RTL_EXERCISE_1 BOUND FLASHER

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RTL_Exercise1 Bound Flasher

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1. Interface

Figure 1: the figure of Bound Flasher System

Signal	Width	In/Out	Description
clk	1	In	Clock Signal
rst	1	In	Reset Signal
flick	1	In	Flick Signal
LED	16	Out	16-bit LED output

Table 1: Description of signals in Bound Flasher

2. Functional implementation.

- Implement a 16-bits LEDs system

- System's Operation base on three input signal

  - Reset

  - Clock

  - Flick

- The system specification

  - Clock signal is provided for system inspire of function status. The function operate state's transition at positive edge of the clock signal.

  - Reset signal is used to reset the system to the initial state ("Start") when rst = 0.

  - Flick is a special input used to control the state transition.

- 16-bit LEDs output is a 16-bit signal representing output. We can consider it as an array with 16 elements (each element represents 1 LED in reality). If a position has signal 1 (for ex. LEDs [0] = 1), it means the LED at that position is currently turned on and the same with signal 0.

- At the initial state, all lamps are OFF. If flick signal is ACTIVE, the flasher start operating:

  - The lamps are turned ON gradually from LEDs [0] to LEDs [5].

  - The LEDs are turned OFF gradually from LEDs [5] **(max)** to LEDs [0] **(min)**.

  - The LEDs are turned ON gradually from LEDs [0] to LEDs [10].

  - The LEDs are turned OFF gradually from LEDs [10] **(max)** to LEDs [5] **(min)**.

  - The LEDs are turned ON gradually from LEDs [5] to LEDs [15].

  - The LEDs are turned OFF gradually from LEDs [15] to LEDs [0].

  - Finally, the LEDs s are turned ON then OFF simultaneously (blink), return to initial state.

- Additional condition: At each kickback point (LEDs [5] and LEDs [10]), if flick signal is ACTIVE, the LEDs will turn off gradually again to the **min** LEDs of the previosu state, then continue operation as above description. Kickback points are only considered when the LEDS are turned ON gradually, except for the first state (**On from LEDs [0] to LEDs [5]**).

- Some insulations:
  - When flick = 0 at kickback points

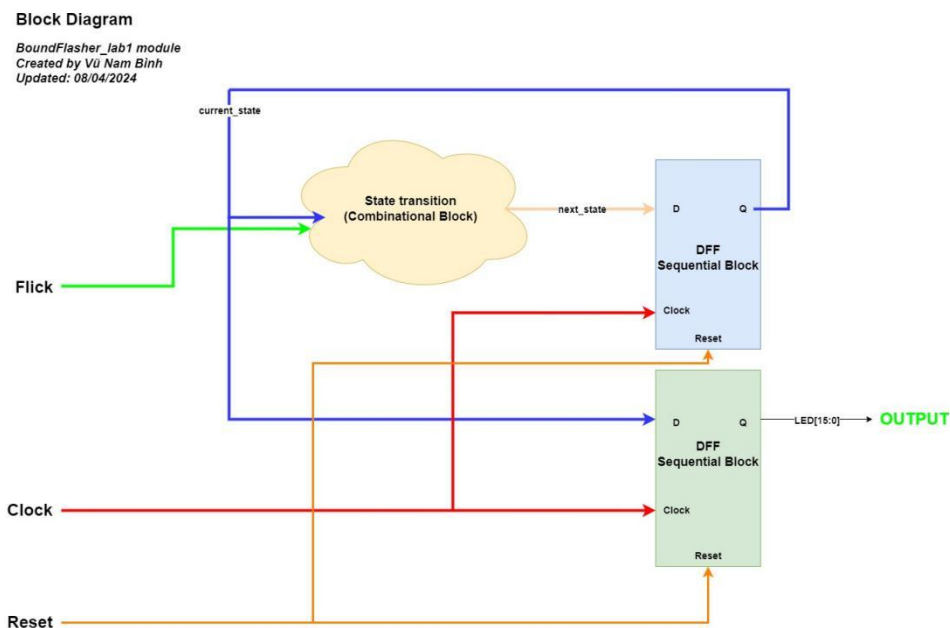 - When flick = 1 at kickback points (lamp[5])

When flick=1 at kickback point, the lamp will turn back to the start point of that state.
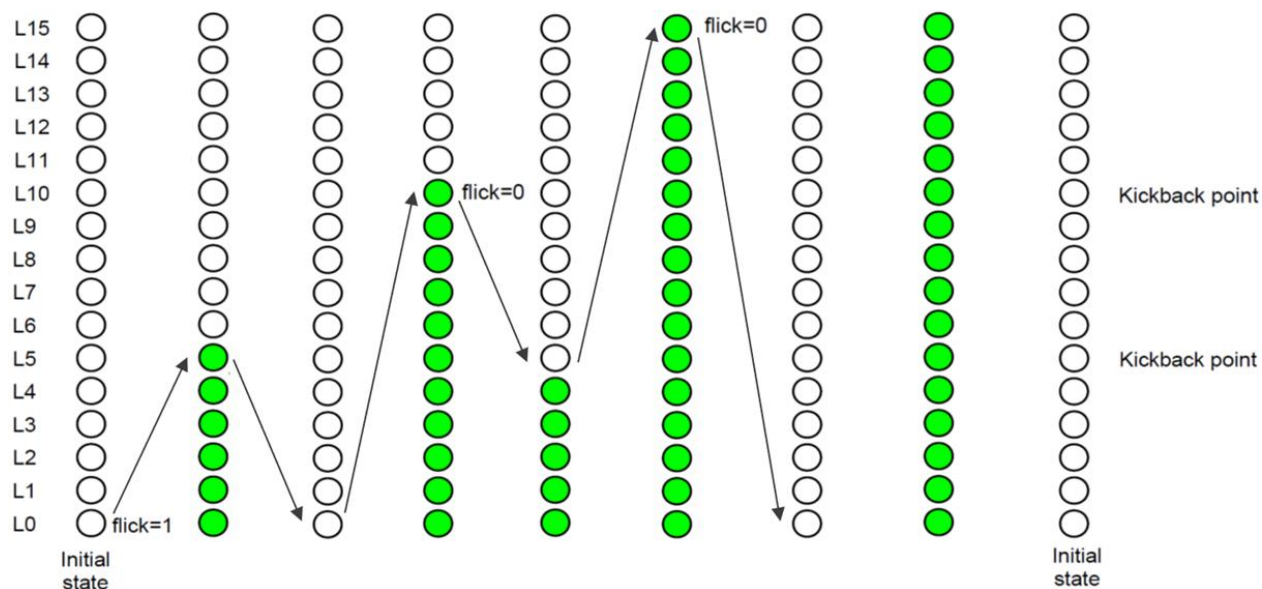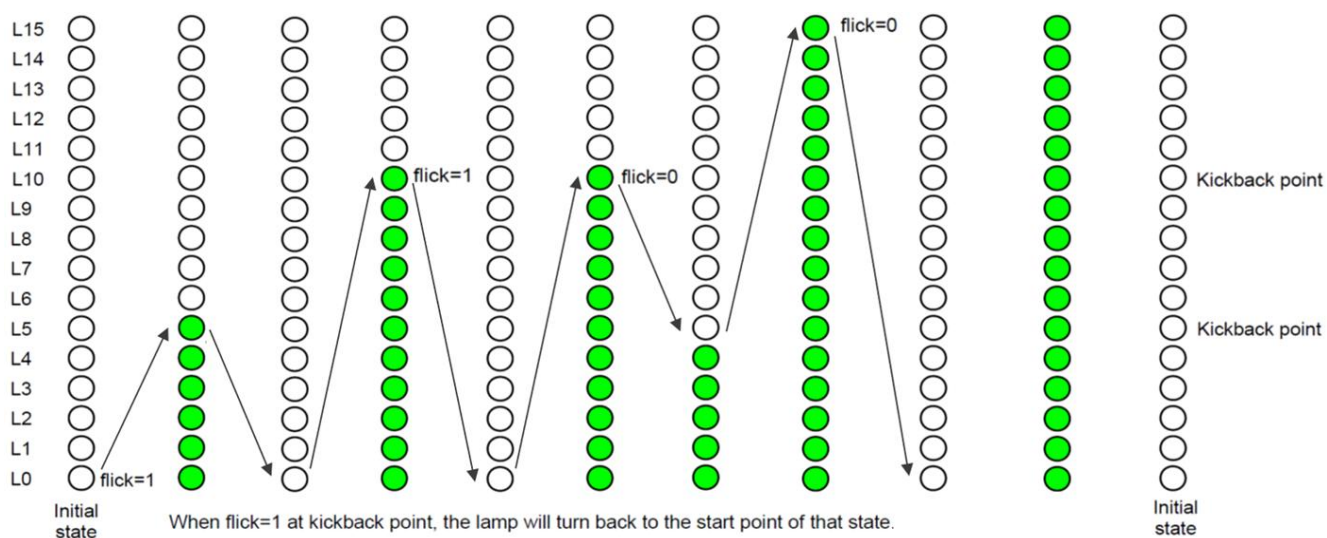
3. Internal implementation.

3.1. Overall.

Figure 3.1: Block diagram of Bound Flasher

Block	Description
State Transition	- This block is used to check conditions and decide whether to change state or remain old state based on current output signal and flick signal.
D FlipFlop	- The first DFF is used to assign value for current_state based on next_state variable. - The second DFF is used to store the value of the output LED[15:0].

Table 3.1: Block diagram of Bound Flasher Description
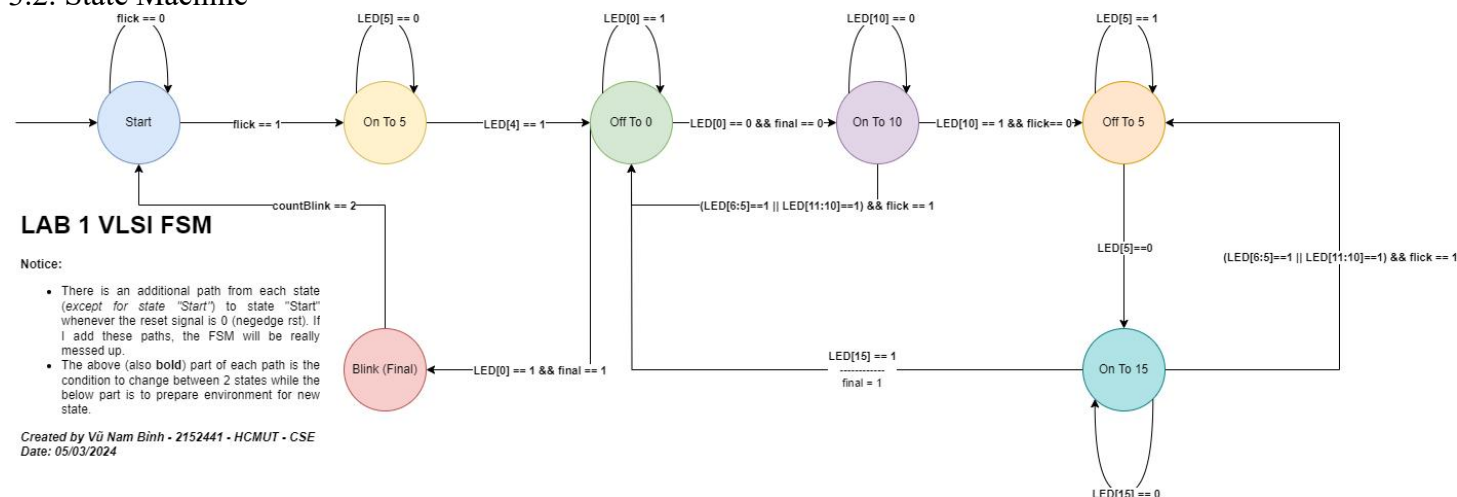
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3.2. State Machine

Figure 3.2: State Machine of Bound Flasher

Variables	Description
1) flick	This is a special signal. When it becomes 1 at: ● State "Start", the system starts to work. ● Kickback points (position 5 and 10) at 2 states **"OnTo10"** and **"OnTo15"**, the LEDs will be turned off **gradually** back to the **MIN** position of the last state (position 0 and 5 respectively).
2) rst	Reset signal is asynchronous. Whenever this signal is 0, it will reset to state "Start", all LEDs will be turned off. Then, it waits until flick turning 1 to start again.
3) LED	Output signal, which is a 16-bit array storing status of each LED at each position. For ex, LED[0]=1 means the LED at position 0 is currently turned on. Meanwhile, LED[1]=0 means the LED at position 1 is currently turned off.

Table 3.2: variable name of State machine

State Name	Description
1) Start	Initial State, loop forever and nothing happen at this state
2) OnTo5	This state is to turn on LED from position 0 to 5. Actually, it can turn on LED from every position below 5 to position 5, not only from position 0.
3) OffTo0	This state is to turn off LED from position 5 to 0. Actually, it can turn off LED from every position above 0 to position 0, not only from position 10. Additionally, when changing from this state to another state, I check the "final" signal to choose the correct next state. In this lab work, there are 2 states turning off LEDs to position 0 (off from 10 to 0 and off from 15 to 0).
4) OnTo10	This state is to turn on LED from position 0 to 10. Actually, it can turn on LED from every position below 10 to position 10, not only from position 0. Specially, in this state, if flick is turned on at kickback point, the state will be immediately changed to the previous state ("OffTo0").
5) OffTo5	This state is to turn off LED from position 10 to 5. Actually, it can turn off LED from every position above 5 to position 5, not only from position 10.
6) OnTo15	This state is to turn on LED from position 5 to 15. Actually, it can turn on LED from every position

	below 15 to position 15, not only from position 5. Specially, in this state, if flick is turned on at kickback point, the state will be immediately changed to the previous state ("OffTo5").
7) Blink (Final)	At this state, all LEDS will blink 1 time then change state to "Start".

Table 3.3: state name of State machine

4. History

Date	Author	Modified part	Description
2024/03/09	Vũ Nam Bình	All	First Lab Design Specification
2024/04/08	Vũ Nam Bình	Block Diagram	Change something that is corresponding to new updated source code
2024/04/09	Vũ Nam Bình	Source Code Verilog	Old source have error in netlist (multiple driver), this new version has fixed the problem