Project: LED Rotating Display

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Abstract

In this project, we use the **Zybo-7000** as the core processor to control the ShakeLED. It involves the knowledege of GPIO, Timer, Interrupt and Matrix KeyPad.

1 Introduction

According to the principle of the ShakeLED, the design uses the visual persistence characteristics of the human eye to control 32 LED light-emitting diodes through Zybo, and can display a complete picture or animation with the left and right shaking of the hand.

Our ShakeLED has the following four mode:

- `Word Mode:` Display the corresponding number(0-F) according to the pressed button of KeyPad, it can display the last pressed 4 bits at the same time.
- `Picture Mode:` Display a static picture(eg. heart).
- `Animation Mode:` Display an animation (a walking man).
- `Time Mode:` Display a digital clock which has minute and second(eg. 00:10).

Thess modes can be converted by pressing the $BNT5$ button on the Zybo board.

2 Overall design and Principle

2.1 Finite State Machine

Pressing the $BNT5$ can convert the display mode.
Pressing the $KeyPad$ button when the mode is word can change the display word.

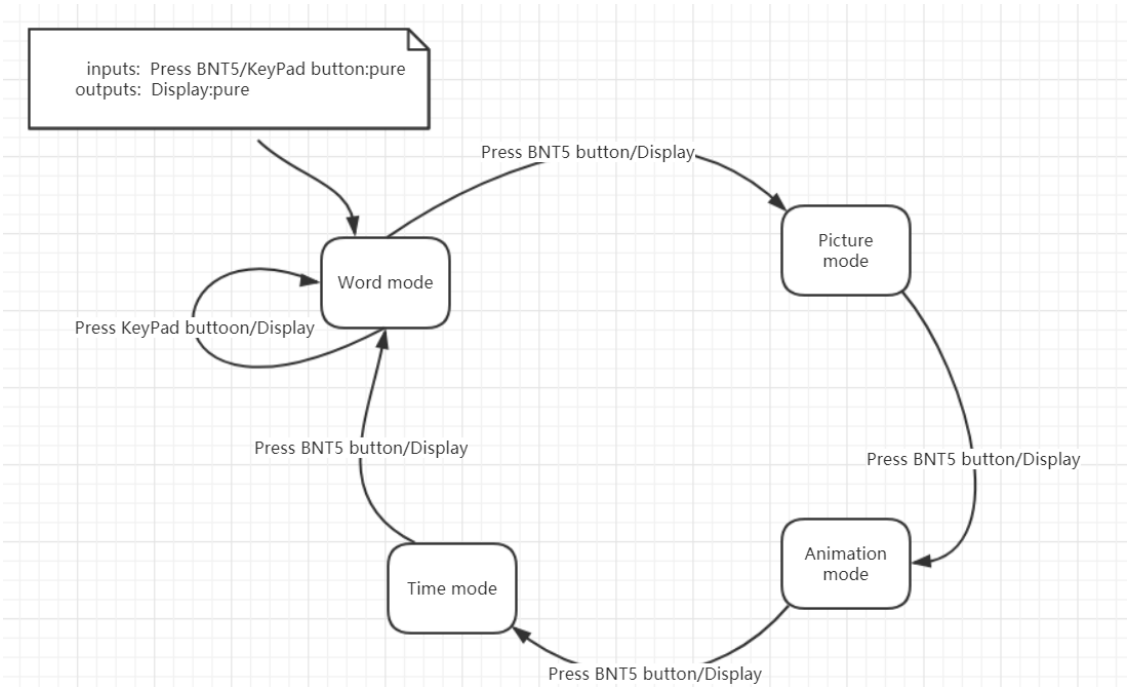

Figure 1: FSM.

2.2 Flow Chart

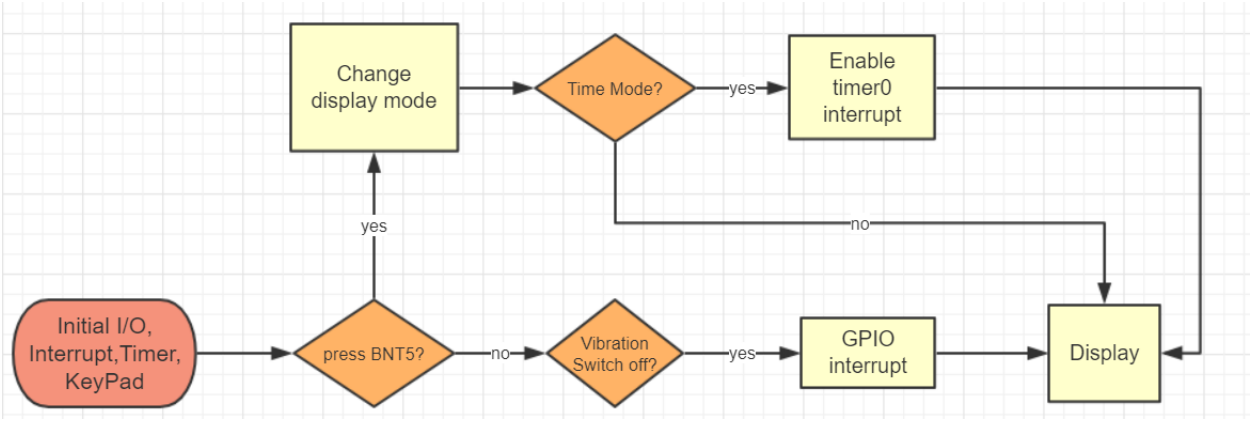

Figure 2: Flow Chart.

2.3 Principle

Controlling the LEDs you want to display with Zybo microcomputer requires only a timed output, but the speed at which each person shakes is different. If an accurate and stable pattern is to be converted, an external interrupt is required. Connect one end of the two pins of the vibration switch to the I/O port, and connect one end to the GND. When

the rocker moves to one side, the LED is displayed according to the program edited, and when the other side moves, the LED is completely off. At this time, a rising edge signal is generated in one cycle, and the signal is transmitted to the I/O port of the Zybo board to generate an interrupt.

Since the human visual retention time is as long as 0.1s, a suitable delay is added after each column of LEDs is displayed, such as 5ms, and a delay of 15ms is added between each word, so that we can see stability word or picture, and there is a gap between each word. In order to allow the word to be displayed in the middle of the space, delay the display of the interrupt for a suitable period of time, so that the bar starts to display at about 1/4 of the semicircular trajectory, so that the direction of the word seen is more positive.

The animation is composed of many consecutive picture, showing every picture after a certain time, then switching to the next one can form an animation.

3 Hardware Design

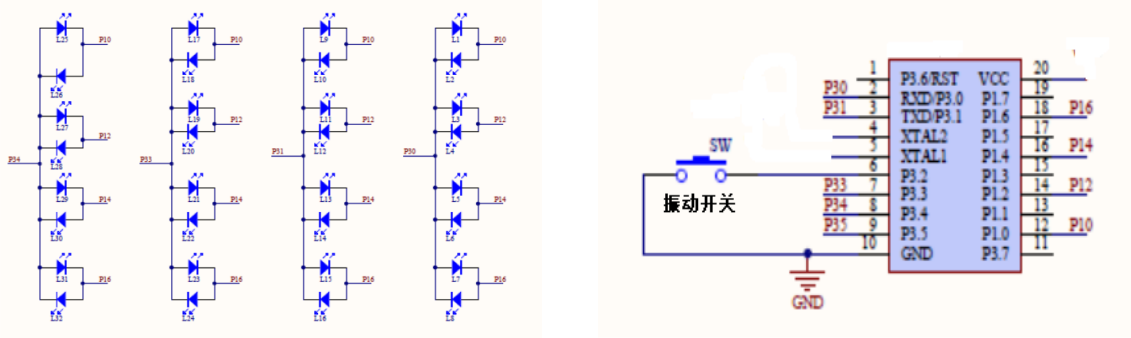

Figure 3: LED pin and port

As a controller, the *Zybo* board just need 8 *EMIO* ports to control the 32 LEDs and one port to accept the vabration switch interrupt signal.

If we want to light the LED, we should enable the corresponding port and disable the other port. For example, enable $P30$ and $P10$, then send the high level to $P30$ and low level to $P10$, the LED1 will light. A useful method is write value first and then enable the port, keep some time(about 100us), disable the port(important, otherwise it could affect other LED).

Scanning method

A line has 32 LEDs, I divided into four groups in order, a group has 8 LEDs,

- Divided 32 LEDs into four groups in order, a group has 8 LEDs.
- A group LEDs divided into two small group by parity and scan 4 LEDs at a time
  - The first time, scan the odd LEDs.
  - The second time, scan the even LEDs.

- The 8 ports
  - The first 4 ports to choose the group.
  - The last 4 ports to choose the LED that needs to light.

GPIO

- Multiplexed I/O
  - bank0: 0-31
  - bank1: 32-53
- Extended Multiplexed I/O
  - bank2: 54-85
  - bank3: 86-117
- I use the bank2 port(EMIO), 54-61 corresponds to 8 pins of LED0, 65 corresponds the vibration switch.

KeyPad

Key	value	Key	value	Key	value	Key	value
0	1	4	1 0000	8	1 0000 0000	C	1 0000 0000 0000
1	10	5	10 0000	9	10 0000 0000	D	10 0000 0000 0000
2	100	6	100 0000	A	100 0000 0000	E	100 0000 0000 0000
3	1000	7	1000 0000	B	1000 0000 0000	F	1000 0000 0000 0000

Table 1: The key value of KeyPad

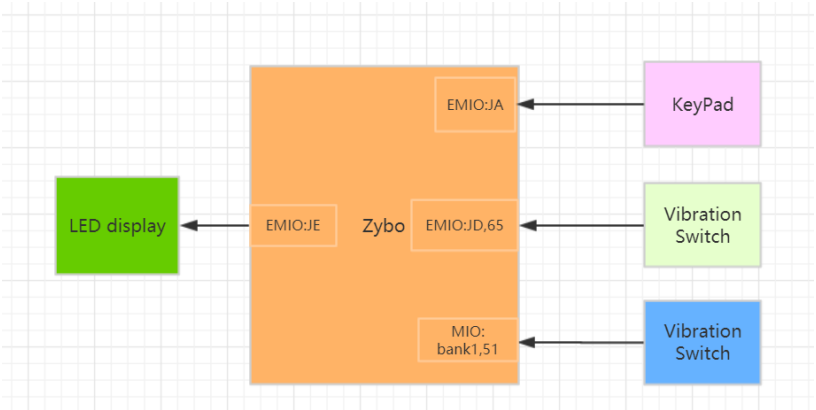

Figure 4: Hardware.

4 Software Design

The program mainly contains 4 parts

- `Main function`: Use to initialize the I/O port, interrupt and timer
- `Interrupt function`: Set the GPIO and timer interrupt
- `Timer`: Set the timer and time interrupt every second
- `Display function`: Display the current mode word, picture or animation.

5 Analysis

- There is a trade-off: If we want to display many words, we should reduce the time of one word since the rotating range is limited, but the brightness would go down, so we should increase the frequency to maintain a certain brightness which means we need to shake the rotating LED faster.
- The different direction we shake would create opposite pattern, so we should define the shaking direction.

6 Result

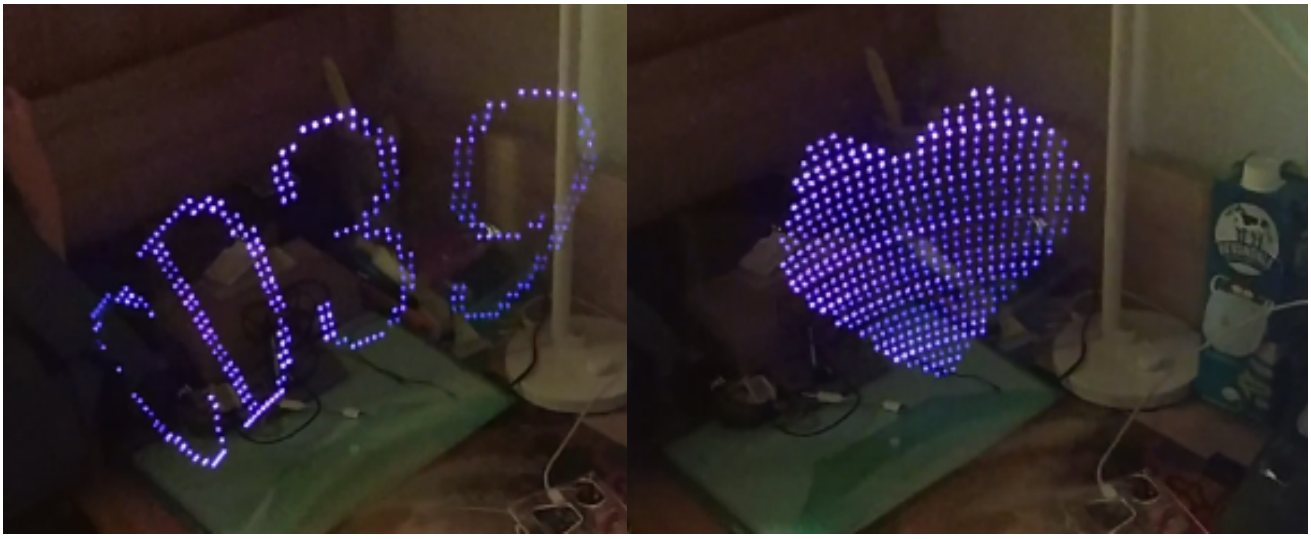

Figure 5: Word Mode and Picture Mode

Figure 6: Animation Mode

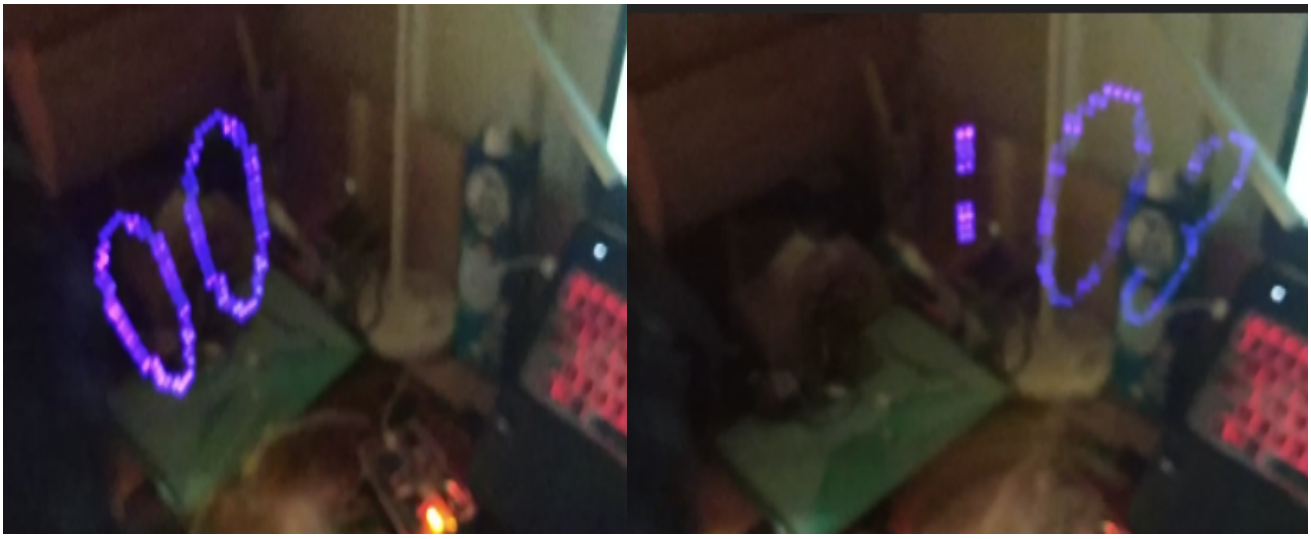

Figure 7: Time Mode

7 Appendix

- **Code** and **Vivado Project file** is attached zip file.