer電路中每個位置是否有數字存入
4. key_buf_code[23:0]為存放6個數字之24位元buffer電路，每個數字4個位元。

Design 3: key_buffer (2/2)

```
always@(posedge clk or posedge rst) begin
    if (rst) begin
        buf_flag = 6'b000000;
        key_buf_code = 24'h000000;
    end
    else
        if (press == 1'b1) begin
            buf_flag =
            key_buf_code[23:0] =
        end
end
endmodule
```

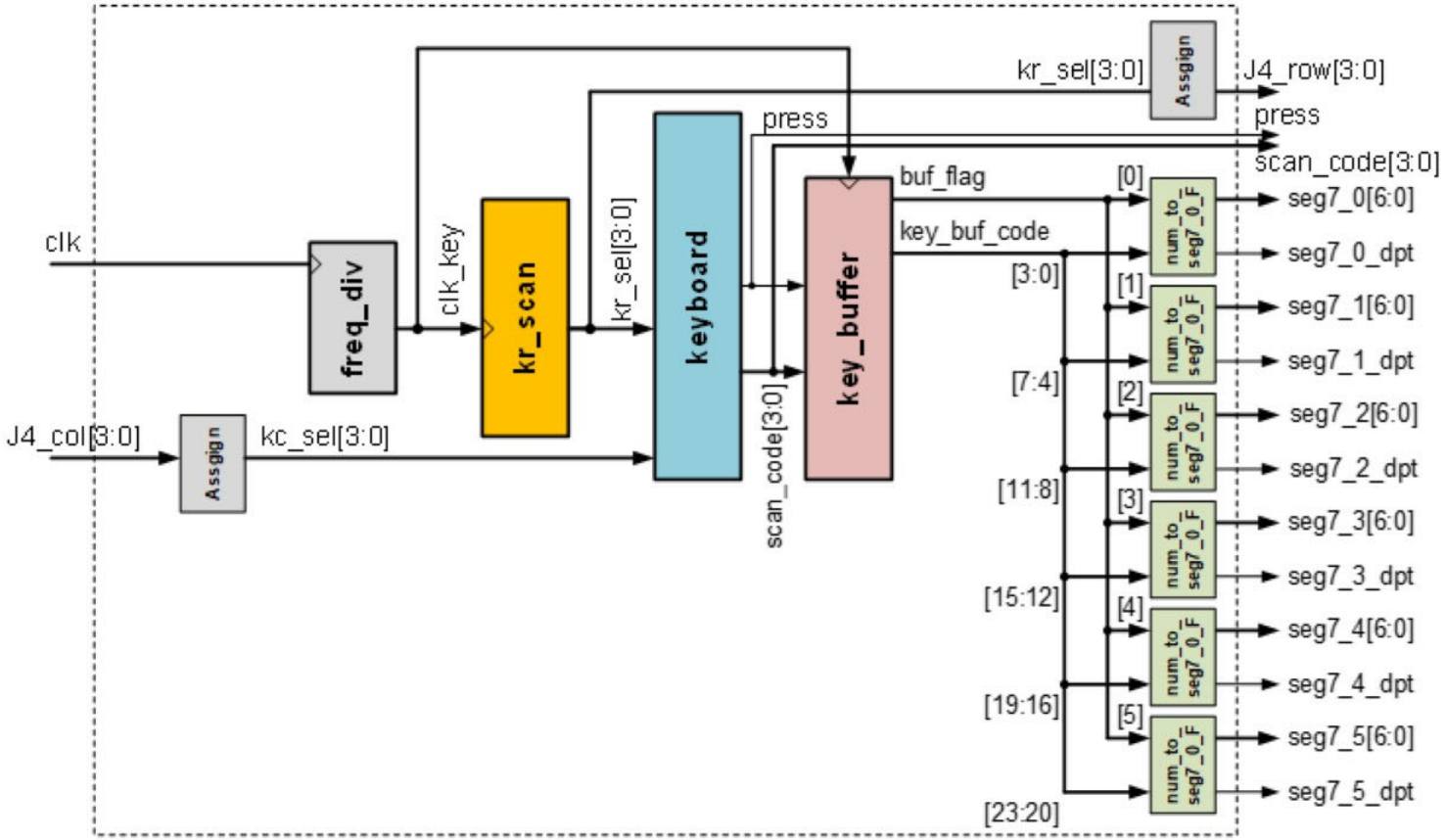
初始時，buffer電路是空的

若有按鍵按下，數字將存入buffer，buf_flag[0]設為1，原buf_flag[4:0]之值左移

所按之鍵的二進位編碼scan_code[3:0]存入key_buf_code[3:0]，原本的[23:20]左移出buffer，[19:0]左移1個數字(4個位元)

Design 4: keyboard_top (1/4)

- 設計keyboard_top .v，整合所有電路模組。



keyboard_top

Design 4: keyboard_top (2/4)

```
module keyboard_top (clk, rst, J4_col, J4_row, press, scan_code,
seg7_0, seg7_0_dpt, seg7_1, seg7_1_dpt, seg7_2, seg7_2_dpt,
seg7_3, seg7_3_dpt, seg7_4, seg7_4_dpt, seg7_5, seg7_5_dpt);

    input clk, rst;
    input [3:0] J4_col;
    output [3:0] J4_row;
    output press;
    output [3:0] scan_code;
    output [6:0] seg7_0, seg7_1, seg7_2, seg7_3, seg7_4, seg7_5;
    output seg7_0_dpt, seg7_1_dpt, seg7_2_dpt,
    seg7_3_dpt, seg7_4_dpt, seg7_5_dpt;
```

Design 4: keyboard_top (3/4)

```
wire [3:0] kr_sel, kc_sel;

assign J4_row[0] = kr_sel[0];
assign J4_row[1] = kr_sel[1];
assign J4_row[2] = kr_sel[2];
assign J4_row[3] = kr_sel[3];
assign kc_sel[0] = J4_col[0];
assign kc_sel[1] = J4_col[1];
assign kc_sel[2] = J4_col[2];
assign kc_sel[3] = J4_col[3];

wire clk_key;
wire [5:0] buf_flag;
wire [23:0] key_buf_code;
```

配合外接keyboard之I/O port

Design 4: keyboard_top (4/4)

```
freq_div        #(21)   m0
kr_scan                 m1
keyboard                m2
key_buffer              m3

num_to_seg7_0_F         m4
num_to_seg7_0_F         m5
num_to_seg7_0_F         m6
num_to_seg7_0_F         m7
num_to_seg7_0_F         m8
num_to_seg7_0_F         m9
```

row scan及資料存入buffer之頻率

rst要反相 -> ~rst

按鍵二進位值對Seg7之編碼
若無資料則Seg7為暗

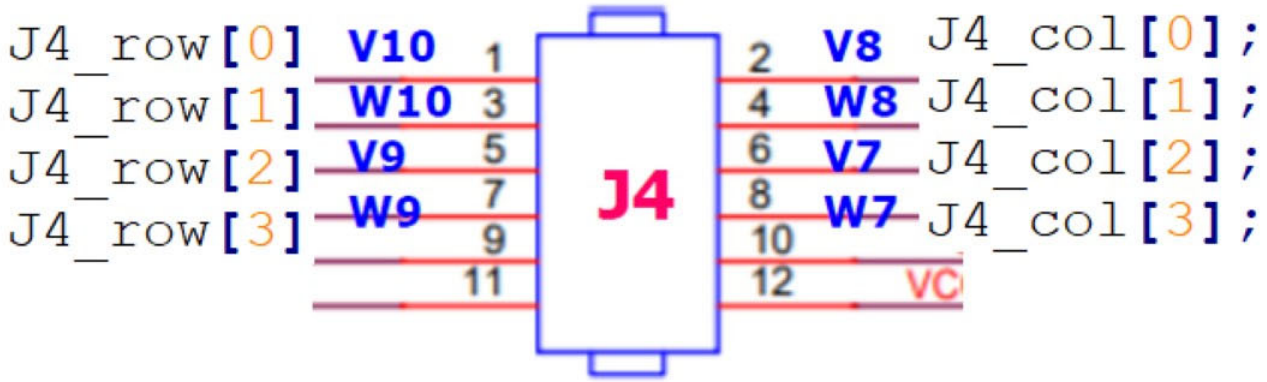
Pin Assignments (1/2)

clk

Clocks: 50 MHZ

CLK1: P11

CLK2: N14



rst

KEY0: B8 **Push: 0**

KEY1: A7 **Not push: 1**

Pin Assignments (2/2)

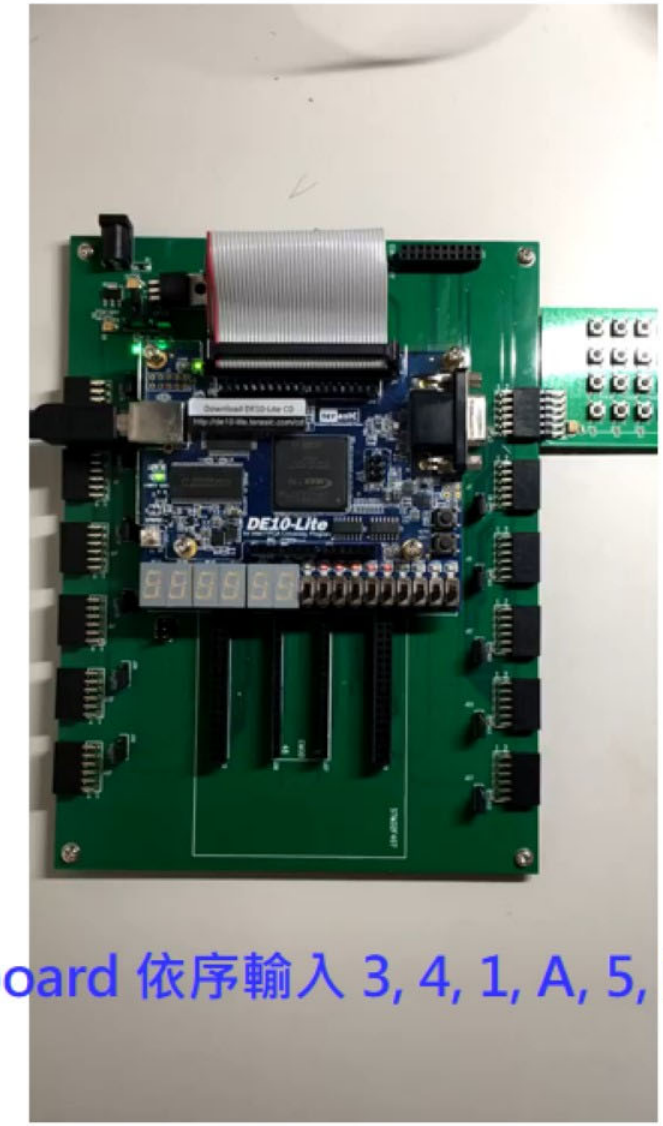
SEG07	SEG06	SEG05	SEG04	SEG03	SEG02	SEG01	SEG00
D15	C17	D17	E16	C16	C15	E15	C14
SEG17	SEG16	SEG15	SEG14	SEG13	SEG12	SEG11	SEG10
A16	B17	A18	A17	B16	E18	D18	C18
SEG27	SEG26	SEG25	SEG24	SEG23	SEG22	SEG21	SEG20
A19	B22	C22	B21	A21	B19	A20	B20
SEG37	SEG36	SEG35	SEG34	SEG33	SEG32	SEG31	SEG30
D22	E17	D19	C20	C19	E21	E22	F21
SEG47	SEG46	SEG45	SEG44	SEG43	SEG42	SEG41	SEG40
F17	F20	F19	H19	J18	E19	E20	F18
SEG57	SEG56	SEG55	SEG54	SEG53	SEG52	SEG51	SEG50
L19	N20	N19	M20	N18	L18	K20	J20

press scan_code[3:0]

1: LED on
0: LED off

LED9	LED8	LED7	LED6	LED5	LED4	LED3	LED2	LED1	LED0
B11	A11	D14	E14	C13	D13	B10	A10	A9	A8

執行結果



Keyboard 依序輸入 3, 4, 1, A, 5, F, 7, 8

File List

- Verilog files
  - freq_div.v (二的次方之除頻電路)
  - num_to_seg7_0_F.v (16進位數字轉Seg7編碼)
  - kr_scan.v (產生列掃描的信號)
  - keyboard.v (產生按鍵編碼)
  - key_buffer.v (將按鍵資料送入buffer)
  - keyboard_top.v (最上層top電路)

實驗結果驗收

- 請老師或助教驗收 keyboard_top 電路於實驗板顯示之圖形