Assignment-4

1) *Introduction*

In this lab we have extended previous lab work now we have to vary the LED brightness using Pulse Width Modulation (pwm) such that brightness increase as we move from right to left of the 7 segment LED display.

Pulse Width Modulation :

a) It is technique which is used to control semiconductor devices.

b) It reduces average power delivered by electrical signal by converting into discrete signals.

c) In this technique , signal's energy is distributed through a series of pulses rather than continuous signal(as happen with analog signals).

PWM signal generation :

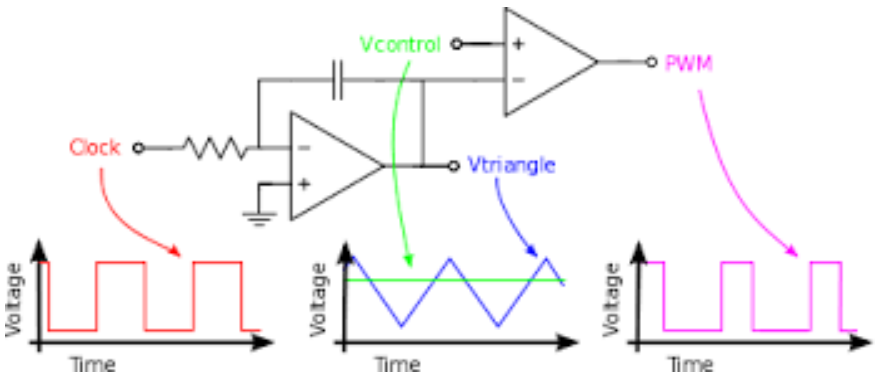


Fig 1: Circuit for generating PWM signal

Some Important Parameters related to PWM signal :

a) Duty Cycle of PWM signal :

$$Duty\ Cycle\ =\ \frac{Turn\ ON\ time}{Turn\ ON\ time+Turn\ OFF\ time}$$

b) Frequency of PWM signal :

$$Frequency\ =\ \frac{1}{Time\ Period}$$

c) Time period of PWM signal :

$$Time\ Period\ =\ ON\ time\ +\ OFF\ time$$

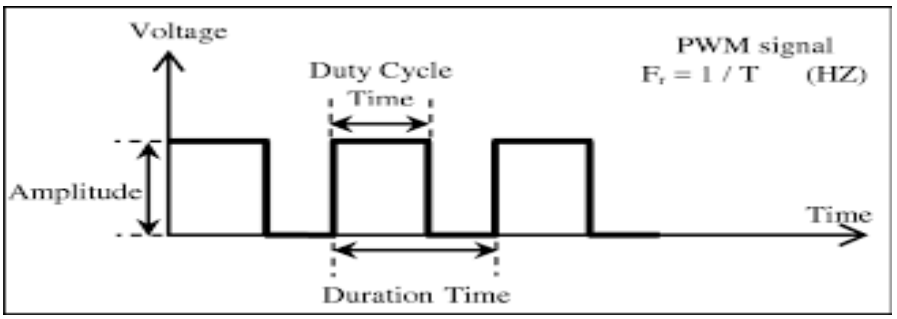


Fig 2 : Diagram of PWM signal

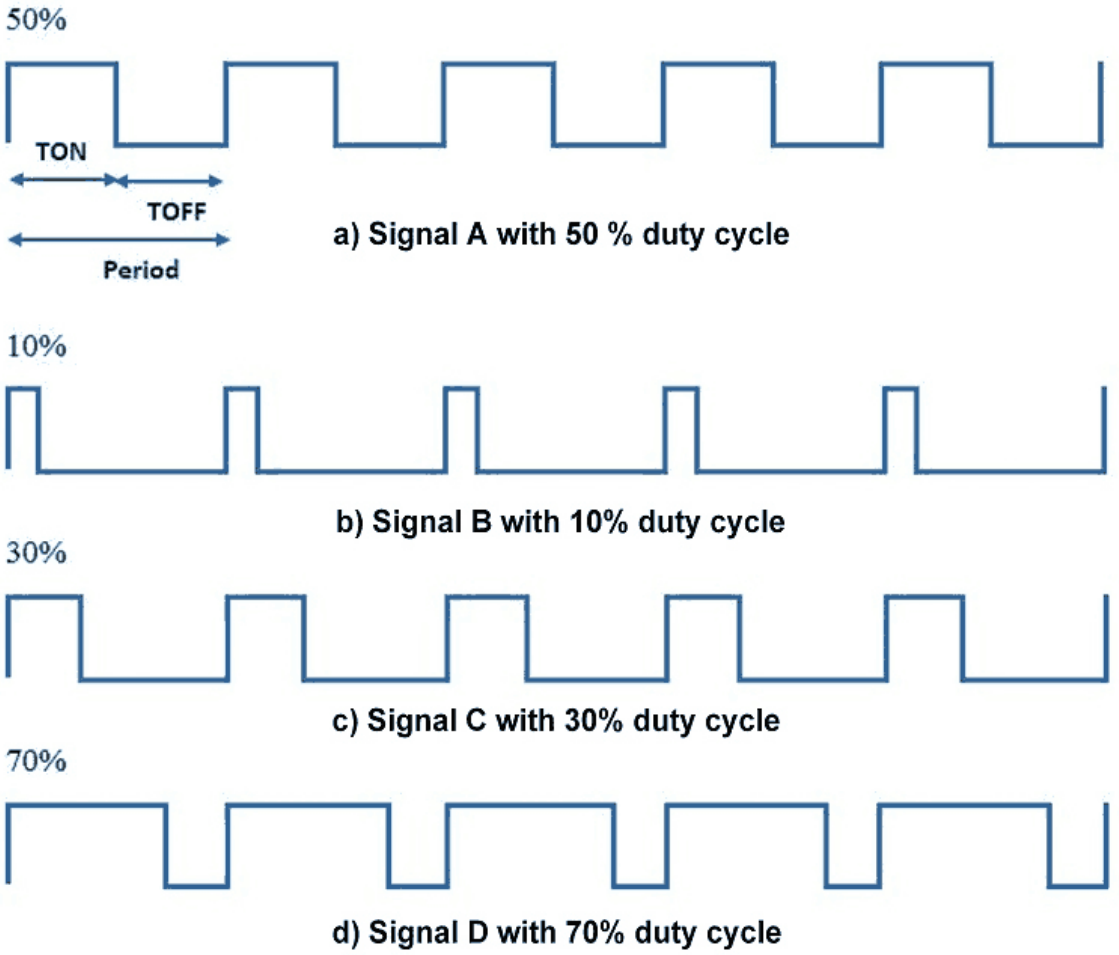


Fig 3 : Diagram of different PWM signal with different duty cycle

2) *Implementation Design*

Most of the implementation remain same as from previous lab now for brightness we have used an integer "counter" which will be incremented on each "rising edge of clock" . Now as counter is increasing with time so to maintain a uniform brightness of 4 LED's we have to use periodic sequence which can be obtained by using the modulo operator .

In this case we have used "2200" *to take counter modulo .*
As brightness of "*Leftmost 7 segment LED display* " *is to be highest basically* 100% *, so we don't apply any condition for its brightness. But for other remaining* "3" *7 segment LED display we have applied condition as follows* :

Position of 7 segment LED display from right side	ON condition
1 (rightmost LED)	(counter mod 2200) < 100
2	(counter mod 2200) < 500
3	(counter mod 2200) < 1200

Table 1 : *condition used for brightness*

Position of 7 segment LED display from right side	Duty Cycle (%) / Brightness in percentage
1 (rightmost)	$\frac{100}{2200} = 4.54\ \%$
2	$\frac{500}{2200} = 22.73\ \%$
3	$\frac{1200}{2200} = 54.54\ \%$
4 (leftmost)	100 %

Table 2 : *LED duty cycle*

3) *Simulation Waveform for 4 digit 7 segment display with varying LED brightness*

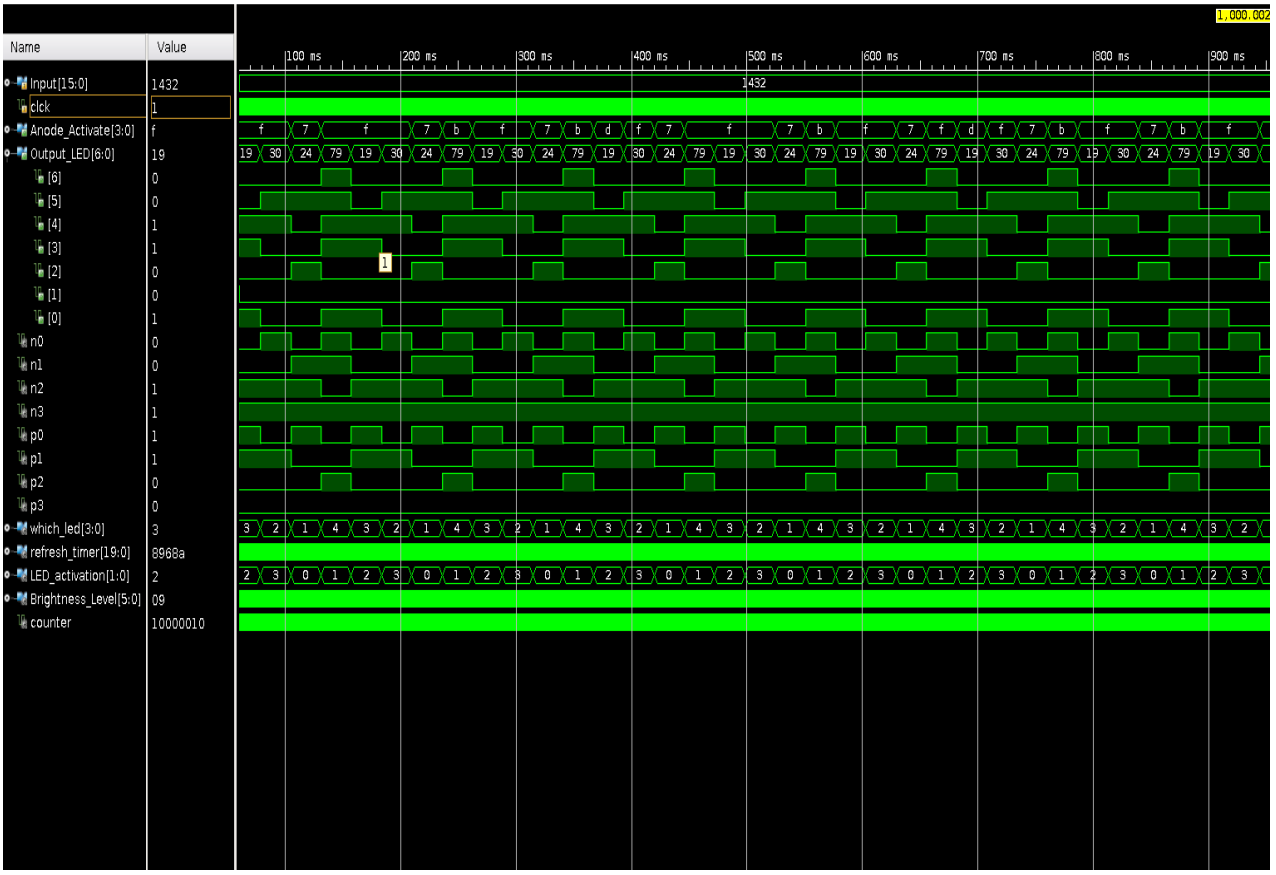


Fig 4 : Waveform of 4 segment LED with different brightness

4) *Digital Circuit for* 4 − *digit* 7 *Segment Display with different brightness*

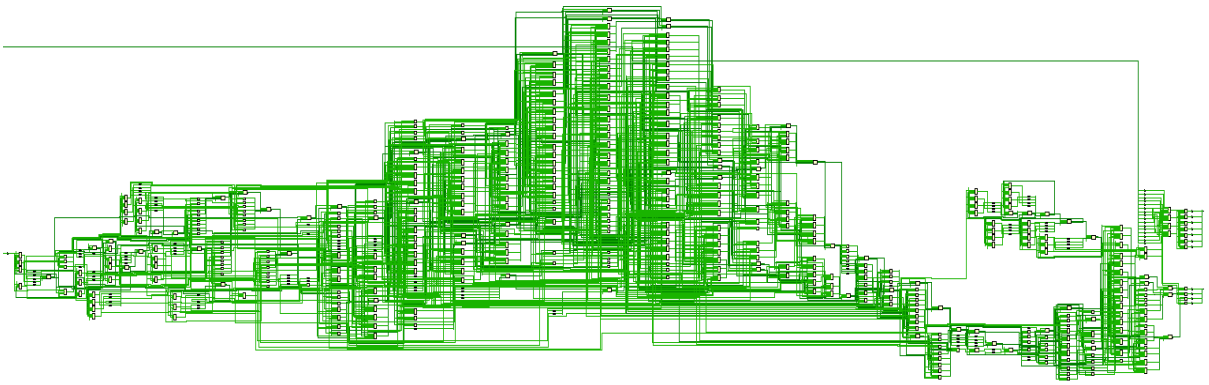


Fig 5 : *Complex Digital circuit for LED brightness control*

5) *Resource Utilisation*

a) LUT Memory =0
b) LUT logic = 373
c) DSP =0
d) Flip Flops =54
e) BRAM = 0

6) *Some other relevant diagram for resource utilisation*

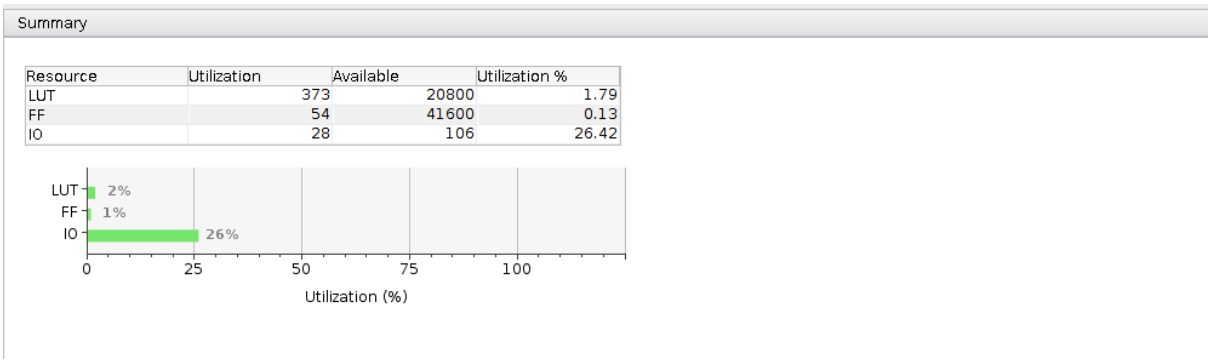


Fig 6 : Summary

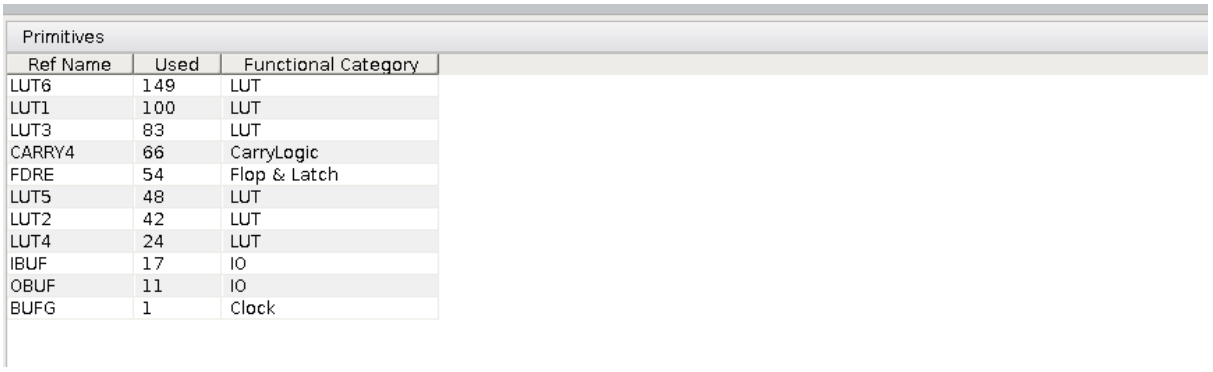


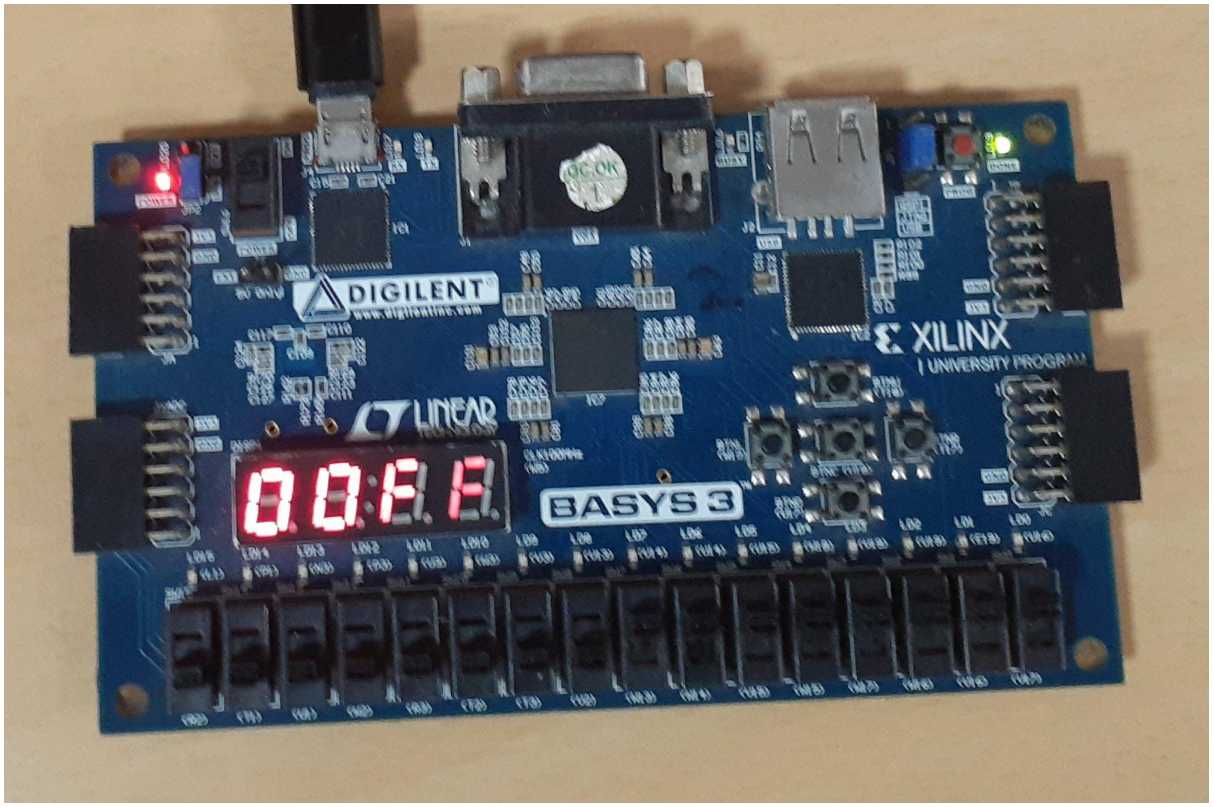
Fig 7 : Primitives

Hierarchy

Name	Slice LUTs (20800)	Slice Registers (41600)	Bonded IOB (106)	BUFGCTRL (32)
LED_brightness	373	54	28	1

Fig 8 : Hierarchy

7) *Some photographs of FPGA Board*



(a)