



Keyboard

黃元豪

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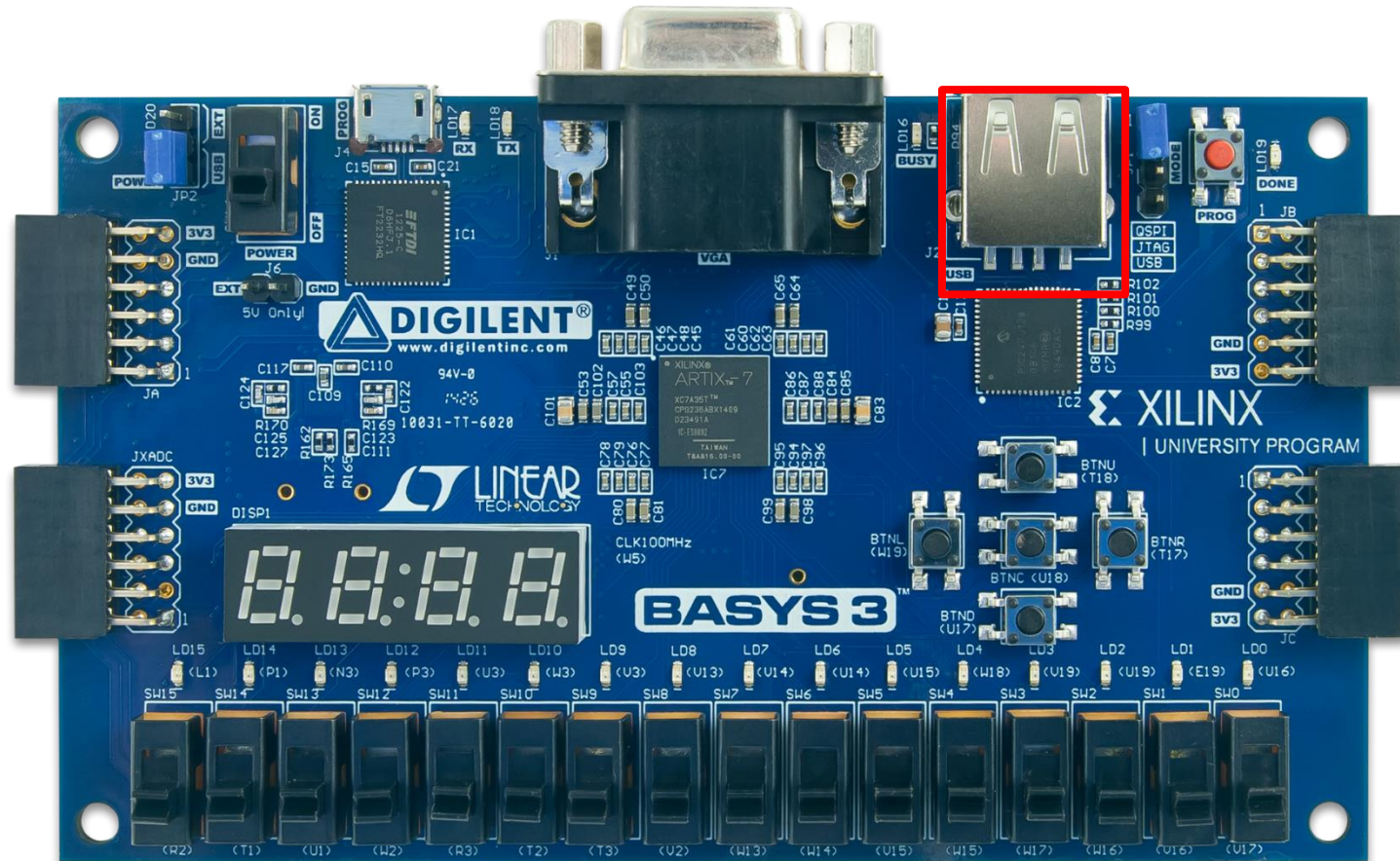
國立清華大學電機工程學系

Department of Electrical Engineering

National Tsing-Hua University

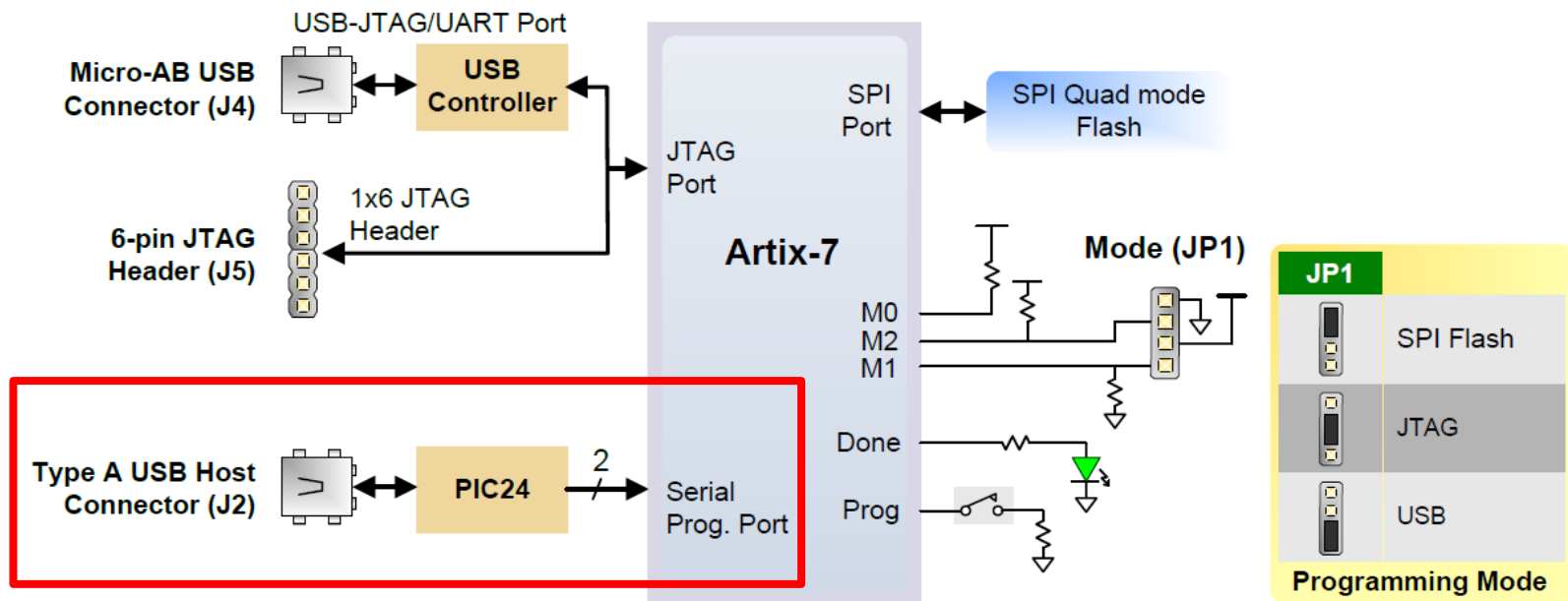
USB HID Host (1/3)

HID : Human Interface Device

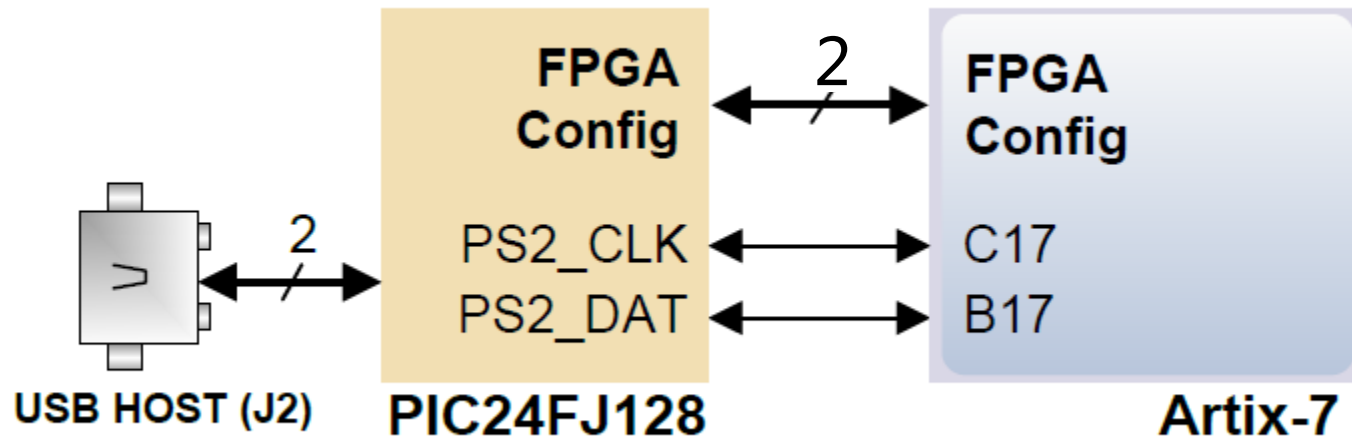




USB HID Host (2/3)



USB HID Host (3/3)



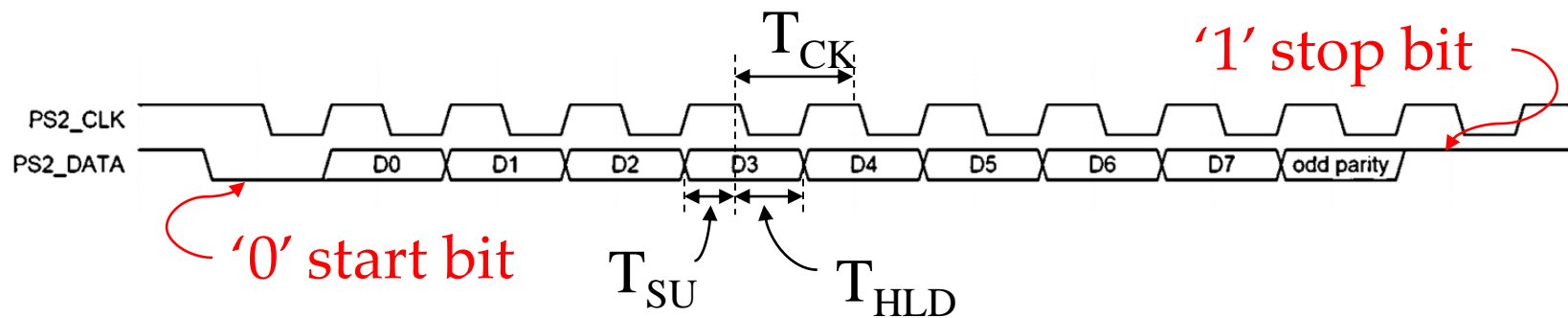
Microchip PIC24FJ128



- Configuration mode
 - Download a bit-stream to the FPGA.
- Application mode
 - In Basys 3, this is called USB HID Host mode.
 - Only a single mouse or a single keyboard can be used.
 - PS2_CLK and PS2_DATA are used to implement a standard PS/2 interface.



HID Controller



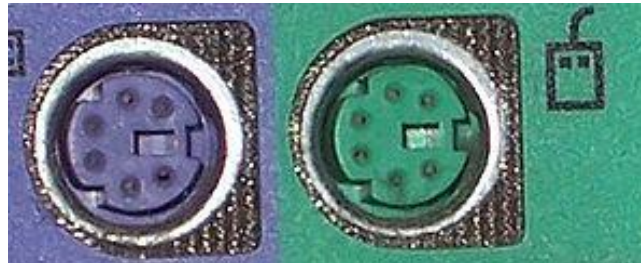
Symbol	Parameter	Min	Max
T_{CK}	Clock time	30 us	50 us
T_{SU}	Data-to-clock setup time	5 us	25 us
T_{HLD}	Clock-to-data hold time	5 us	25us



Initialization

- Initially, Basys3 identifies the devices through PS2_CLK and PS2_DATA.
- When Basys3 is idled (unconnected), Basys3 reads 0xFA using a Read ID command.
- When a keyboard or mouse is connected to the Basys3, a “self-test passed” command (0xAA) is sent to the Basys3.
 - 0xFA → 0xAA
- Scancode of keyboard
 - Each key is assigned a code
 - If the key is held down, the scan code will be sent repeatedly about once every 100ms.
 - When a key is released, an F0 key-up code is sent, followed by the scan code of the released key.
 - Some keys (right Ctrl, right Alt, ...) , called extended keys, send an E0 ahead of the scan code.

PS/2 Port



Example PC compatible (IBM PS/2) scancodes

key	set 1 (IBM PC XT)		set 2 (IBM PC AT)		set 3 (IBM 3270 PC)	
	press	release	press	release	press	release
A (normal letter)	1E	9E	1C	F0 1C	1C	F0 1C
Return / Enter (main keyboard)	1C	9C	5A	F0 5A	5A	F0 5A
Enter (numeric keypad)	E0 1C	E0 9C	E0 5A	E0 F0 5A	79	F0 79
Left Windows key	E0 5B	E0 DB	E0 1F	E0 F0 1F	8B	F0 8B
Right Windows key	E0 5C	E0 DC	E0 27	E0 F0 27	8C	F0 8C

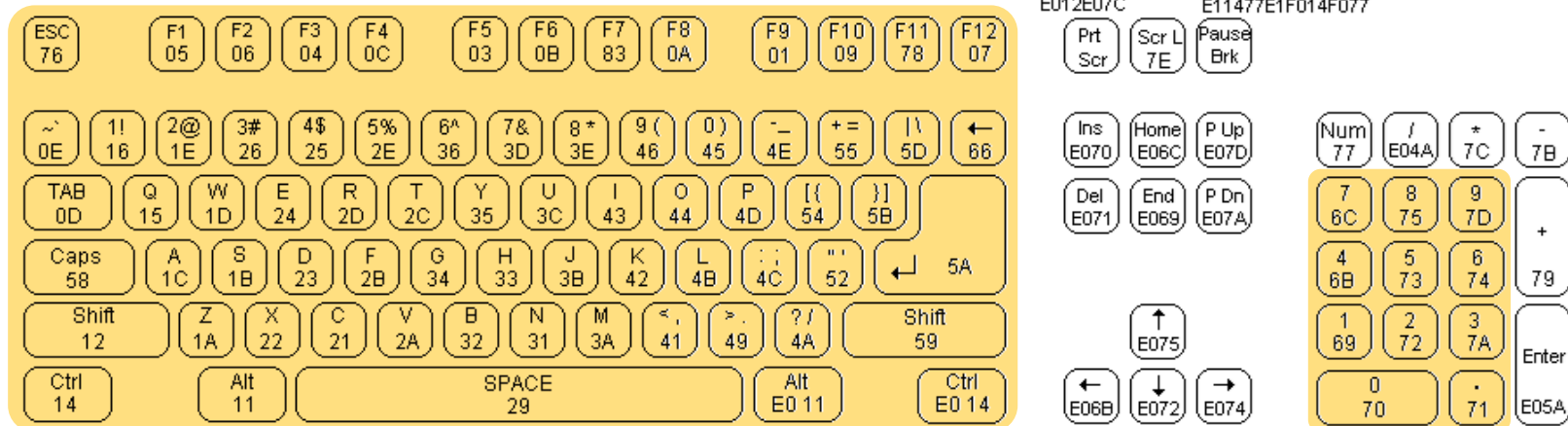
from Wiki



PS/2 Scancode

Extend Code	Break Code	Make code
E0	F0	XX

(means “release”)

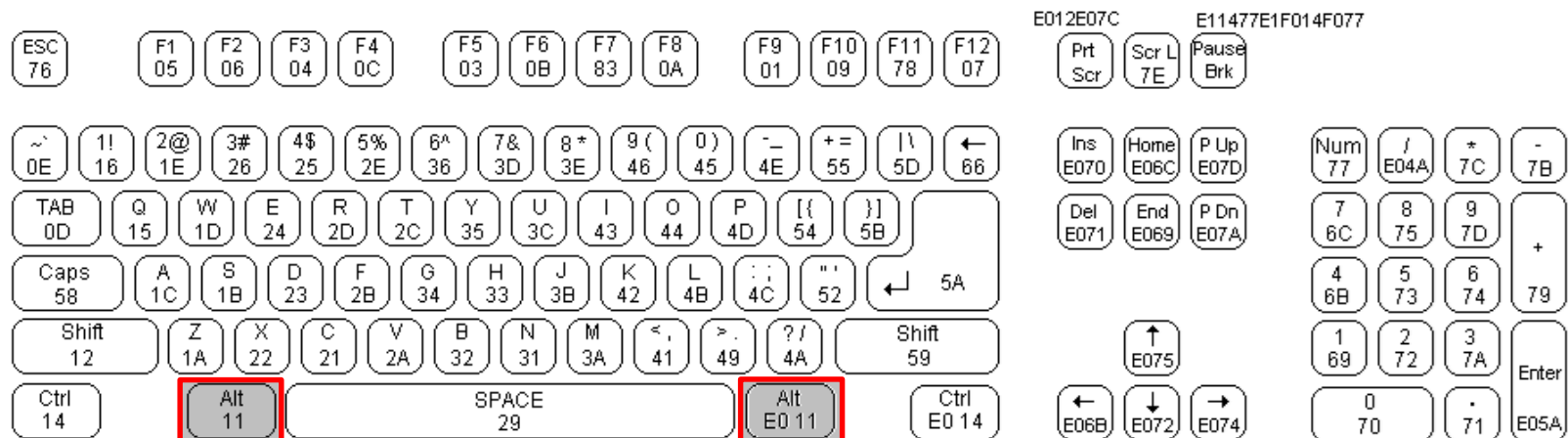


We only use the yellow parts of the keyboard.



PS/2 Scancode (Example)

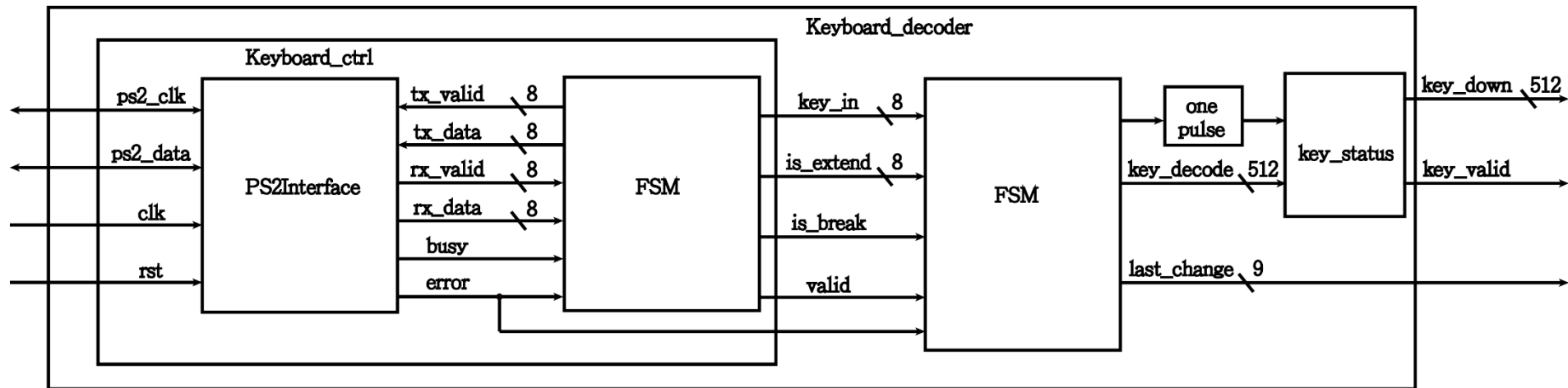
L Alt press			11
L Alt release		F0	11
R Alt press	E0		11
R Alt release	E0	F0	11



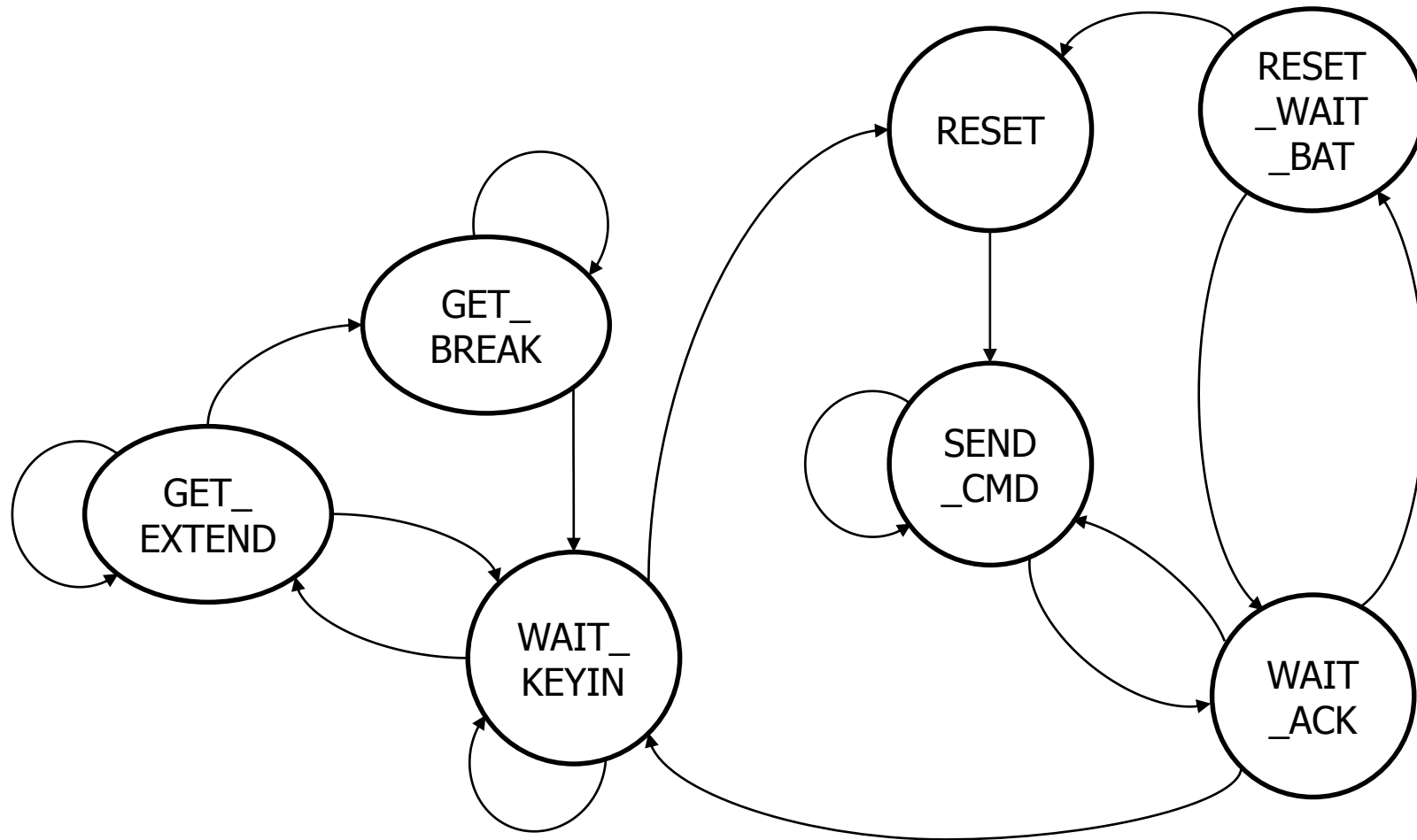
Verilog Module: KeyboardCtrl(1/2)



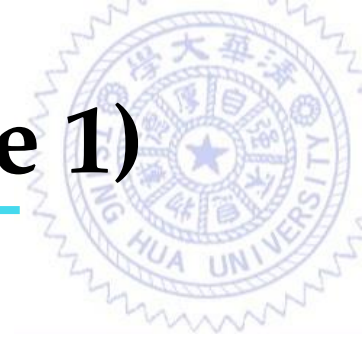
- In Keyboard-Controller
 - Ps2Interface.v
 - KeyboardCtrl.v
- KeyboardCtrl.v
 - **Input** : PS2_CLK, PS2_DATA, rst, clk
 - **Output** : key_in, is_extend, is_break, valid, err



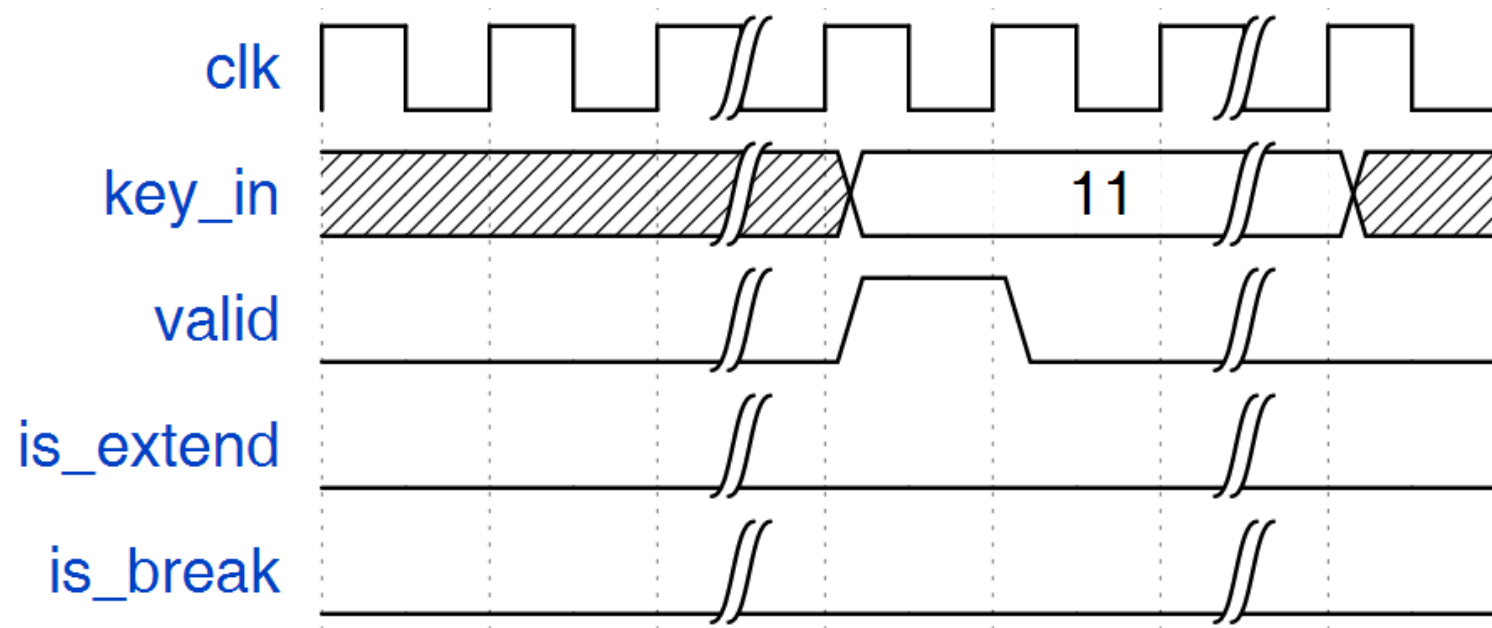
Verilog Module: KeyboardCtrl(1/2)



KeyboardCtrl (Output Example 1)



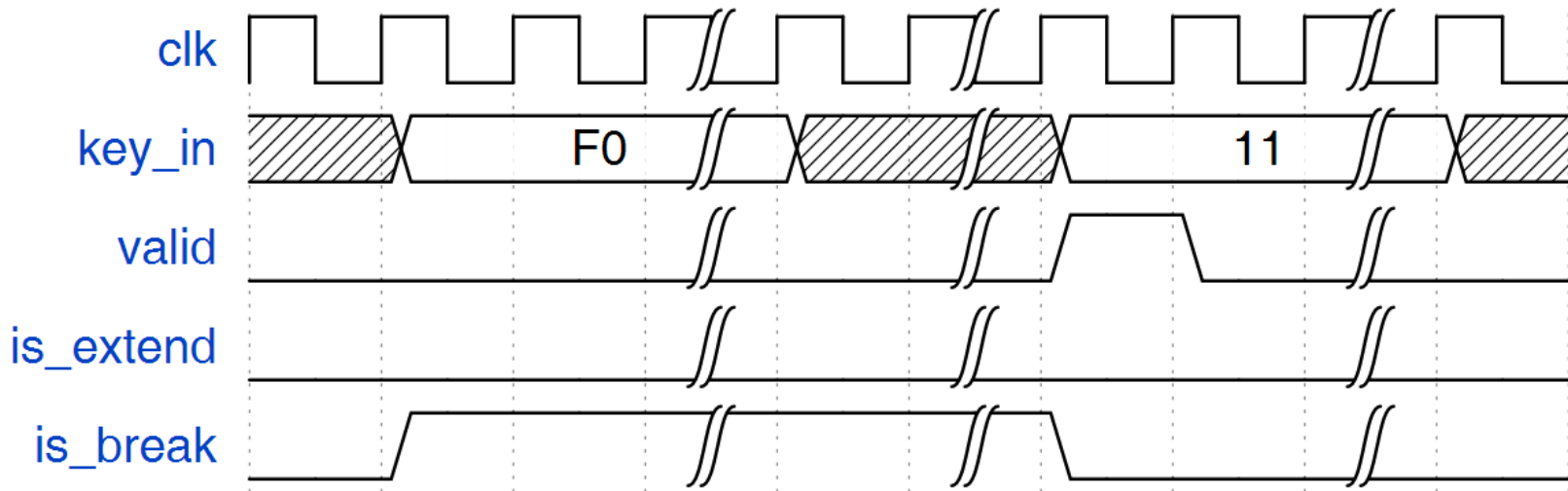
L Alt press



KeyboardCtrl (Output Example 2)



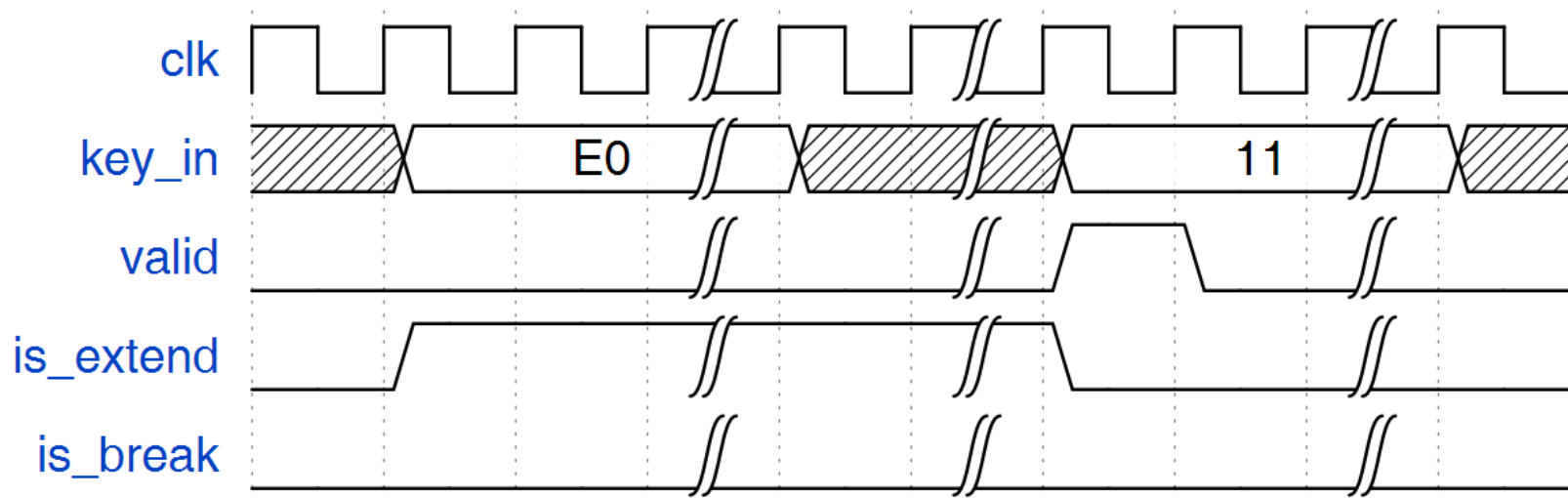
L Alt release



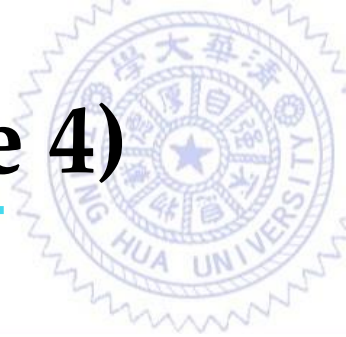
KeyboardCtrl (Output Example 3)



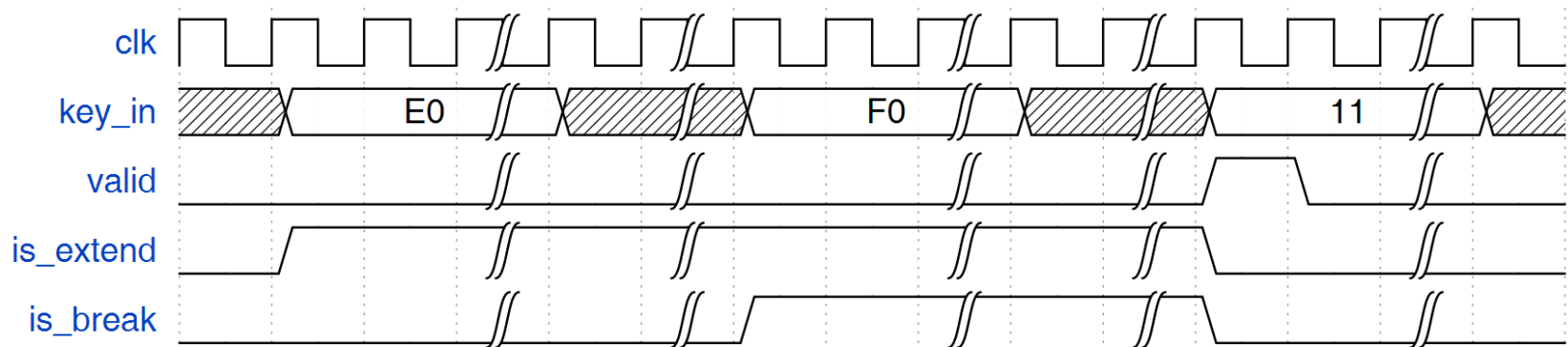
R Alt press



KeyboardCtrl (Output Example 4)



R Alt release

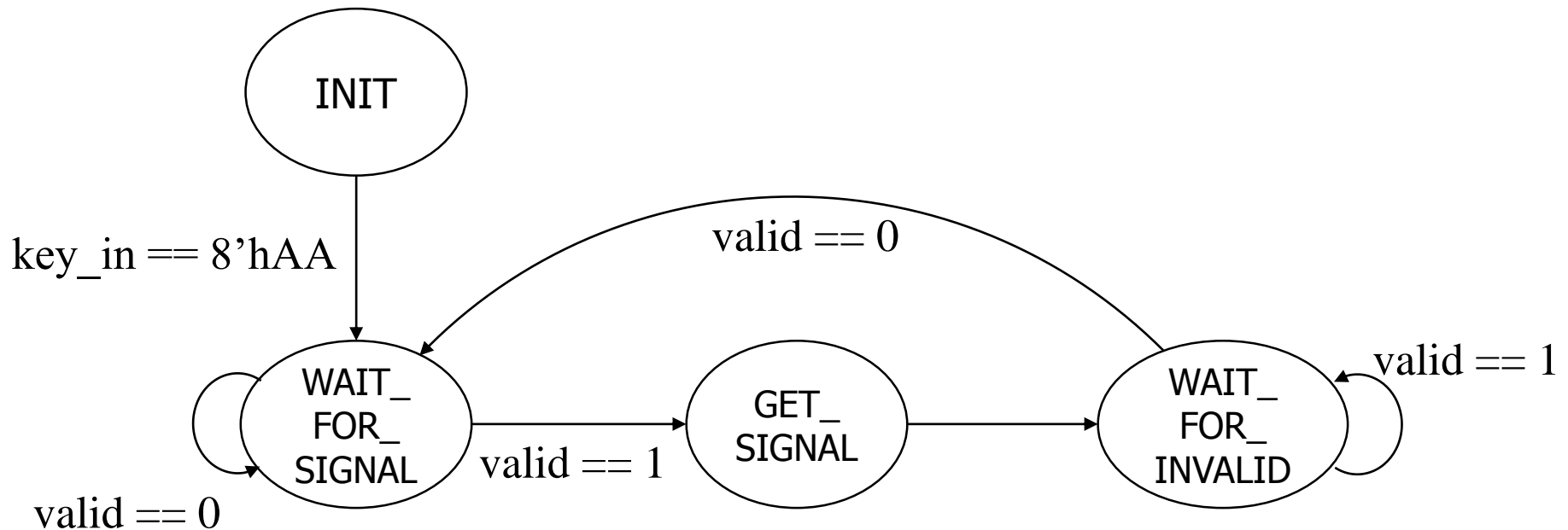
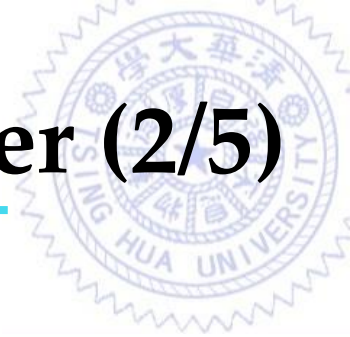


Verilog Module: KeyboardDecoder (1/5)



- In Keyboard Sample Code
 - KeyboardDecoder.v
- I/O for KeyboardDecoder
 - Input : PS2_CLK, PS2_DATA, rst, clk
 - Output : key_down, last_change, Key_valid

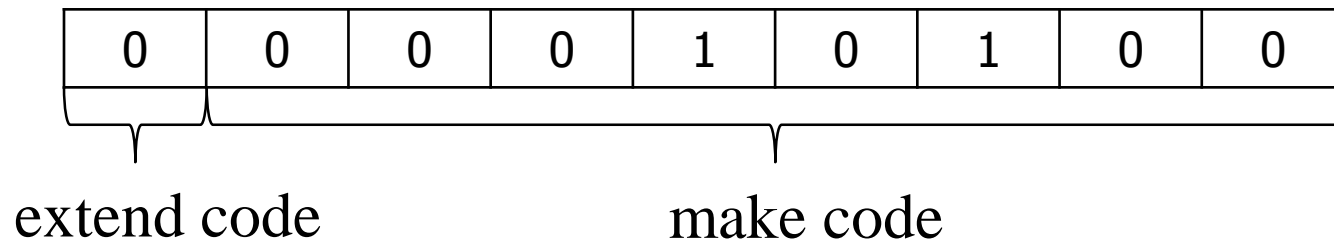
Verilog Module: KeyboardDecoder (2/5)



Verilog Module: KeyboardDecoder (3/5)



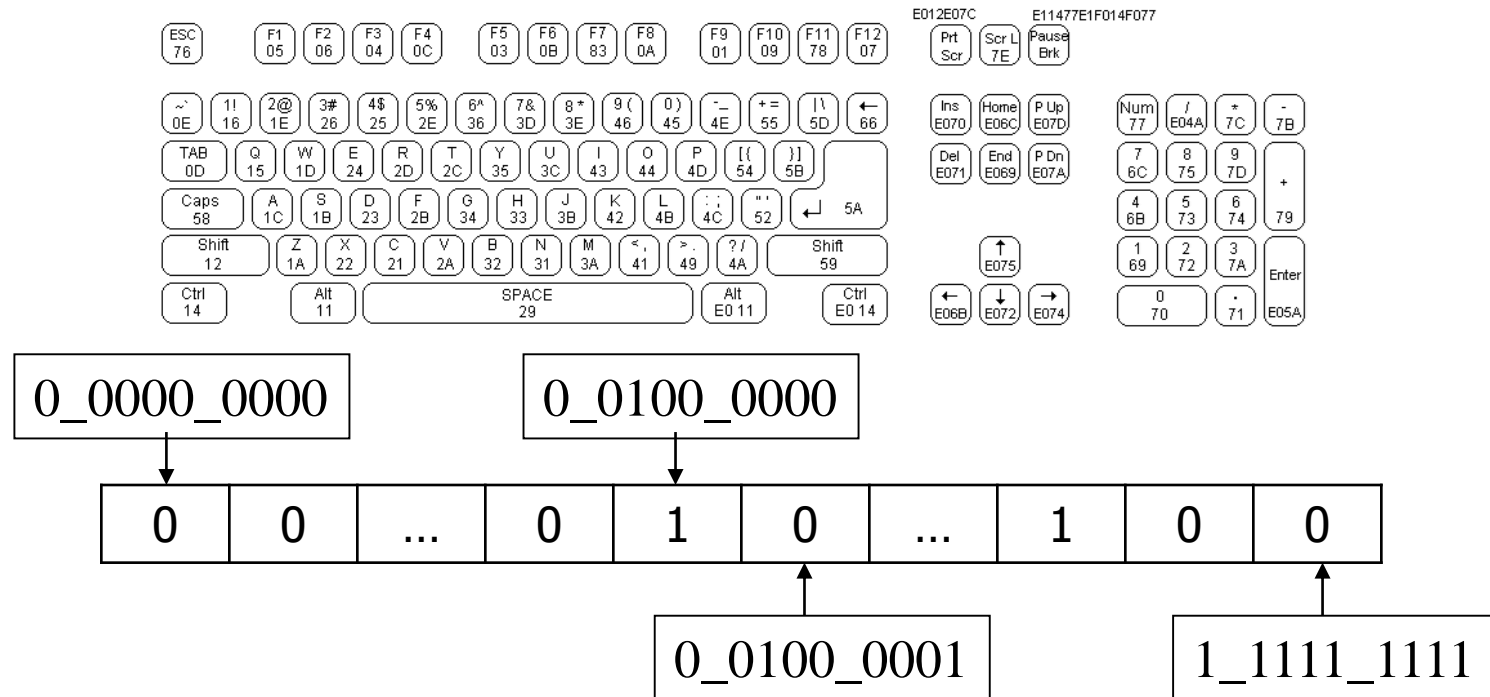
- last_change: 9 bits
 - represent the key which has been pressed or released.



- key_valid: 1 bit
 - should be active for one clock period (100MHz) when any key is pressed or released.

Verilog Module: KeyboardDecoder (4/5)

- key_down [511:0] are status bits. Each bit indicates pressed (1) or released (0) of each button of the keyboard.



- the key indexed by “0_0100_0000” is pressed.
- the key indexed by “0_0100_0001” is released.

Verilog Module: KeyboardDecoder (5/5)



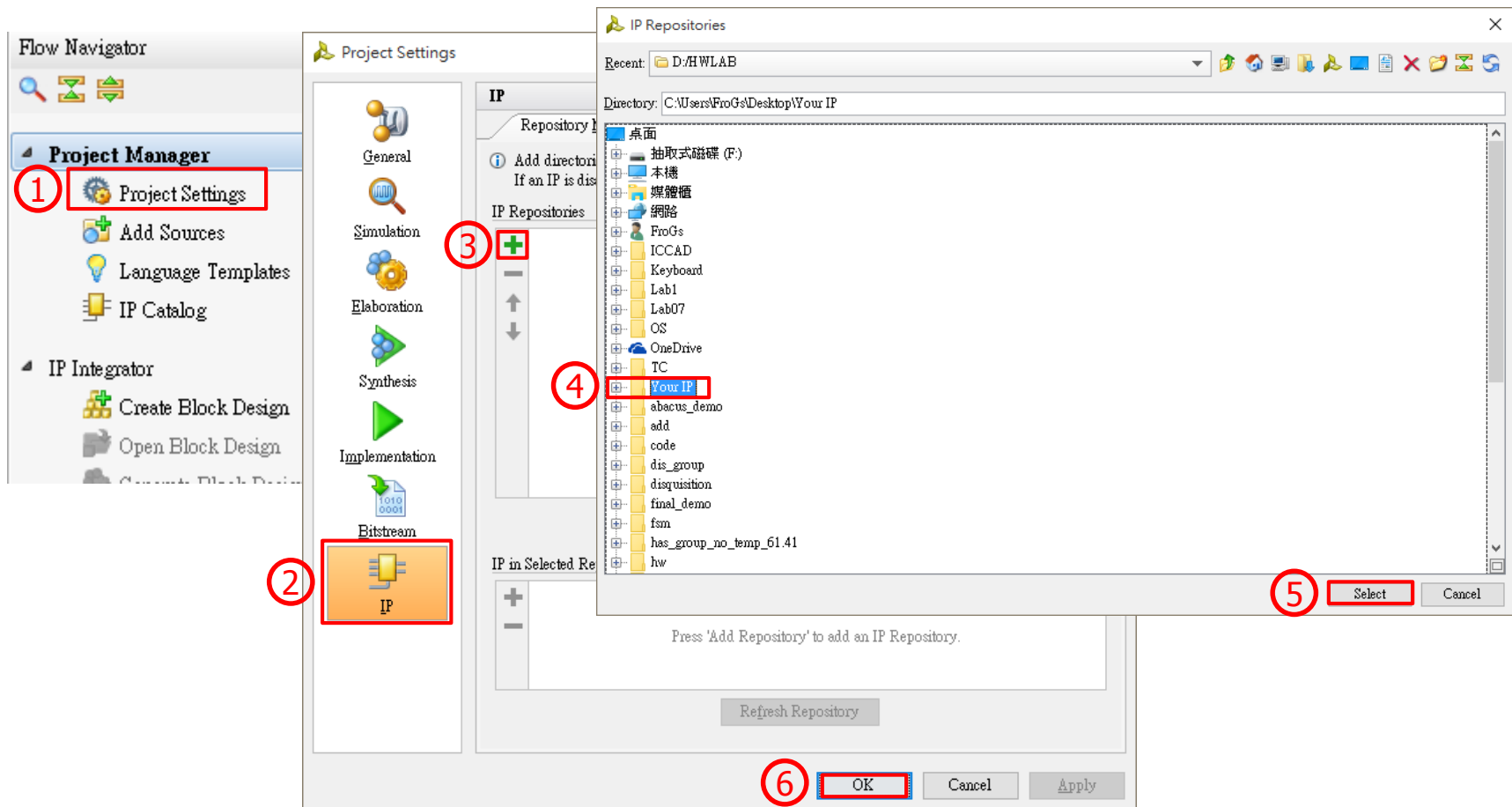
- key_down [511:0]
- key_down <= key_down | key_decode;

	0	1	1	0	1
or	0	0	0	1	0
<hr/>					
	0	1	1	1	1

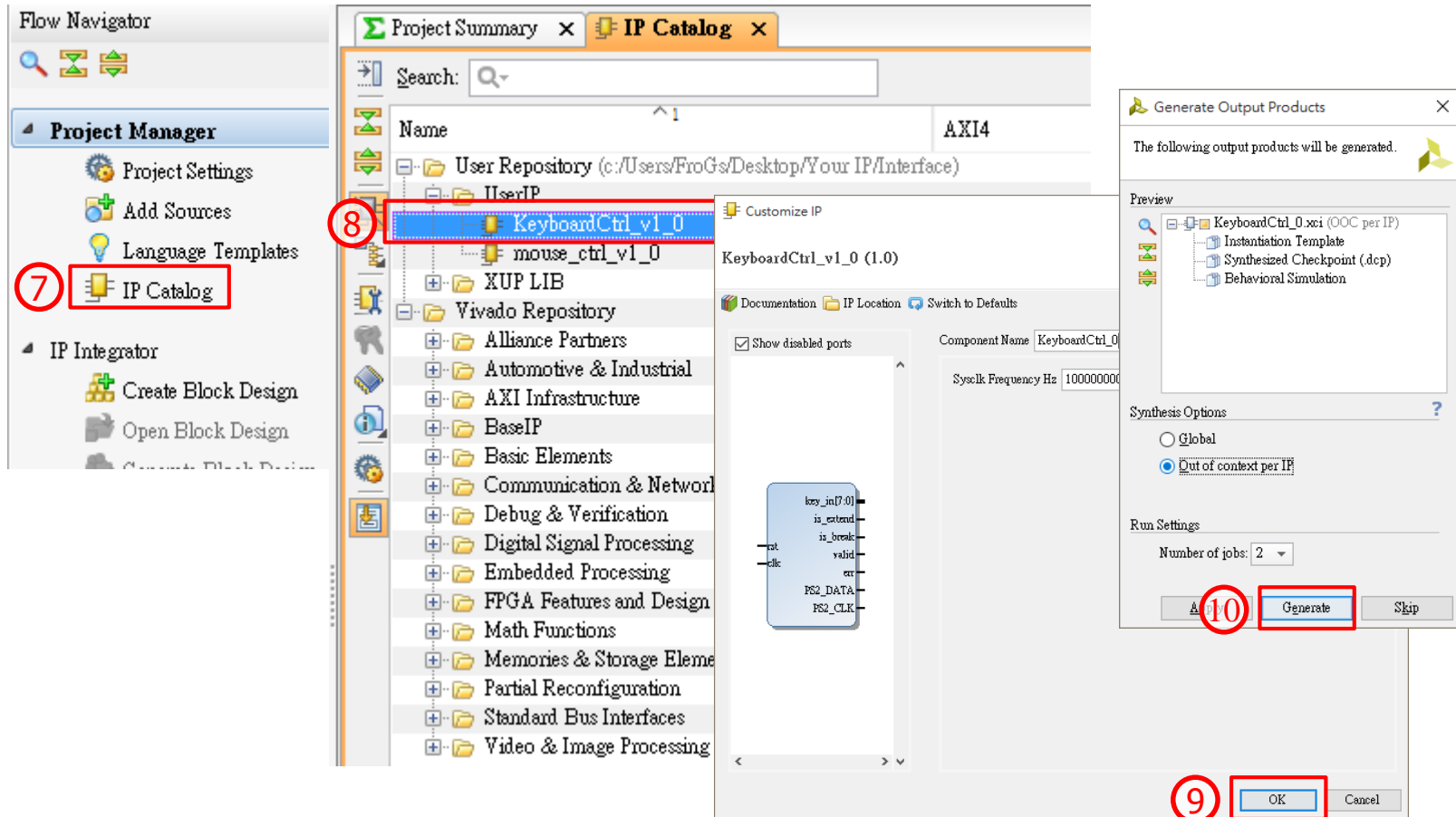
- key_down <= key_down & (~key_decode);

	0	1	1	0	1
and	1	1	0	1	1
<hr/>					
	0	1	0	0	1

How to Use IP (1/3)



How to Use IP (2/3)



The screenshot illustrates the process of using an IP block in Vivado. It shows the **Flow Navigator** on the left, the **IP Catalog** in the center, and the **Generate Output Products** dialog on the right.

Flow Navigator: The **IP Catalog** icon is highlighted with a red circle and the number 7.

IP Catalog: The **KeyboardCtrl_v1_0** IP block is selected in the **User Repository** and highlighted with a red circle and the number 8. The **Customize IP** panel shows the component name **KeyboardCtrl_0** and the system clock frequency **100000000 Hz**.

Generate Output Products: This dialog shows the output products to be generated, including the **KeyboardCtrl_0.xci** (OOB per IP), **Instantiation Template**, **Synthesized Checkpoint (.dcp)**, and **Behavioral Simulation**. The **Synthesis Options** section shows **Out of context per IP** selected. The **Run Settings** section shows **Number of jobs: 2**. The **Generate** button is highlighted with a red circle and the number 10. The **OK** button in the bottom right corner is highlighted with a red circle and the number 9.

How to Use IP (3/3)

