

## Traffic Light Controller

### Requirements for the exercise (issues and skills necessary to complete the task):

- representation of numbers in decimal, binary and hexadecimal systems;
- setting up a new project in Quartus Prime;
- creating a hardware module (symbol) in Quartus Prime based on a schematic file (\*.bdf);
- creating a hardware module (symbol) in Quartus Prime based on a source code file (eg. \*.vhd);
- ability to simplify a logical expressions using the Karnaugh Map method;
- ability to implement a scheme with logic gates based on an algebraic equation.

### FREQUENCY DIVIDER (Toggle Mode)

Each kind of Flip-Flop can be configured to work in switching mode called Toggle Mode, works as a binary, frequency divider. In this mode, a rectangular wave is generated at the outputs Q and  $\bar{Q}$  with the frequency equal to half of the clock frequency given to the flip-flop. The figure below shows several flip-flops configured in toggle mode.

Moreover, by connecting several flip-flops in series, you can obtain a mod  $2^N$  counter (eg. counter mod 4, mod 8, mod 16, mod 32, ...).

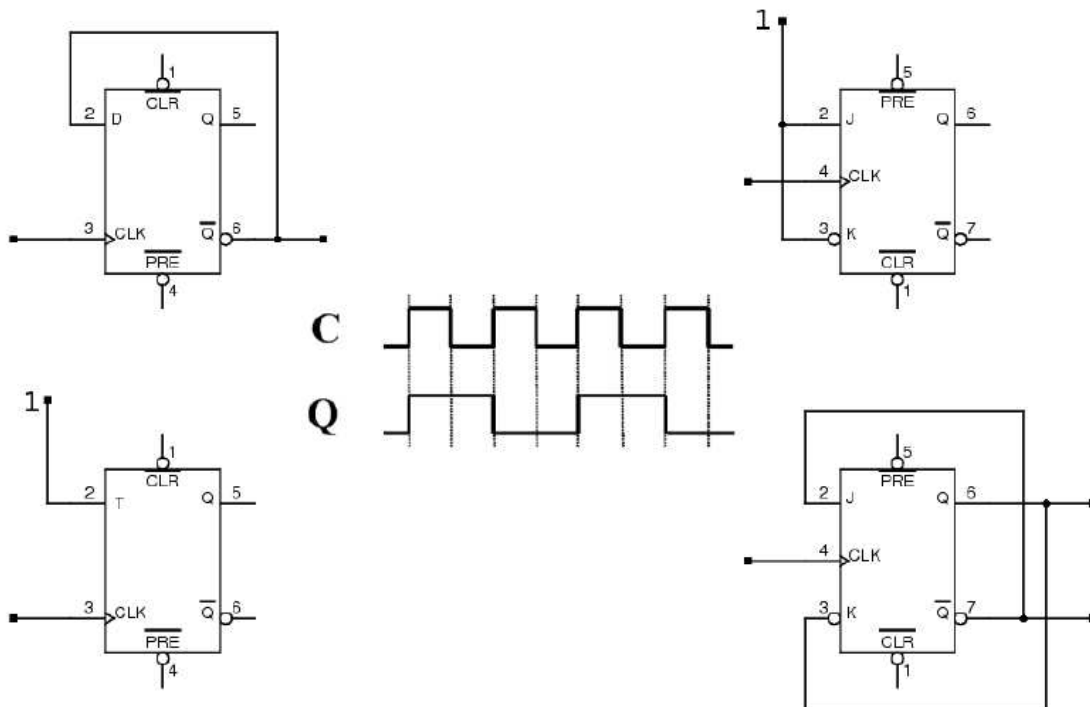
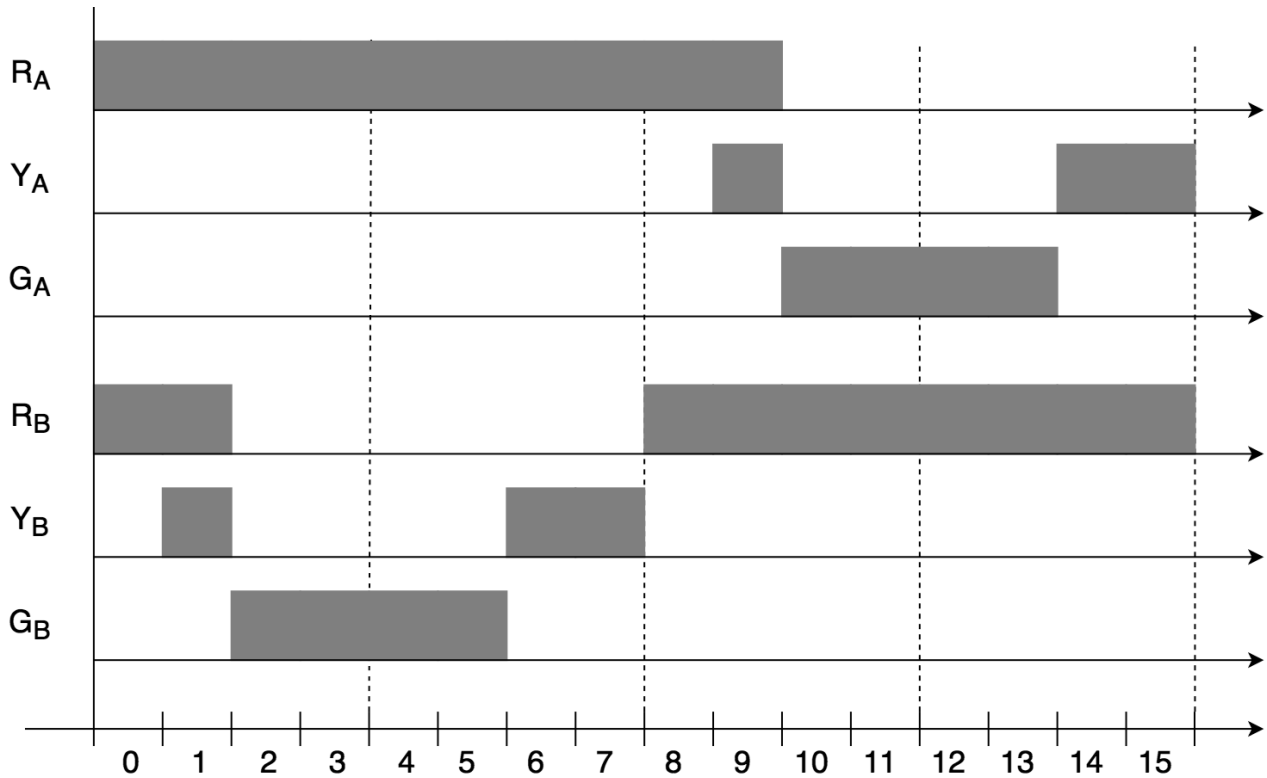


Fig. 1: D, T and JK Flip-flops configured to work in switching mode.

**TRAFFIC LIGHT CONTROLLER**

Design and implement the up-counter (mod 16) by connecting in series toggle mode configured flip-flops. Next, design combinational logic circuit to control the led traffic to get the sequence, as on the figure below. The inputs of the combinational circuit should be the counter outputs..



**Fig. 2: Traffic light sequence at the intersection of roads A and B**

Use the 1Hz signal from the Multiprescaler block as the clock signal for the counter. An example of the mod 16 up-counter, based on flip-flops configured as toggle mode, is shown in Fig. 3. Table 1 shows the Karnaugh map for the red light signal, for road A (RA signal). Based on such maps, combinational circuits should be implemented for all traffic light signals (RA, YA, GA, RB, YB, GB). Implement the logic for controlling the lights (combination circuits) in the form of a hardware module (in the form of a symbol).

As a street light simulator on the DE10-Lite board, use the 7-segment displays HEX0 and HEX1, as shown in Fig. 4. Connect the unused display bars to the high state - VCC (HEX0[1], HEX0[2], HEX0[4], HEX0 [5], HEX1[1], HEX1[2], HEX1[4], HEX1[5]). Figure 5 shows the final circuit diagram of the Traffic Light Controller.

$x_3 \ x_2 \backslash \ x_1 \ x_0$	00	01	11	10
00	1	1	1	1
01	1	1	1	1
11	0	0	0	0
10	1	1	0	0

Tab. 1: Karnaugh map for  $R_A$  signal

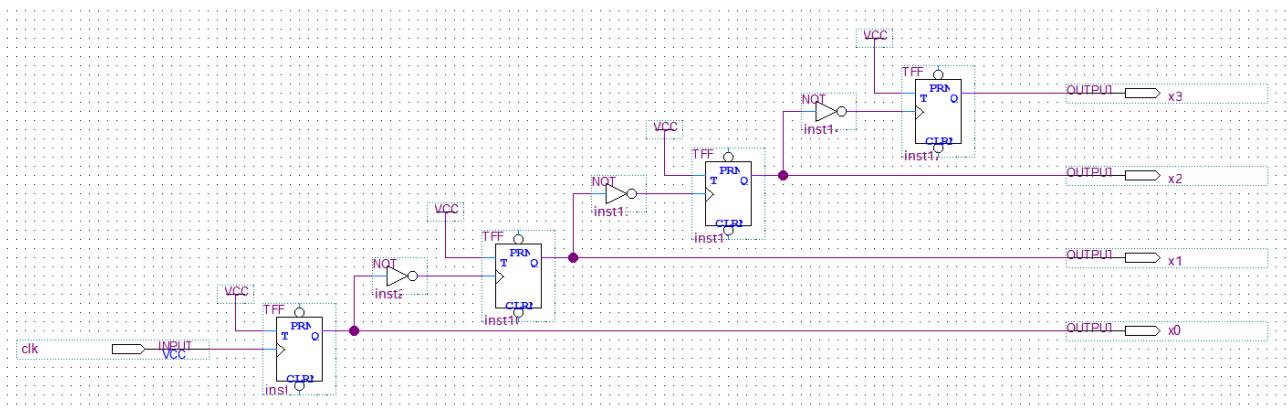


Fig. 3: Up counter mod 16

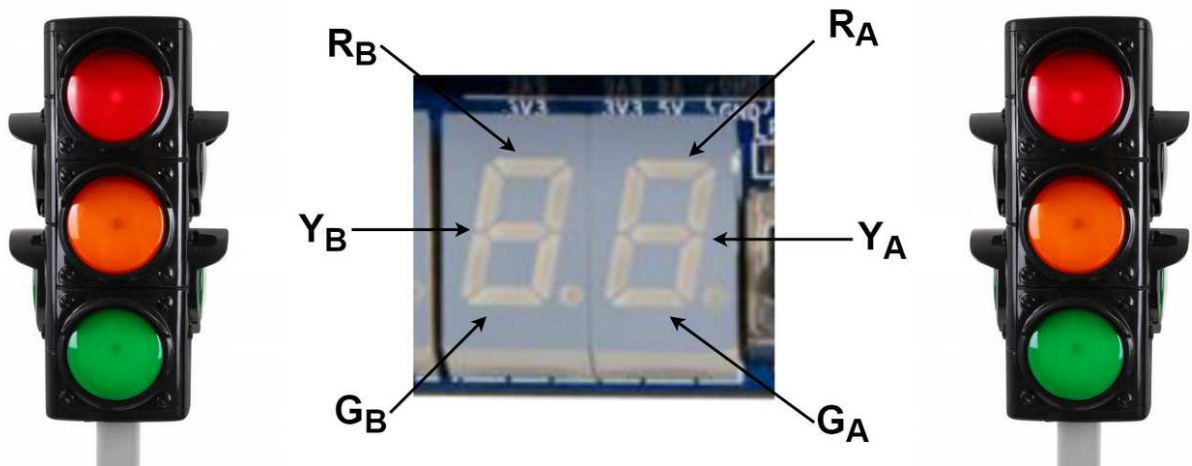


Fig. 4: Using 7-segment displays as a traffic light simulator

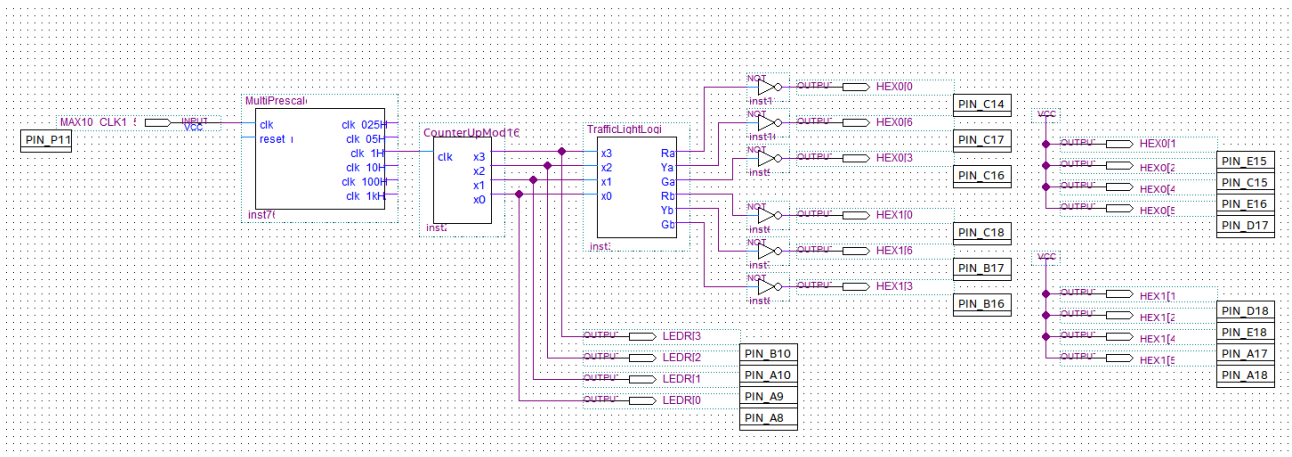


Fig. 5: Diagram of the traffic light controller system