Basys3 键盘操作原理及参考代码

实验原理

BASYS3 开发板集成了一个 USB 鼠标键盘接口转 PS/2 接口的硬件模块 PIC24FJ128(如图 1),这样对于 FPGA 来说,外部连接的鼠标键盘就是 PS/2 接口的。PS/2 接口采用一种双向的同步串行协议。无论是主机-设备通信,还是设备-主机通信,时钟总是由设备产生,频率为 10~16.7KHZ。数据传输方式为每次一字节,用 11 位的帧来传送,它由起始位、8 位数据、奇偶检验位和停止位构成。

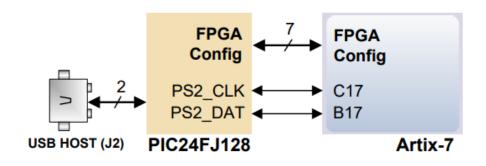


图 1 BASYS3 开发板集成的 PIC24FJ128 模块电路

图 2 给出了设备-主机通讯方式的时序图。由设备产生时钟和数据。在空闲时,时钟和数据线处于高电平。主机在主机时钟下降沿记录从设备发送过来的数据。

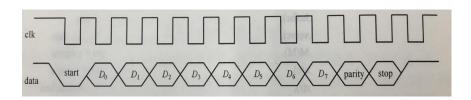


图 2 设备-主机通信方式的时序图

数据帧的对应位表示如下:

Start:起始位, 总为'0'(低电平);

D0~D7: 8 位数据位(地位在前,高位在后);

Parity: 奇偶校验位(为奇校验);

Stop: 停止位,总为'1'(高电平)。

对于键盘来说,可通过扫描编码来识别按键输入。键盘的每个按键都有

不同的编码。每个按键的编码分为通码和断码。当按下键盘上的按键时,通码被发到 PS/2 接口; 当释放案件时,断码被发送到 PS/2 接口。如下表 1 给出了键盘上所有按键的通码和断码。

表 1 PS2 键盘通码断码表

C 21 FO 21 — 4E FO 4E HOME EO 6C E D 23 FO 23 = 55 FO 55 PG UP EO 7D E E 24 FO 24 \ 5D FO 5D DELETE EO 7D E F 2B FO 2B BKSP 66 FO 66 END EO 69 E G 34 FO 34 SPACE 29 FO 29 PG DN EO 7A E H 33 FO 33 TAB OD FO 0D U ARROW EO 75 E I 43 FO 43 CAPS 58 FO 58 L ARROW EO 6B E J 38 FO 3B L SHFT 12	F0 54 0 F0 70 0 F0 6C 0 F0 7D 0 F0 71 0 F0 69 0 F0 7A 0 F0 75 0 F0 6B
C 21 FO 21 - 4E FO 4E HOME EO 6C E D 23 FO 23 = 55 FO 55 PG UP EO 7D E E 24 FO 24 \ 5D FO 5D DELETE EO 7D E F 2B FO 2B BKSP 66 FO 66 END EO 69 E G 34 FO 34 SPACE 29 FO 29 PG DN EO 7A E H 33 FO 33 TAB OD FO 0D U ARROW EO 75 E I 43 FO 43 CAPS 58 FO 58 L ARROW EO 6B EO FO 15 ARROW EO 72 EO EO BARROW EO	F0 6C F0 7D F0 7T F0 69 F0 7A F0 75 F0 6B
D 23 FO 23 = 55 FO 55 PG UP EO 7D E E 24 FO 24 \ 5D FO 5D DELETE EO 7D E F 2B FO 24 \ 5D FO 5D DELETE EO 7D E F 2B FO 2B BKSP 66 FO 66 END EO 69 E G 34 FO 34 SPACE 29 FO 60 D BC 69 E H 33 FO 34 SPACE 29 FO 60 D D CO EO CO FO A CO CO FO A CO	FO 7D FO 7D FO 71 FO 69 FO 7A FO 75 FO 6B
E 24 FO 24 \ 5D FO 5D DELETE EO 71 E F 2B FO 2B BKSP 66 FO 66 END EO 69 E G 34 FO 34 SPACE 29 FO 29 PG DN EO 7A E H 33 FO 34 SPACE 29 FO 29 PG DN EO 7A E H 33 FO 34 SPACE 29 FO 29 PG DN EO 7A E H 33 FO 34 SPACE 29 FO 59 PG DN EO FO 58 EO FO 58 EO FO 58 EO FO FO 59 FO F	F0 71 F0 69 F0 7A F0 75 F0 6B
F 2B FO 2B BKSP 66 FO 66 END EO 69 E G 34 FO 34 SPACE 29 FO 29 PG DN EO 7A E H 33 FO 33 TAB OD FO 0D U ARROW EO 75 E I 43 FO 43 CAPS 58 FO 58 L ARROW EO 6B E J 3B FO 3B L SHFT 12 FO 12 D ARROW EO 72 E K 42 FO 42 L CTRL 14 FO 14 R ARROW EO 74 E L 4B FO 4B L GUI EO 1F EO FO 1F NUM 77 FO M 3A FO 3A L ALT 11 FO 11 KP / EO 4A E N 31 FO 31 R SHFT 59 FO 59 KP * 7C FO O 44 FO 44 R CTRL EO 14 EO	FO 69 FO 7A FO 75 FO 6B
G 34 F0 34 SPACE 29 F0 29 PG DN E0 7A E H 33 F0 33 TAB OD F0 0D U ARROW E0 75 E I 43 F0 43 CAPS 58 F0 58 L ARROW E0 6B E J 3B F0 3B L SHFT 12 F0 12 D ARROW E0 72 E K 42 F0 42 L CTRL 14 F0 14 R ARROW E0 74 E L 4B F0 4B L GUI E0 1F E0 F0 1F NUM 77 F0 M 3A F0 3A L ALT 11 F0 11 KP / E0 4A E N 31 F0 31 R SHFT 59 F0 59 KP * 7C F0 O 44 F0 44 R CTRL E0 14 E0 F0 14 KP - 7B P 4D F0 4D R GUI E0 27 E0 F0 27	F0 7A F0 75 F0 6B
H 33 FO 33 TAB OD FO 0D U ARROW EO 75 E I 43 FO 43 CAPS 58 FO 58 L ARROW EO 6B E J 3B FO 3B L SHFT 12 FO 12 D ARROW EO 72 E K 42 FO 42 L CTRL 14 FO 14 R ARROW EO 74 E L 4B FO 4B L GUI EO 1F EO FO 1F NUM 77 FO M 3A FO 3A L ALT 11 FO 11 KP / EO 4A E N 31 FO 31 R SHFT 59 FO 59 KP * 7C FO O 44 FO 44 R CTRL EO 14 EO FO 14 KP - 7B P 4D FO 4D R GUI EO 27 EO FO 27 KP + 79 Q 15 FO 15 R ALT EO 11 EO FO 11 KP EN <td>F0 75 F0 6B</td>	F0 75 F0 6B
I 43 FO 43 CAPS 58 FO 58 L ARROW EO 6B E J 3B FO 3B L SHFT 12 FO 12 D ARROW EO 72 E K 42 FO 42 L CTRL 14 FO 14 R ARROW EO 74 E L 4B FO 4B L GUI EO 1F EO FO 1F NUM 77 FO M 3A FO 3A L ALT 11 FO 11 KP / EO 4A E N 31 FO 31 R SHFT 59 FO 59 KP * 7C FO O 44 FO 44 R CTRL EO 14 EO FO 14 KP - 7B P 4D FO 4D R GUI EO 27 EO FO 27 KP + 79 Q 15 FO 15 R ALT EO 11 KP EN EO 5A E R 2D FO 2D APPS EO 2F EO FO 2F KP 71) F0 6B
J 3B FO 3B L SHFT 12 FO 12 D ARROW EO 72 E K 42 FO 42 L CTRL 14 FO 14 R ARROW EO 74 E L 4B FO 4B L GUI EO 1F EO FO 1F NUM 77 FO M 3A FO 3A L ALT 11 FO 11 KP / EO 4A E N 31 FO 31 R SHFT 59 FO 59 KP * 7C FO O 44 FO 44 R CTRL EO 14 EO FO 14 KP - 7B FO FO AP TO FO FO FO AP TO FO F	
K 42 FO 42 L CTRL 14 FO 14 R ARROW EO 74 E L 4B FO 4B L GUI EO 1F EO FO 1F NUM 77 FO M 3A FO 3A L ALT 11 FO 11 KP / EO 4A E N 31 FO 31 R SHFT 59 FO 59 KP * 7C FO O 44 FO 44 R CTRL EO 14 EO FO 14 KP - 7B P 4D FO 4D R GUI EO 27 EO FO 27 KP + 79 Q 15 FO 15 R ALT EO 11 EO FO 27 KP + 79 Q 15 FO 2D APPS EO 2F EO FO 2F KP 71 S 1B FO 1B ENTER 5A FO 5A KP 0 70 T 2C FO 2C ESC 76 FO 76 KP 1 69 U) FO 72
L 4B F0 4B L GUI E0 1F E0 F0 1F NUM 77 F0 M 3A F0 3A L ALT 11 F0 11 KP / E0 4A E N 31 F0 31 R SHFT 59 F0 59 KP * 7C F0 O 44 F0 44 R CTRL E0 14 E0 F0 14 KP - 7B P 4D F0 4D R GUI E0 27 E0 F0 27 KP + 79 Q 15 F0 15 R ALT E0 11 E0 F0 11 KP EN E0 5A E R 2D F0 2D APPS E0 2F E0 F0 2F KP 71 T S 1B F0 1B ENTER 5A F0 5A KP 0 70 T T 2C F0 2C ESC 76 F0 76 KP 1 69 T U 3C F0 3C F1 5 F0 05 KP 2 72	, 10 12
M 3A FO 3A L ALT 11 FO 11 KP / EO 4A E N 31 FO 31 R SHFT 59 FO 59 KP * 7C FO O 44 FO 44 R CTRL EO 14 EO FO 14 KP - 7B P 4D FO 4D R GUI EO 27 EO FO 27 KP + 79 Q 15 FO 15 R ALT EO 11 EO FO 11 KP EN EO 5A E R 2D FO 2D APPS EO 2F EO FO 2F KP 71 S 1B FO 1B ENTER 5A FO 5A KP 0 70 T 2C FO 2C ESC 76 FO 76 KP 1 69 U 3C FO 3C F1 5 FO 05 KP 2 72 V 2A FO 2A F2 6 FO 06 KP 3 7A W 1D FO 1D) F0 74
N 31 FO 31 R SHFT 59 FO 59 KP * 7C FO O 44 FO 44 R CTRL EO 14 EO FO 14 KP - 7B P 4D FO 4D R GUI EO 27 EO FO 27 KP + 79 Q 15 FO 15 R ALT EO 11 EO FO 11 KP EN EO 5A E R 2D FO 2D APPS EO 2F EO FO 2F KP 71 S 1B FO 1B ENTER 5A FO 5A KP 0 70 T 2C FO 2C ESC 76 FO 76 KP 1 69 U 3C FO 3C F1 5 FO 05 KP 2 72 V 2A FO 2A F2 6 FO 06 KP 3 7A W 1D FO 1D F3 4 FO 04 KP 4 6B X 22 FO 22 F4 <td< td=""><td>77</td></td<>	77
0 44 F0 44 R CTRL E0 14 E0 F0 14 KP - 7B P 4D F0 4D R GUI E0 27 E0 F0 27 KP + 79 Q 15 F0 15 R ALT E0 11 E0 F0 11 KP EN E0 5A E R 2D F0 2D APPS E0 2F E0 F0 2F KP 71 S 1B F0 1B ENTER 5A F0 5A KP 0 70 T 2C F0 2C ESC 76 F0 76 KP 1 69 U 3C F0 3C F1 5 F0 05 KP 2 72 V 2A F0 2A F2 6 F0 06 KP 3 7A W 1D F0 1D F3 4 F0 04 KP 4 6B X 22 F0 22 F4 0C F0 0C KP 5 73 Y 35 F0 35 F5 3 F0 0) FO 4A
P 4D F0 4D R GUI E0 27 E0 F0 27 KP + 79 Q 15 F0 15 R ALT E0 11 E0 F0 11 KP EN E0 5A E R 2D F0 2D APPS E0 2F E0 F0 2F KP 71 S 1B F0 1B ENTER 5A F0 5A KP 0 70 T 2C F0 2C ESC 76 F0 76 KP 1 69 U 3C F0 3C F1 5 F0 05 KP 2 72 V 2A F0 2A F2 6 F0 06 KP 3 7A W 1D F0 1D F3 4 F0 04 KP 4 6B X 22 F0 22 F4 0C F0 0C KP 5 73 Y 35 F0 35 F5 3 F0 03 KP 6 74 Z 1A F0 1A F6 0B F0 0B	7C
Q 15 F0 15 R ALT E0 11 E0 F0 11 KP EN E0 5A E R 2D F0 2D APPS E0 2F E0 F0 2F KP 71 S 1B F0 1B ENTER 5A F0 5A KP 0 70 T 2C F0 2C ESC 76 F0 76 KP 1 69 U 3C F0 3C F1 5 F0 05 KP 2 72 V 2A F0 2A F2 6 F0 06 KP 3 7A W 1D F0 1D F3 4 F0 04 KP 4 6B X 22 F0 22 F4 0C F0 0C KP 5 73 Y 35 F0 35 F5 3 F0 03 KP 6 74 Z 1A F0 1A F6 0B F0 0B KP 7 6C	F0 7B
R 2D FO 2D APPS EO 2F EO FO 2F KP 71 S 1B FO 1B ENTER 5A FO 5A KP 0 70 T 2C FO 2C ESC 76 FO 76 KP 1 69 U 3C FO 3C F1 5 FO 05 KP 2 72 V 2A FO 2A F2 6 FO 06 KP 3 7A W 1D FO 1D F3 4 FO 04 KP 4 6B X 22 FO 22 F4 OC FO 0C KP 5 73 Y 35 FO 35 F5 3 FO 0B KP 7 6C Z 1A FO 1A F6 OB FO 0B KP 7 6C	F0 79
S 1B FO 1B ENTER 5A FO 5A KP 0 70 T 2C FO 2C ESC 76 FO 76 KP 1 69 U 3C FO 3C F1 5 FO 05 KP 2 72 V 2A FO 2A F2 6 FO 06 KP 3 7A W 1D FO 1D F3 4 FO 04 KP 4 6B X 22 FO 22 F4 OC FO 0C KP 5 73 Y 35 FO 35 F5 3 FO 08 KP 7 6C Z 1A FO 1A F6 OB FO 0B KP 7 6C) FO 5A
T 2C F0 2C ESC 76 F0 76 KP 1 69 U 3C F0 3C F1 5 F0 05 KP 2 72 V 2A F0 2A F2 6 F0 06 KP 3 7A W 1D F0 1D F3 4 F0 04 KP 4 6B X 22 F0 22 F4 0C F0 0C KP 5 73 Y 35 F0 35 F5 3 F0 03 KP 6 74 Z 1A F0 1A F6 0B F0 0B KP 7 6C	F0 71
U 3C F0 3C F1 5 F0 05 KP 2 72 V 2A F0 2A F2 6 F0 06 KP 3 7A W 1D F0 1D F3 4 F0 04 KP 4 6B X 22 F0 22 F4 0C F0 0C KP 5 73 Y 35 F0 35 F5 3 F0 03 KP 6 74 Z 1A F0 1A F6 0B F0 0B KP 7 6C	F0 70
V 2A F0 2A F2 6 F0 06 KP 3 7A W 1D F0 1D F3 4 F0 04 KP 4 6B X 22 F0 22 F4 0C F0 0C KP 5 73 Y 35 F0 35 F5 3 F0 03 KP 6 74 Z 1A F0 1A F6 0B F0 0B KP 7 6C	F0 69
W 1D F0 1D F3 4 F0 04 KP 4 6B X 22 F0 22 F4 0C F0 0C KP 5 73 Y 35 F0 35 F5 3 F0 03 KP 6 74 Z 1A F0 1A F6 0B F0 0B KP 7 6C	F0 72
X 22 F0 22 F4 OC F0 0C KP 5 73 Y 35 F0 35 F5 3 F0 03 KP 6 74 Z 1A F0 1A F6 OB F0 0B KP 7 6C	F0 7A
Y 35 F0 35 F5 3 F0 03 KP 6 74 Z 1A F0 1A F6 0B F0 0B KP 7 6C	F0 6B
Z 1A F0 1A F6 OB F0 OB KP 7 6C	F0 73
	F0 74
0 45 F0 45 F7 83 F0 83 KP 8 75	F0 6C
0 40 10 40 11 00 10 M 0 10	F0 75
1 16 F0 16 F8 OA F0 0A KP 9 7D	F0 7D
2 1E F0 1E F9 1 F0 01] 58	F0 58
3 26 F0 26 F10 9 F0 09 ; 4C	F0 4C
4 25 F0 25 F11 78 F0 78 ' 52	F0 52
5 2E F0 2E F12 7 F0 07 , 41	F0 41
6 36 FO 36 PRNTSCRN EO 12 EO 7C EO FO 7C EO FO 12 . 49	F0 49
7 3D F0 3D SCROLL 7E F0, 7E / 4A	
8 3E FO 3E PAUSE E1 14 77 -NONE-	FO 4A
E1 F0 14	FO 4A
F0 77	FO 4A

主机接收到的时钟、数据信号常常含有噪声信号。为了准确读取输入数据,通常需要将输入信号过滤。本次实验可采用频率为 25MHz 的时钟,通过规定连续出现 8 个 "1" 为高电平,连续出现 8 个 "0" 为低电平来对键盘时钟和数据信号进行过滤,并将过滤后的数据信号送入移位寄存器中。

参考代码

```
module keyboard(
input wire clk 25M,
input wire clr,
input wire PS2C,
input wire PS2D,
output wire [15:0]xkey
    );
    reg PS2Cf,PS2Df;
    reg [7:0]ps2c filter,ps2d filter;
    reg [10:0]shift1,shift2;
    assign xkey={shift2[8:1],shift1[8:1]};
    always@(posedge clk 25M or posedge clr)
    begin
         if(clr==1)
              begin
                   ps2c filter<=0;
                   ps2d filter<=0;
                   PS2Cf \le 1;
                   PS2Df \le 1;
              end
         else
              begin
                   ps2c filter[7]<=PS2C;
                   ps2c filter[6:0]<=ps2c filter[7:1];
                   ps2d_filter[7]<=PS2D;
                   ps2d filter[6:0]<=ps2d filter[7:1];
                   if(ps2c filter==8'b11111111)
                        PS2Cf \le 1;
                   else
                        if(ps2c filter==8'b00000000)
                             PS2Cf<=0;
                   if(ps2d filter==8'b11111111)
                             PS2Df \le 1;
                   else
                        if(ps2d filter==8'b00000000)
```

```
PS2Df<=0;
              end
    end
    always@(negedge PS2Cf or posedge clr)
         begin
              if(clr==1)
                   begin
                       shift1<=0;
                       shift2 \le 1;
                   end
               else
                   begin
                       shift1<={PS2Df,shift1[10:1]};
                       shift2<={shift1[0],shift2[10:1]};
                   end
         end
endmodule
module keyboard top(
input wire clk_100M,
input wire PS2C,
input wire PS2D,
input wire[3:3] btn,
output wire[6:0]a to g,
output wire[7:0]an
    wire clk_25M,clk_190,clr;
    wire [15:0]xkey;
    reg [18:0]count1;
    reg [2:0]count2;
    assign clr=btn[3];
    assign an[7:4]=4'b1111;
    always@(posedge clk_100M or posedge clr)
           if(clr==1)
              begin
                   count1=0;
                   count2=0;
               end
             else
              begin
                   count1=count1+1;
                   count2=count2+1;
```

);

```
end
      assign clk_190=count1[18];
      assign clk_25M=count2[2];
    keyboard U2 (clk 25M,clr,PS2C,PS2D,xkey);
    x7seg4 U3 (xkey,clk_190,clr,a_to_g,an);
endmodule
module x7seg4(
input wire[15:0]s,
input wire clk,clr,
output wire[6:0] a to g,
output reg[3:0] ans
    );
    reg [20:0]count;
    reg [3:0]digit;
    always@(posedge clk or posedge clr)
              if(clr==1)
                   count=0;
              else
                   count=count+1;
    always@(posedge clk)
         case(count[20:19])
         2'b00:
              begin
                   digit=s[3:0];
                   ans=4'b1110;
              end
         2'b01:
                   begin
                        digit=s[7:4];
                        ans=4'b1101;
                   end
         2'b10:
                        begin
                            digit=s[11:8];
                            ans=4'b1011;
                        end
          2'b11:
                            begin
                                 digit=s[15:12];
                                 ans=4'b0111;
                            end
```

```
seg7 U4(.hex(digit),.segs(a_to_g));
endmodule
module seg7(
input wire[3:0]hex,
output reg[6:0]segs
    );
     always@(*)
     case(hex)
         // abc defg
         4'h0: segs = 7'b000 0001;
         4'h1: segs = 7'b100_1111;
         4'h2: segs = 7'b001 0010;
         4'h3: segs = 7'b000_0110;
         4'h4: segs = 7'b100 1100;
         4'h5: segs = 7'b010 0100;
         4'h6: segs = 7'b010_0000;
         4'h7: segs = 7'b000 1111;
         4'h8: segs = 7'b000_0000;
         4'h9: segs = 7'b000 1100;
         4'ha: segs = 7'b000_1000;
         4'hb: segs = 7'b110 0000;
```

4'hd: segs = 7'b111_0010; 4'hd: segs = 7'b100_0010; 4'he: segs = 7'b011_0000; 4'hf: segs = 7'b011_1000;

segs = 7'b111_1111;

endmodule

default:

endcase