RTL_EXERCISE_1 BOUND FLASHER

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Contents

1. Interface

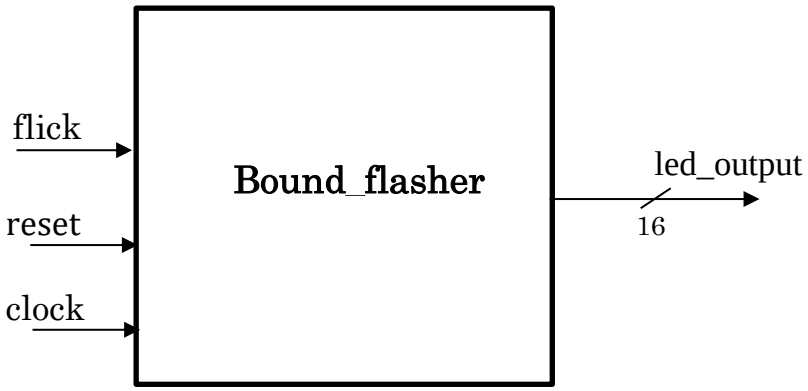


Figure 1: The figure of Bound Flasher System

Signal	Width	In/Out	Description
flick	1	In	Input signal; when the output (led) turns ON gradually, at LED [5] or LED [10] of state 3 or state 5, if flick = 1 then the led_output will turn OFF gradually again to the min led of the previous state, except the final state.
reset	1	In	Reset signal; LOW-ACTIVE; if reset = 0 then the system will restart to the initial state; “reset” is asynchronous signal and it does not depend on the clock signal.
clock	1	In	Clock signal, the system operates state transition based on the rising edge of the clock signal
led_output	16	Out	16-bit led output from led_output[0] to led_output[15]; led_output[0] is the least significant bit and led_output[15] is the most significant bit.

Table 1: Description of signals in Bound Flasher

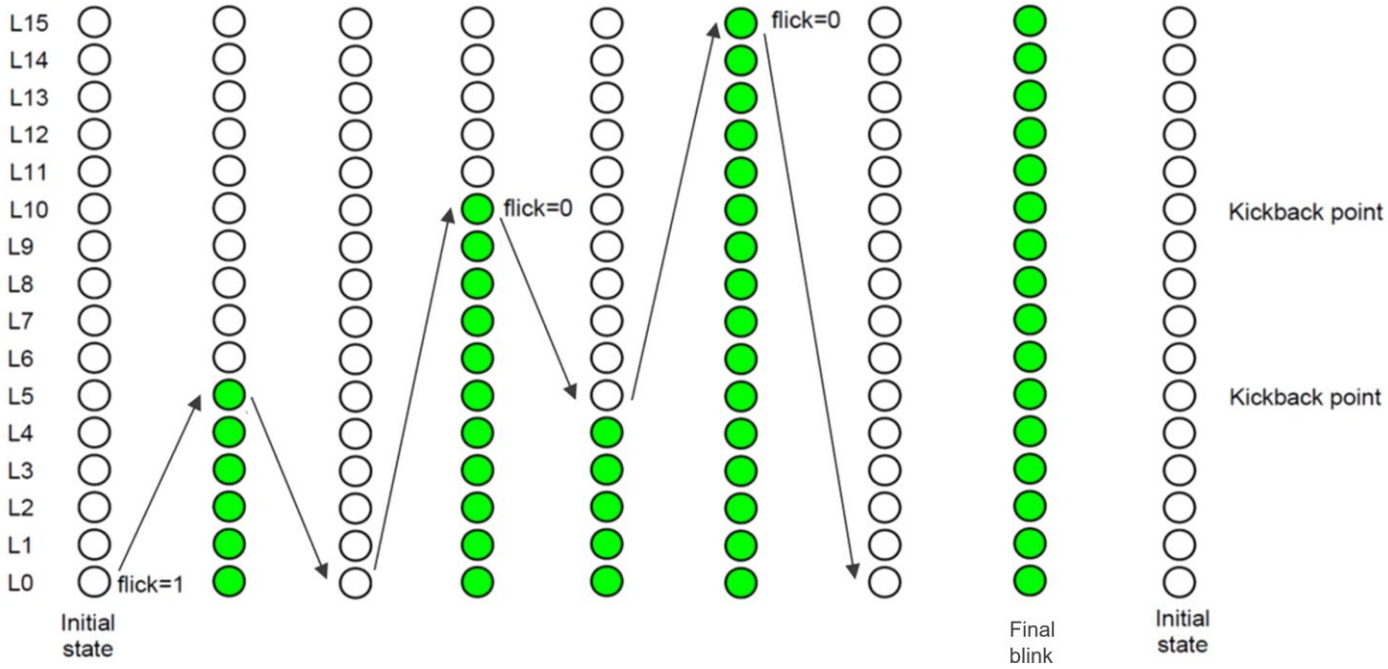
2. Functional implementation.

- 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:
    - LOW-ACTIVE Reset = 0: System is restarted to Initial State.
    - HIGH-ACTIVE Reset = 1: System is started with initial state.
- Flick signal: special input for controlling state transfer.
- 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 LEDSs are turned OFF gradually from LEDs [5] to LEDs [0].
  - The LEDSs are turned ON gradually from LEDs [0] to LEDs [10].
  - The LEDSs are turned OFF gradually from LEDs [10] to LEDs [5].
  - The LEDSs are turned ON gradually from LEDs [5] to LEDs [15].
  - The LEDSs are turned OFF gradually from LEDs [15] to LEDs [0].
  - Finally, the lamps are turned ON then OFF simultaneously (blink), return to the initial state.
- Additional condition: At each kickback point (lamp[5] and lamp[10]), if flick signal is ACTIVE, the lamps will turn OFF gradually again to the **min** lamp of the previous state, then continue operation as above description.

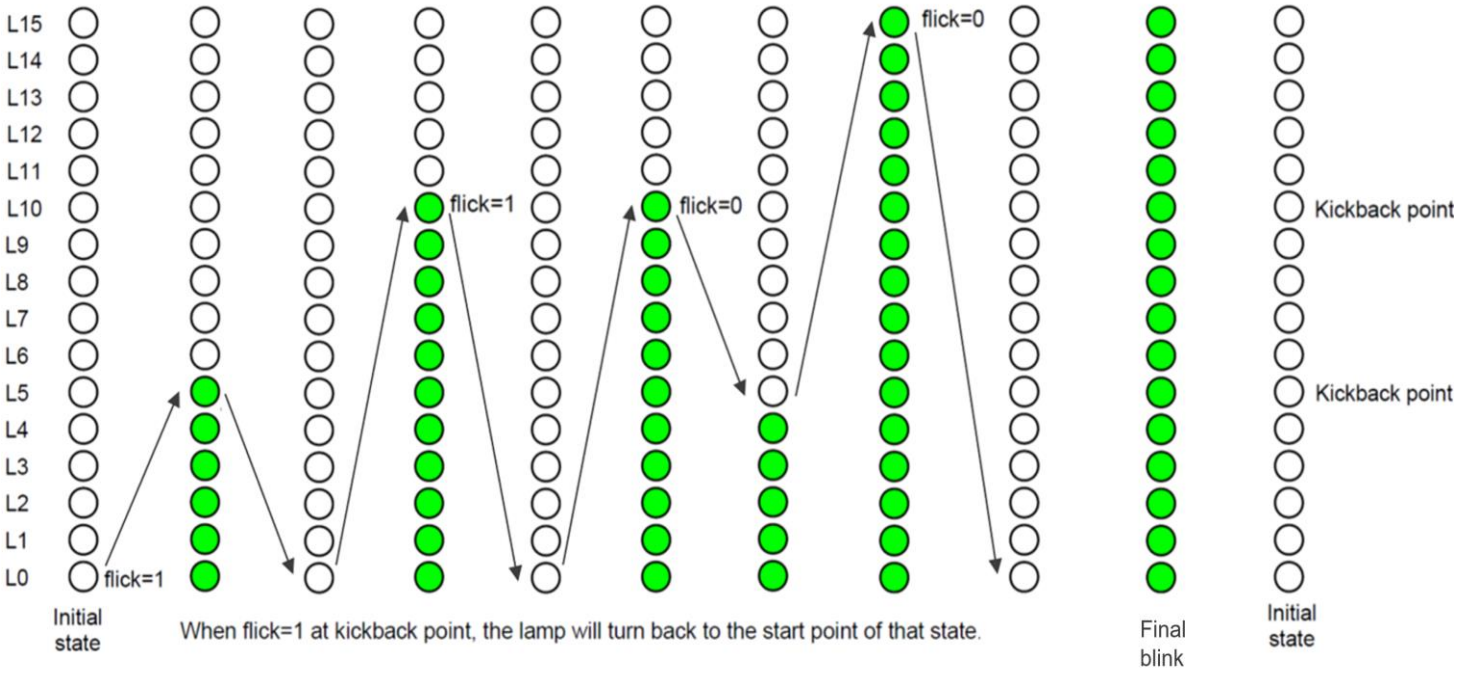
- For simplicity, kickback points are considered only when the lamps are turned ON gradually, except the first state.

– Some insulations:

- When flick = 0 at kickback points



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


L15
L14
L13
L12
L11
L10
L9
L8
L7
L6
L5
L4
L3
L2
L1
L0
flick=1
flick=1
flick=0
flick=0
Kickback point
Kickback point
Initial state
When flick=1 at kickback point, the lamp will turn back to the start point of that state.
Final blink
Initial state

3. Internal implementation.

3.1. Overall.

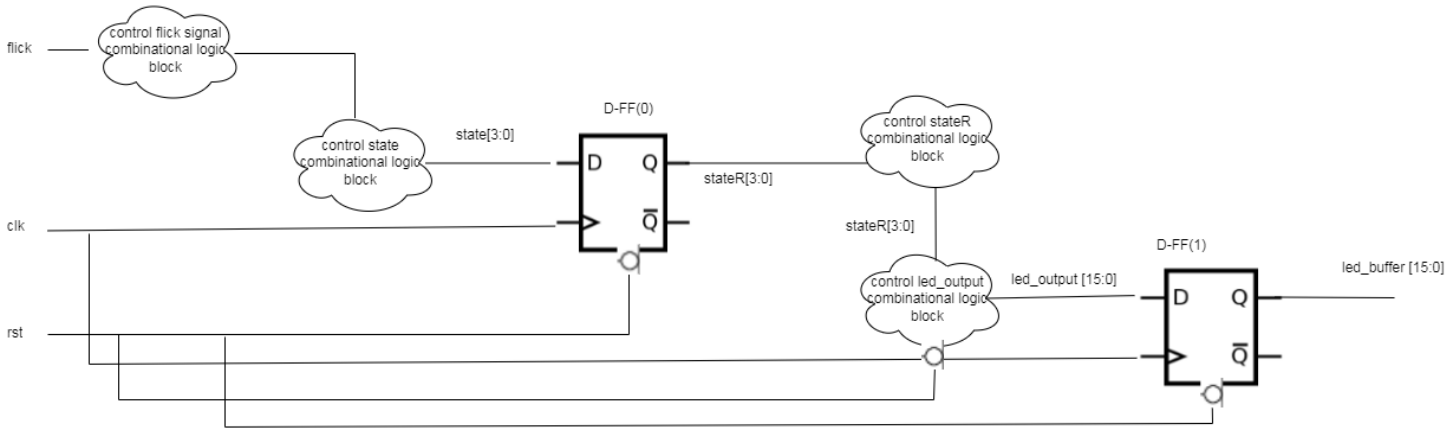


Figure 3.1: Block diagram of Bound Flasher

Block	Description
"control flick signal" combinational logic block	Using a flag signal to check if there is a flag signal (flick == 1) at "kick-back points" (at lamp [5] or lamp [10] of state 3 or state5). If flick signal is active the it will control the state to change to kick-back states.
"control state" combinational logic block	If flick signal equal to 1 the system will operate then it change to state 1 and operates normally until final state. Additional condition state only changes to kick-back states and then change to previous state wheneven it receive the flick = 1 at kick-back points.
D-FF(0)	Synchronize the input signal state[3:0] with the rising edge clock. The clock signal will control the stateR[3:0] which mean the real state assigned parallel by the state in the system. The rst signal is the active-low asynchronous signal whenever rst = 0 the stateR will be reset immediate to the initial state.
"control stateR and led_output" combinational logic block	Using the stateR[3:0] signal to control the led_output[15:0] signal whenever rst = 0 the all the leds will be turned off immediately.
D-FF(1)	Synchronize the input led_output[15:0] with the rising edge

	clock, then the led_buffer[15:0] will be assigned at the output. Whenever rst = 0 the all the leds will be turned off immediately.

Table 3.1: Block diagram of Bound Flasher Description

3.2. State Machine

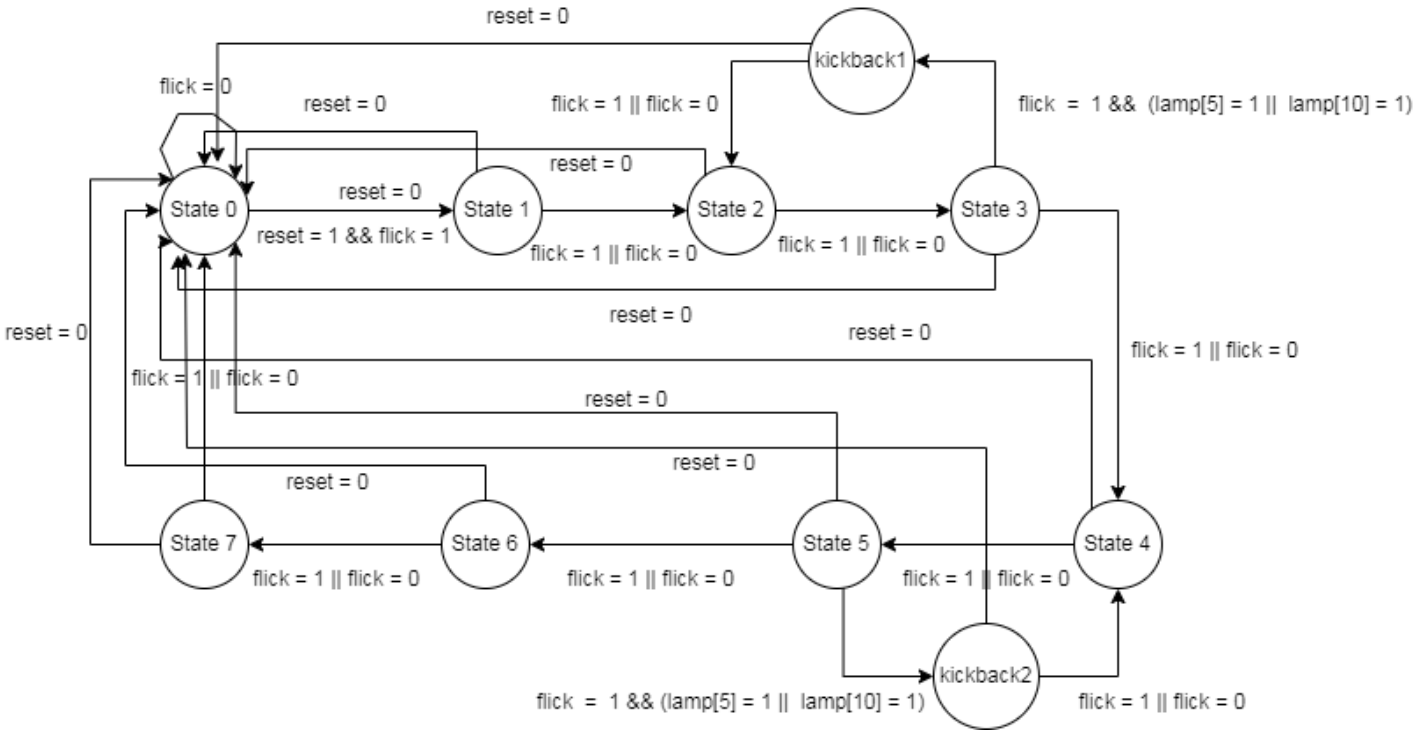


Figure 3.2: State Machine of Bound Flasher

Variable name	Description
reset	Asynchronous signal input. When reset = 0, the state will return to the initial state.
flick	At the initial state flick = 1 to operate at the state 3 or state 5 if flick = 1 at lamp [5] or lamp [10] it will change to kickback states and it will operate normally at the rest of cases with flick = 1 or flick = 0.
lamps	lamp[5] and lamp[10] represent the special case of additional condition for the kickback states.

Table 3.2: variable name of State machine

State name	Description
State 0	All LEDs is OFF (16 bits output=lamp [0:15] =0). If flick = 1, then state will change to State 1, while flick = 0 it will stay at State 0.
State 1	The lamps turned ON from lamp [0]to lamp [5] gradually, if reset = 0, the state will return to State 0. If lamp [5] is ON, the state will change to State 2.
State 2	The lamps turned OFF from lamp [5] to lamp [0] gradually, if reset = 0, the state will return to State 0. If lamp [0] is OFF, the state will return to State 3.
State 3	The lamps turned ON from lamp [0]to lamp [10] gradually, if flick = 1 && (lamp [5] = 1 || lamp [10] = 1), the state will change to kickback1. If reset = 0, the state will return to State 0. If lamp [10] is ON and no kickback point, the state will change to State 4.
kickback1	The lamps turned OFF from lamp [5] or lamp [10] gradually to lamp [0], if reset = 0, the state will return to State 0. If lamp [0] is OFF, the state will return to State 2.
State 4	The lamps turned OFF from lamp [10]to lamp [5] gradually, if reset = 0, the state will return to State 0. If lamp [5] is OFF, the state will change to State 5.
State 5	The lamps turned ON from lamp [5]to lamp [15] gradually, if flick = 1 && (lamp [5] = 1 || lamp [10] = 1), the state will change to kickback2. If reset = 0, the state will return to State 0. If lamp [15] is ON and no kickback point, the state will change to State 6.

State 6	The lamps turned OFF from lamp [15] to lamp [0] gradually, if reset = 0, the state will return to State 0. If lamp [0] is OFF, the state will return to State 7.
State 7	All the lamps are turned ON then OFF simultaneously (blink) then return to State 0. If reset = 0, the state will return to State 0.

Table 3.3: state name of State machine

4. History

Date	Author	Modified part	Description
2024/03/05	VO TRUNG KIEN	All	New creation