

# ARM Assignment

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**Problem Statement** - A sequential circuit has a single input  $x$  and a single output  $z$ . The input signal  $x$  can occur in groups of 1, 2 and 3 pulses. If  $x = 1$  for one clock period, the output  $z$  will be 1 for three clock periods before returning to the starting state. If  $x = 1$  for two clock periods, the output  $z$  will be 1 for two clock periods before returning to the starting state. If  $x = 1$  for three clock periods, the output  $z$  will be 1 for a single clock period before returning to the starting state. Construct a state diagram and implement your design with D F F s . The circuit when designed acts as a pulse width adjuster.

## Hardware

### Components

Component	Value	Count
Vaman board	-	1
Flip Flop	7474	2
LED	Red	1
Resistor	220ohm	1
Jumper wires	-	as required

### Connections

The following connections are to be read as **IC-Name-IC-pin no:Vaman-pin no** :

- **IC7447(1)** - (1:5.5V), (2:8), (3:13), (4:5.5V), (5:2), (6:None), (7:Gnd), (8:None), (9:3), (10:5.5V), (11:13), (12:9), (13:5.5V), (14:5.5V)
- **IC7447(2)** - (1:5.5V), (2:10), (3:13), (4:5.5V), (5:4), (6:None), (7:Gnd), (8:None), (9:5), (10:5.5V), (11:13), (12:11), (13:5.5V), (14:5.5V)

Connect LED to pin 12 of Vaman board with the 220ohm resistor in series. Use pin 6 of Vaman board to input  $X$ .

## State Diagram

The state diagram shown in 1 can be understood easily by grouping the states according to the clock pulse number. Consider one cycle of the state machine to contain three clock pulses numbered 1, 2 and 3. The states 0, 1 and 2 in the clock-1 group are the entry states to produce the  $Z$  values for the successive 2 clock pulses (clock-2 and clock-3). Distinct entry states are necessary in order to remember the input sequence of the previous cycle. While entering into any of these three states, the  $Z$  value for clock-1 is already determined by

the input at clock-3 of the previous cycle. In order to keep track of the number of ones in the input sequence  $X$  and to output the proper values at  $Z$  (determined by the entry state), the remaining 7 states (3-9) are required.

Since the state diagram uses 10 states, the design requires 4 DFFs. Let the present state be denoted by  $\mathbf{P} = P_3P_2P_1P_0$  and the next state as  $\mathbf{S} = S_3S_2S_1S_0$  with  $X$  as input and  $Z$  as output.

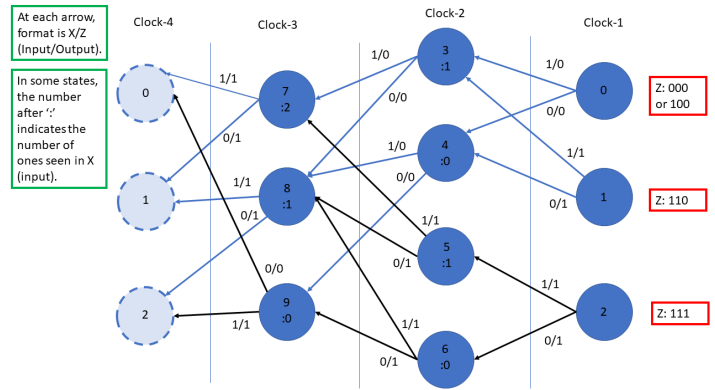


Figure 1: State diagram for pulse width adjuster

## Truth table

$P_3$	$P_2$	$P_1$	$P_0$	$X$	$S_3$	$S_2$	$S_1$	$S_0$	$Z$
0	0	0	0	0	0	1	0	0	0
0	0	0	0	1	0	0	1	1	0
0	0	0	1	0	0	1	0	0	1
0	0	0	1	1	0	0	1	1	1
0	0	1	0	0	0	1	1	0	1
0	0	1	0	1	0	1	0	1	1
0	0	1	1	0	1	0	0	0	0
0	0	1	1	1	0	1	1	1	0
0	1	0	0	0	1	0	0	1	0
0	1	0	0	1	1	0	0	0	0
0	1	0	1	0	1	0	0	0	1
0	1	0	1	1	0	1	1	1	1
0	1	1	0	0	1	0	0	1	1
0	1	1	0	1	1	0	0	0	1
0	1	1	1	0	0	0	0	1	1
0	1	1	1	1	0	0	0	0	1
1	0	0	0	0	0	0	1	0	1
1	0	0	0	1	0	0	0	1	1
1	0	0	1	0	0	0	0	0	0
1	0	0	1	1	0	0	1	0	1
1	0	1	0	0	X	X	X	X	X

$P_3$	$P_2$	$P_1$	$P_0$	$X$	$S_3$	$S_2$	$S_1$	$S_0$	$Z$
1	0	1	0	1	X	X	X	X	X
1	0	1	1	0	X	X	X	X	X
1	0	1	1	1	X	X	X	X	X
1	1	0	0	0	X	X	X	X	X
1	1	0	0	1	X	X	X	X	X
1	1	0	1	0	X	X	X	X	X
1	1	0	1	1	X	X	X	X	X
1	1	1	0	0	X	X	X	X	X
1	1	1	0	1	X	X	X	X	X
1	1	1	1	0	X	X	X	X	X
1	1	1	1	1	X	X	X	X	X

## Minimization using Kmap

$P_3P_2P_1 \backslash P_0X$	00	01	11	10
000	0	0	0	0
001	0	0	0	1
011	1	1	0	0
010	1	1	0	1
110	$x$	$x$	$x$	$x$
111	$x$	$x$	$x$	$x$
101	$x$	$x$	$x$	$x$
100	0	0	0	0

$P_3P_2P_1 \backslash P_0X$	00	01	11	10
000	1	0	0	1
001	1	1	1	0
011	0	0	0	0
010	0	0	1	0
110	$x$	$x$	$x$	$x$
111	$x$	$x$	$x$	$x$
101	$x$	$x$	$x$	$x$
100	0	0	0	0

$P_3P_2P_1 \backslash P_0X$	00	01	11	10
000	0	1	1	0
001	1	0	1	0
011	0	0	0	0
010	0	0	1	0
110	$x$	$x$	$x$	$x$
111	$x$	$x$	$x$	$x$
101	$x$	$x$	$x$	$x$
100	1	0	1	0

$P_3P_2P_1 \backslash P_0X$	00	01	11	10
000	0	1	1	0
001	0	1	1	0
011	1	0	0	1
010	1	0	1	0
110	$x$	$x$	$x$	$x$
111	$x$	$x$	$x$	$x$
101	$x$	$x$	$x$	$x$
100	0	1	0	0

$P_3P_2P_1 \backslash P_0X$		$P_0X$			
		00	01	11	10
000	0	0	1	1	
001	1	1	0	0	
011	1	1	1	1	
010	0	0	1	1	
110	$x$	$x$	$x$	$x$	
111	$x$	$x$	$x$	$x$	
101	$x$	$x$	$x$	$x$	
100	1	1	1	0	

## Boolean expressions

The boolean expressions for **S** and **Z** are:

$$\begin{aligned}
S_3 &= P_2P'_0 + P_2P'_1X' + P'_2P_1P_0X' \\
S_2 &= P'_2P_1P'_0 + P'_2P_1X + P'_3P'_2P'_1X' + P_2P'_1P_0X \\
S_1 &= P'_2P_0X + P'_1P_0X + P_3P'_0X' + P'_3P'_2P'_1X + P'_2P_1P'_0X' \\
S_0 &= P'_3P'_2X + P'_2P'_0X + P_2P'_0X' + P_2P_1X' + P'_3P'_1P_0X \\
Z &= P_1P'_0 + P_2P_0 + P_3P'_0 + P_3X + P'_3P'_1P_0
\end{aligned}$$

## Software

Make the connections and connect the Vaman board to the PC via USB. In the location of choice, type the below commands

1. `svn co https://github.com/Muhammed-Hamdan/iith-fwc-2022-23/trunk/fwc_arm/assignment`
2. `cd pw_modulator/GCC_Project/`
3. `make`
4. `cd ../..`
5. `bash scp_send.sh pw_modulator`