Digital System Design

TIMER

Faculty of Automation and Computer Science

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Student:
Vidrean Marius-Iuliu
Group 30412

Coordinating Teacher:
Asist. Univ. Maier Noema

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Contents

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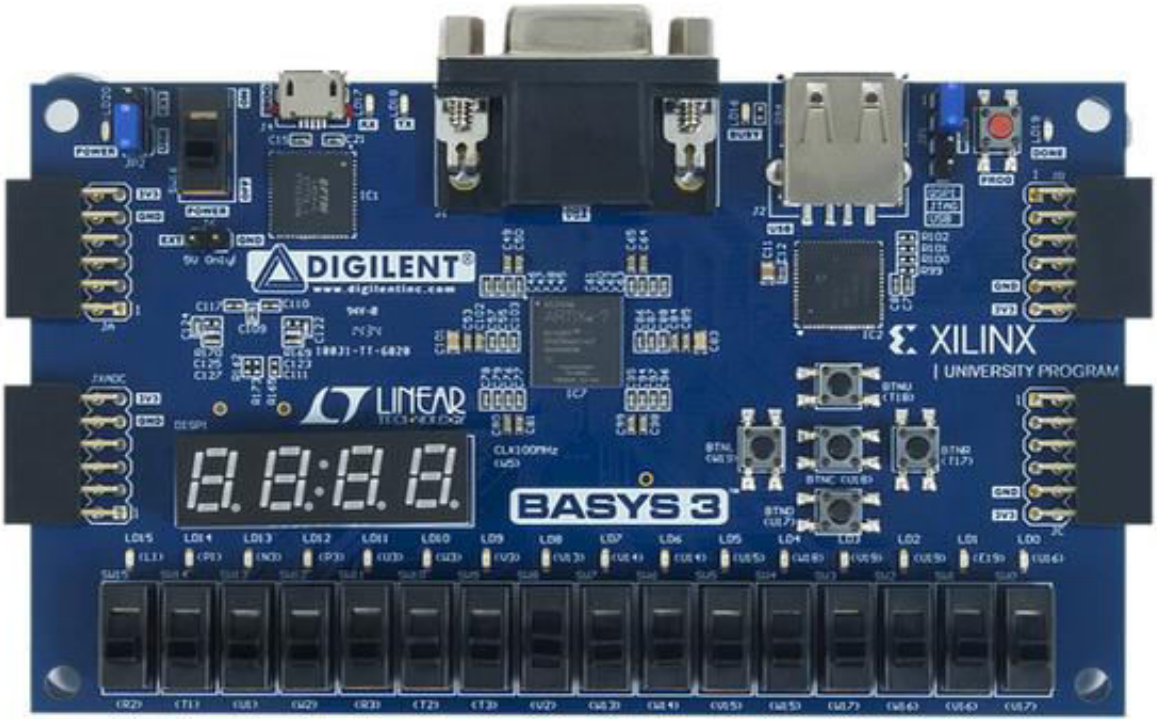
About Basys 3



The Basys 3 is one of the best boards on the market for getting started with FPGA. It is an entry-level development board built around a Xilinx Artix-7 FPGA.

As a complete and ready-to use digital circuit development platform, it includes enough switches, LEDs, and other I/O devices to allow a large number of designs to be completed without the need for any additional hardware. There are also enough uncommitted FPGA I/O pins to allow designs to be expanded using Digilent Pmods or other custom boards and circuits, and all of this at a student-friendly price point.

Given Task

Build a timer with the following functionalities: the device should have four BCD 7 segments displays. The first two are for the minutes and the following two are for the seconds. Therefore, the maximum value that can be projected is 99 minutes and 59 seconds.

The device has 3 buttons: “M” (from minutes), “S” (from seconds) and “START / STOP”.

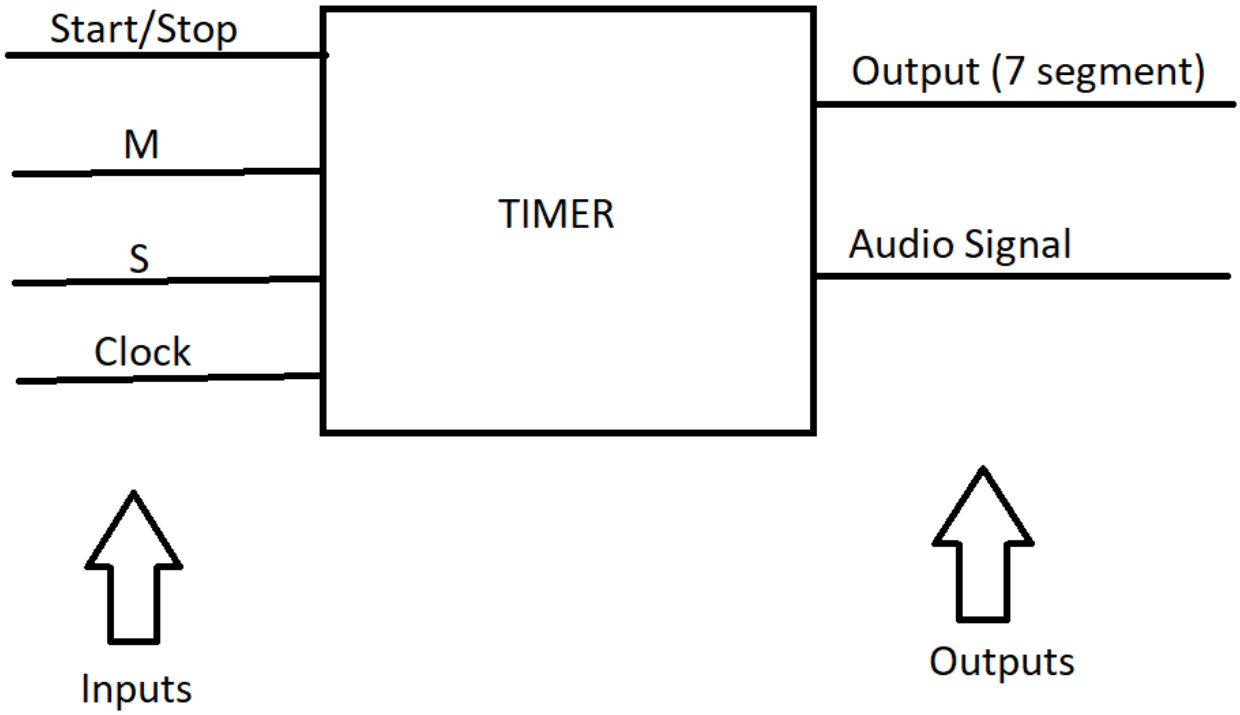
Assuming that initially, the timer is in the ZERO state, if we press the “START / STOP” button, the timer should start counting up. If we press again “START / STOP”, the timer freezes at that particular time. If we press again “START / STOP”, the timer resumes its counting. If it reaches 99 minutes and 59 seconds, the next state would be the ZERO state.

If we press simultaneously the “M” (from minutes) and “S” (from seconds) buttons, the timer resets and becomes ZERO.

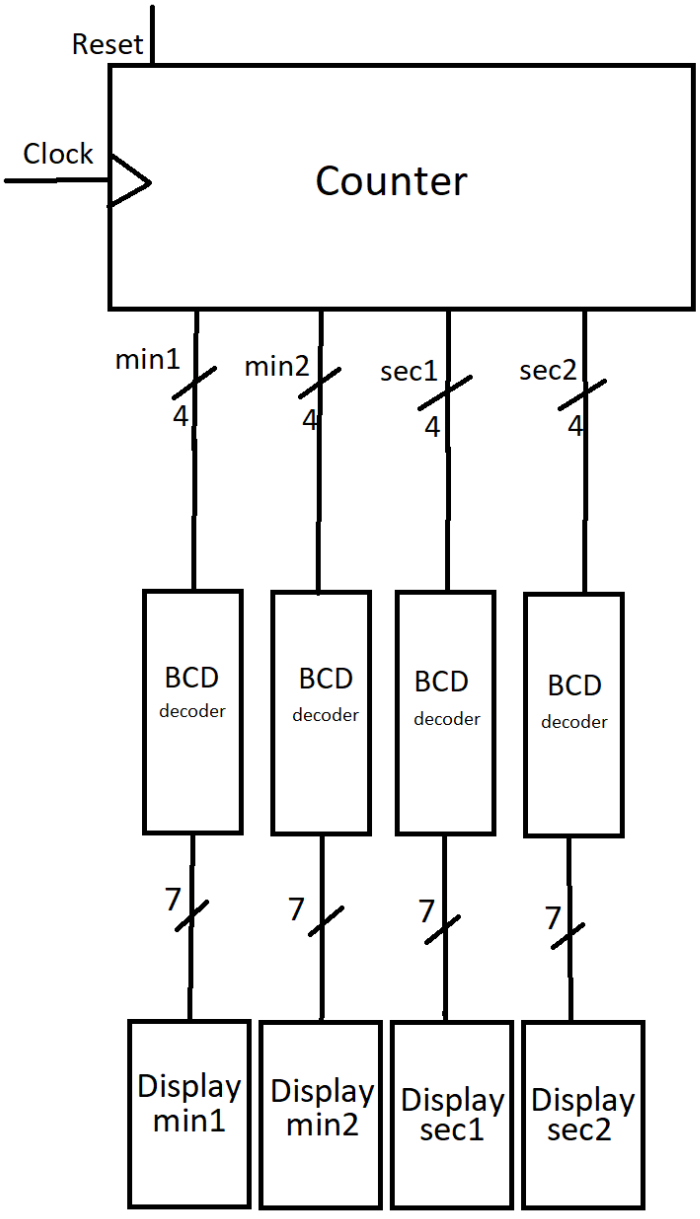
In any state, if we press the “M” button, the value of the minutes would be displayed and incremented. Also, in any state, if we press the “S” button, the value of the seconds would be displayed and incremented. Once the desired value is setted, (using the “M” and “S” buttons), when we press the “START / STOP” button, the timer starts counting down from its current state till it reaches the ZERO state, and when it does, it will emit a sound signal (alarm) which can be setted for a particular period of time.

We consider that we have a periodic signal with the frequency of 1 Hz. The project would be realized by one student.

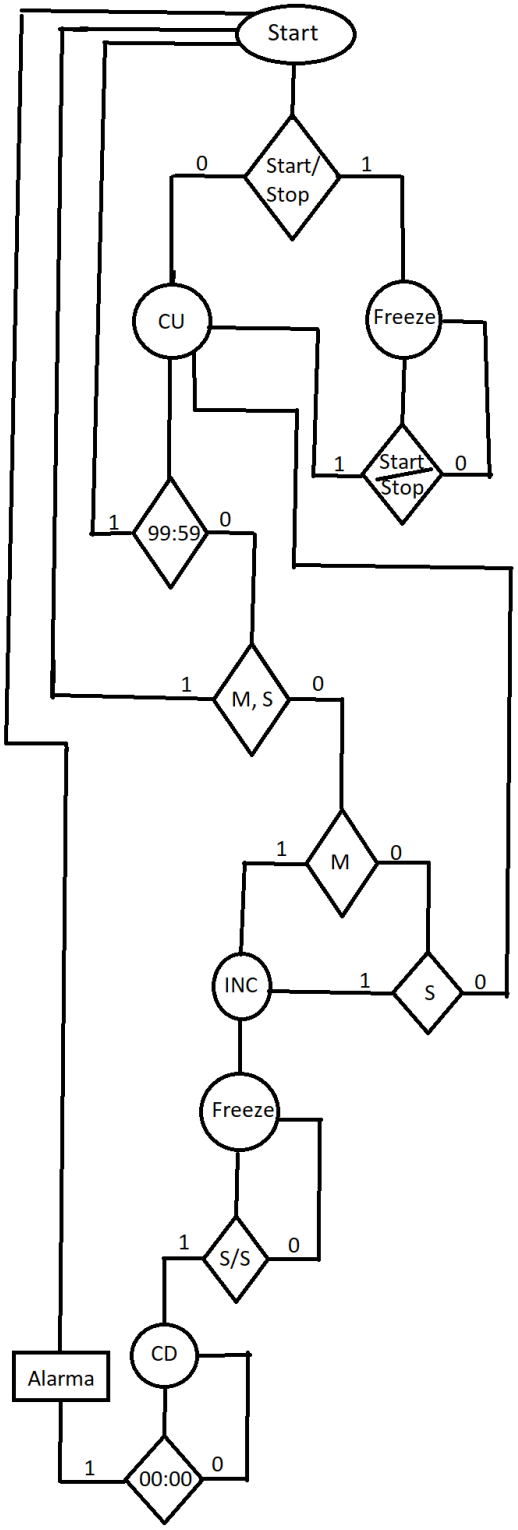
Black Box


Start/Stop
M
S
Clock
TIMER
Output (7 segment)
Audio Signal
Inputs
Outputs

Block Scheme



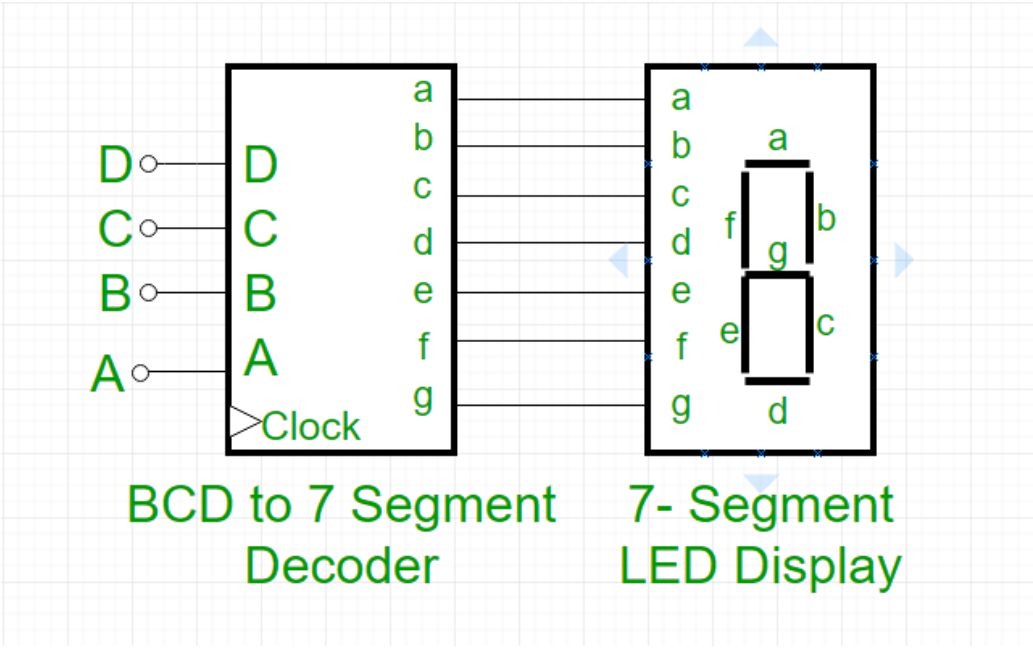
Organigram


Start
Start/
Stop
0
1
CU
Freeze
Start
Stop
1
0
99:59
1
0
M, S
1
0
M
1
0
INC
S
1
0
Freeze
S/S
1
0
CD
Alarma
00:00
1
0

Components

My Timer is made of only two components: a counter and a bcd decoder. The counter is programmed to count up starting from 0 minutes and 0 seconds until 99 minutes and 59 seconds, and also down starting from any value needed till 0 minutes and 0 seconds.

The bcd decoder has ten output bits. It accepts an input value consisting of a binary-coded decimal integer value and activates one specific, unique output for every input value in the range [0,9]. This was used in order to present the result on the fpga's led displays.



TRUTH TABLE:

BCD Inputs				Output Logic Levels							Decimal number display
D	C	B	A	a	b	c	d	e	f	g	
0	0	0	0	0	0	0	0	0	0	1	0
0	0	0	1	1	0	0	1	1	1	1	1
0	0	1	0	0	0	1	0	0	1	0	2
0	0	1	1	0	0	0	0	1	1	0	3
0	1	0	0	1	0	0	1	1	0	0	4
0	1	0	1	0	1	0	0	1	0	0	5
0	1	1	0	1	1	0	0	0	0	0	6
0	1	1	1	0	0	0	1	1	1	1	7
1	0	0	0	0	0	0	0	0	0	0	8
1	0	0	1	0	0	0	1	1	0	0	9

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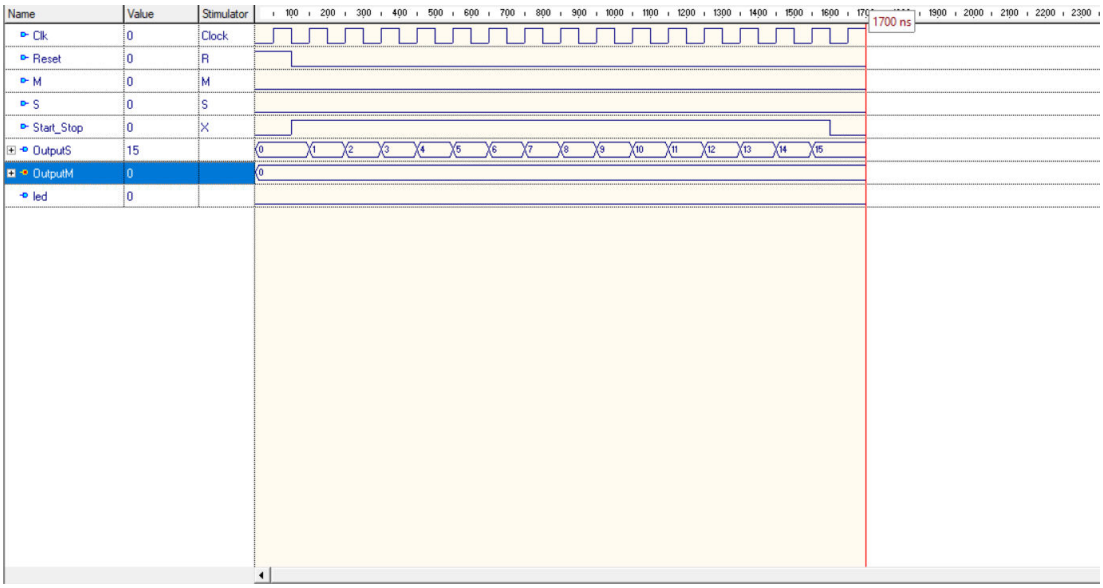
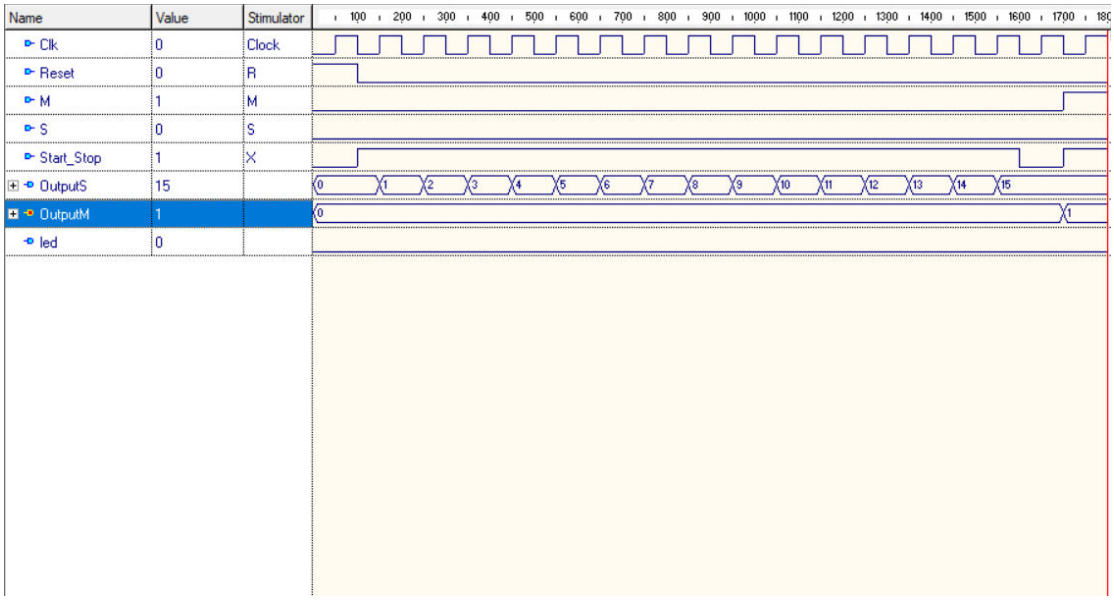
Project Description and Simulation

The project contains a timer which has multiple possibilities of counting. We could start by counting up from 0 minutes and 0 seconds and freeze the counter after fifteen seconds. First thing first, we have to press the "Reset" button which brings our counter to the initial state of 0 minutes and 0 seconds, then move on to press the "Start/Stop" button which enables the counter. In order to freeze our counter we just need to press "Start/Stop" again, so that the button gets the "0" value.



Now, I would like to keep counting again, so I will just enable the "Start/Stop" button, bringing it back to value '1'. But also I want to increment the number of minutes using the "M" button.



After using any of the “S” or “M” button for incrementing the minutes or the seconds, if we press the “Start/Stop” button again, it will start counting down from the previous value (in our case 1 minute and 15 seconds), and when it hits the value of 0 minutes and 0 seconds a signal, in our case a led is activated.

Justifying the Solution

I choose to write the code in a behavioral way over the comportamental mode, since its similar with a high end programming language, with which I am more familiar with, and it was easier for me to write and understand the code as I implemented it.

Possible Improvements

What I could improve on this project is maybe adding the option to show the hour also, not only minutes and seconds, that way I could use it to count way more. And maybe add multiple options for the led signal. For example it could get activated when it hits a particular time, not only when is zero.