ESKİŞEHİR TECHNICAL UNIVERSITY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

EEM 334 - Digital Systems II

LAB 5 – SEQUENTIAL DESIGN I
DIGITAL CLOCK

1. PURPOSE

In this lab, you will learn how to design a synchronous sequential circuit in VHDL. A special kind of sequential circuits are counters which are frequently used in digital systems. Thus, you will first design an up-down counter with synchronous reset and enable inputs. After that, you will design, simulate, and realize a digital clock based on this counter.

2. BACKGROUND

A sequential circuit is a circuit with memory, which forms the internal state of the circuit. Unlike a combinational circuit, in which the output is a function of input only, the output of a sequential circuit is a function of the input and the internal state. The synchronous design methodology is the most commonly used practice in designing a sequential circuit. In this methodology, all storage elements are controlled (i.e., synchronized) by a global clock signal and the data is sampled and stored at the rising or falling edge of the clock signal.

The sequential domain is represented by a process that contains sequential statements. These statements are executed in the order in which they appear within the process, as in programming languages.

```
process_label : process(sensitivity_list)
-- declarative part
begin
-- sequential statement
end process process_label;
```

Fig. 1 Process structure

3. PROCEDURE

1. Design your 32-bit up_down counter with a synchronous reset and an enable input (it is already given).

2. Simulate your 32-bit up_down counter on ISE simulator.

3. Using a counter, obtain a new clock signal based on clock input by modifying the example code given as follows:
   a. 1-bit "clock_out" output port will be needed for new clock signal output. 1-bit "clock_out" output port will be 0 for the half of the new clock period and 1 for the other half.

   b. "result" output port will not be necessary.

   b. New clock (clock_out) period will be 10x of the input clock period .

4. Using a counter, design a "Digital clock component" as follows.

   a. The new clock signal obtained in Step 3 will be used as the clock input for the Sec and Min components.
   b. You need a 1-bit "enable_out" output port and 4-bit "upperlimit" input port.
   c. In up mode, your counter will count up to until this "upperlimit" and then reset to zero.
   d. In down mode, your counter will count down to zero and then reset to this "upperlimit".
   e. "enable_out" output signal will be an asynchronous one. It will be 1 for a clock cycle if the current counter value is "upperlimit" and 0 for all other values while counting up.

5. Build your top module and instantiate all components according to Figure 2.

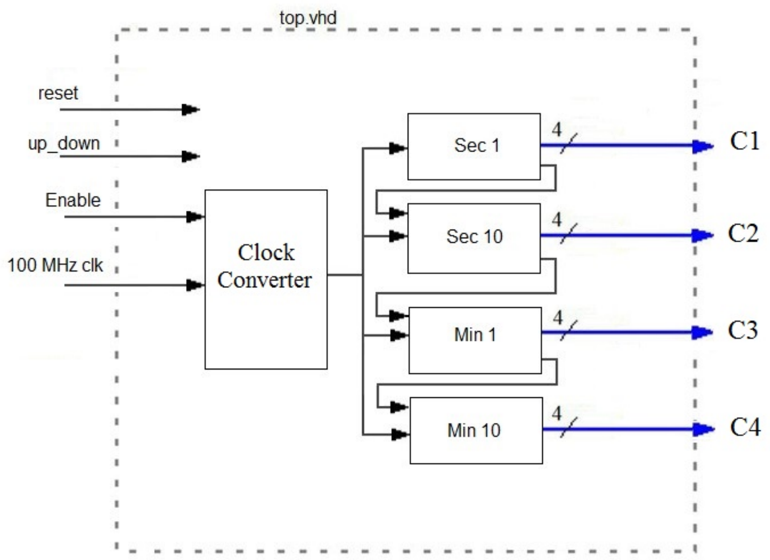

Fig. 2. Block diagram of top module

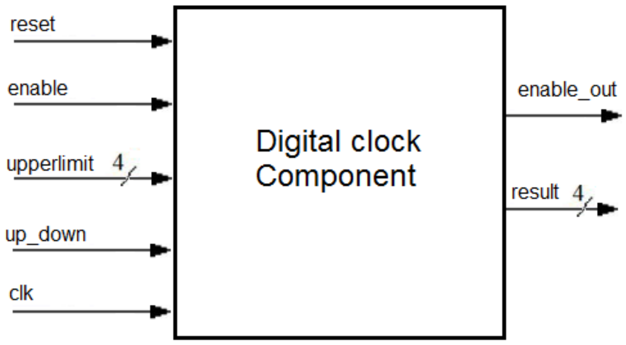

Fig. 3 Digital clock component

Note: Sec 1, Sec 10, Min 1 and Min 10 are the instantiations of the Digital clock component. Sec 1 enable input is connected to top enable port.

Example Up-Down Counter

```
library IEEE;
use IEEE.STD_LOGIC_1164.ALL;
use IEEE.NUMERIC_STD.ALL;

 entity    universal_counter    is
  Port ( clk : in  STD_LOGIC;
           rst     :     in      STD_LOGIC;
           up_down  :  in   STD_LOGIC;
           enable : in  STD_LOGIC;
           result : out  STD_LOGIC_VECTOR (31 downto 0));
 end universal_counter;

 architecture Behavioral of universal_counter is
    signal count : unsigned (31 downto 0) := x"00000000";
 begin

  process (clk, rst, enable, up_down)
  begin
     if (clk = '1' and clk'event) then
        if (rst = '1') then
           count <= (others => '0');
        elsif (enable = '1') then
           if (up_down = '1') then
              count <= count + 1;
           else
              count <= count – 1;
           end if ;
        end if ;
     end if;
  end process;

  result <= count;

  end Behavioral;
```