



Digital Design of an Automated Irrigation System

ENGG 121.02-A
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Background



- Create an automatic irrigation system that would turn on two times a day.
- The user can set the times for watering.
- The irrigation system would not start through the user set times if it had already rained that day.
- However, the user can also start the automated irrigation system manually.
- If the plants' soil is super dry, the system should open.



Limitations/Assumptions

01

Soil Moisture Sensors

Returns 5 Volt signal to the System to the “Dry Land?” input

02

User Set Times

Two times for irrigation

03

Clock Circuit

Synchronized with the user’s time zone



Take Note!

04

Frequency of Clocks

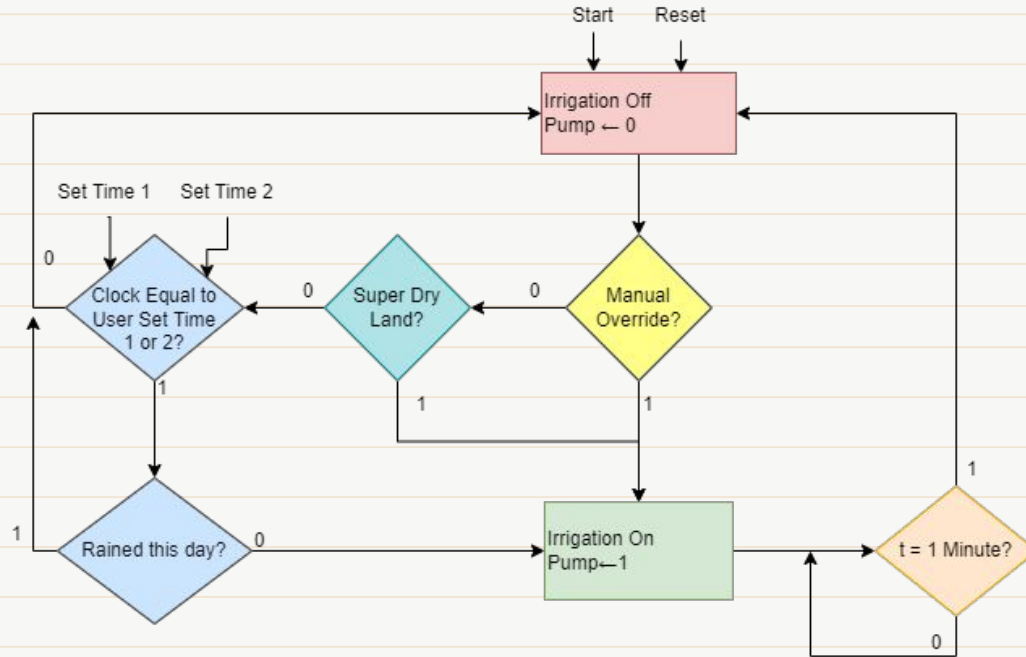
4 times faster than a second

05

Rain

Assume that it would be heavy rain

ASM Diagram






1

Circuit Parts

3 Parts: Pump System, Clock Comparator, Rain
Checker





Pump System and Countdown Subsystem

Pump System: The brain of the whole circuit, taking all of the inputs considered in the ASM diagram

Countdown Subsystem: Resets the Pump System after turning on at a certain time (60 seconds)

Pump System Transition Table

Present State	Inputs					Next State	Flip-Flop Inputs		
	Manual Override	Super Dry?	Time Equal?	Did it Rain Today?	Minute passed?		D	J	K
A	B	C	D	E	F		D	J	K
0	1	x	x	x	x	1	1	1	x
0	0	1	x	x	x	1	1	1	x
0	0	0	1	0	x	1	1	1	x
0	0	0	1	1	x	0	0	0	x
1	x	x	x	x	0	1	1	x	0
1	x	x	x	x	1	0	0	x	1





Why are
there D and
JK flip-flops?

Note:

There are different kinds of flip-flops. Let's see which one is better for implementation!

D Input Equation for Pump System

		<i>EF</i>			
		00	01	11	10
<i>CD</i>	00	0	0	0	0
	01	1	1	0	0
	11	1	1	1	1
	10	1	1	1	1
		<i>AB = 00</i>			

		<i>EF</i>			
		00	01	11	10
<i>CD</i>	00	1	1	1	1
	01	1	1	1	1
	11	1	1	1	1
	10	1	1	1	1
		<i>AB = 01</i>			

$$D_{\text{Pump}} = A'DE' + A'B + A'C + AF'$$

		<i>EF</i>			
		00	01	11	10
<i>CD</i>	00	1	0	0	1
	01	1	0	0	1
	11	1	0	0	1
	10	1	0	0	1
		<i>AB = 10</i>			

		<i>EF</i>			
		00	01	11	10
<i>CD</i>	00	1	0	0	1
	01	1	0	0	1
	11	1	0	0	1
	10	1	0	0	1
		<i>AB = 11</i>			

J Input Equation for Pump System

		EF			
		00	01	11	10
CD	00	0	0	0	0
	01	1	1	0	0
	11	1	1	1	1
	10	1	1	1	1

$AB=00$

		EF			
		00	01	11	10
CD	00	1	1	1	1
	01	1	1	1	1
	11	1	1	1	1
	10	1	1	1	1

$AB=01$

$$J_{\text{Pump}} = B + C + DE'$$

		EF			
		00	01	11	10
CD	00	X	X	X	X
	01	X	X	X	X
	11	X	X	X	X
	10	X	X	X	X

$AB=10$

		EF			
		00	01	11	10
CD	00	X	X	X	X
	01	X	X	X	X
	11	X	X	X	X
	10	X	X	X	X

$AB=11$

K Input Equation for Pump System

		<i>EF</i>			
		00	01	11	10
<i>CD</i>	00	X	X	X	X
	01	X	X	X	X
	11	X	X	X	X
	10	X	X	X	X
		<i>AB = 00</i>			

		<i>EF</i>			
		00	01	11	10
<i>CD</i>	00	X	X	X	X
	01	X	X	X	X
	11	X	X	X	X
	10	X	X	X	X
		<i>AB = 01</i>			

$$K_{\text{Pump}} = F$$

		<i>EF</i>			
		00	01	11	10
<i>CD</i>	00	X	1	1	0
	01	0	1	1	0
	11	0	1	1	0
	10	0	1	1	0
		<i>AB = 10</i>			

		<i>EF</i>			
		00	01	11	10
<i>CD</i>	00	0	1	1	0
	01	0	1	1	0
	11	0	1	1	0
	10	0	1	1	0
		<i>AB = 11</i>			

Countdown Subsystem Transition Table

Present State	Inputs			Next State	Outputs		Flip-Flop Inputs		
	Pump System	RCO' Left Counter	RCO' Right Counter		Q	Q'			
G	H	I	J		Q	Q'	D	J	K
0	0	x	x				0	0	x
0	1	1	x				0	0	x
0	1	x	1				0	0	x
0	1	0	0				1	1	x
1	x	x	x				0	x	1

D Input Equation for Countdown Subsystem

		<i>IJ</i>			
		00	01	11	10
<i>GH</i>	00	0	0	0	0
	01	1	0	0	0
	11	0	0	0	0
	10	0	0	0	0

$$D_{\text{Countdown}} = G'HI'J'$$

J Input Equation for Countdown Subsystem

		<i>IJ</i>			
		00	01	11	10
<i>GH</i>	00	0	0	0	0
	01	1	0	0	0
	11	x	x	x	x
	10	x	x	x	x

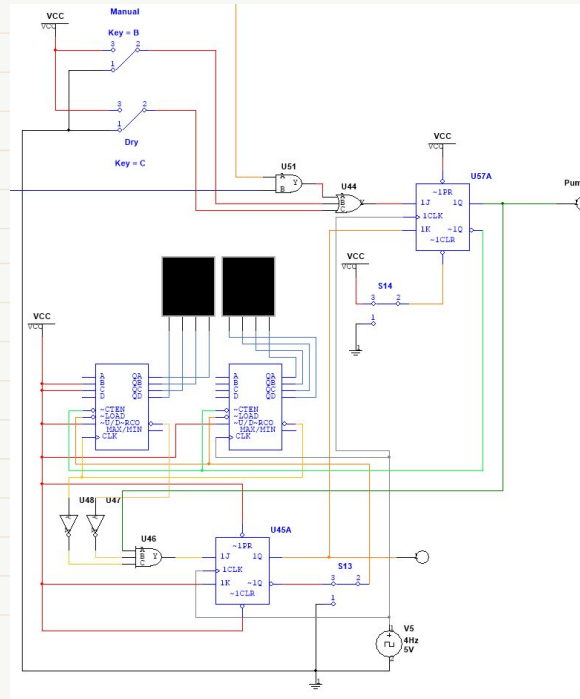
$$J_{\text{Countdown}} = HI'J'$$

K Input Equation for Countdown Subsystem

		IJ			
		00	01	11	10
GH	00	x	x	x	x
	01	x	x	x	x
	11	1	1	1	1
	10	1	1	1	1

$$K_{\text{Countdown}} = 1$$

JK Flip-Flop Implementation of Pump System





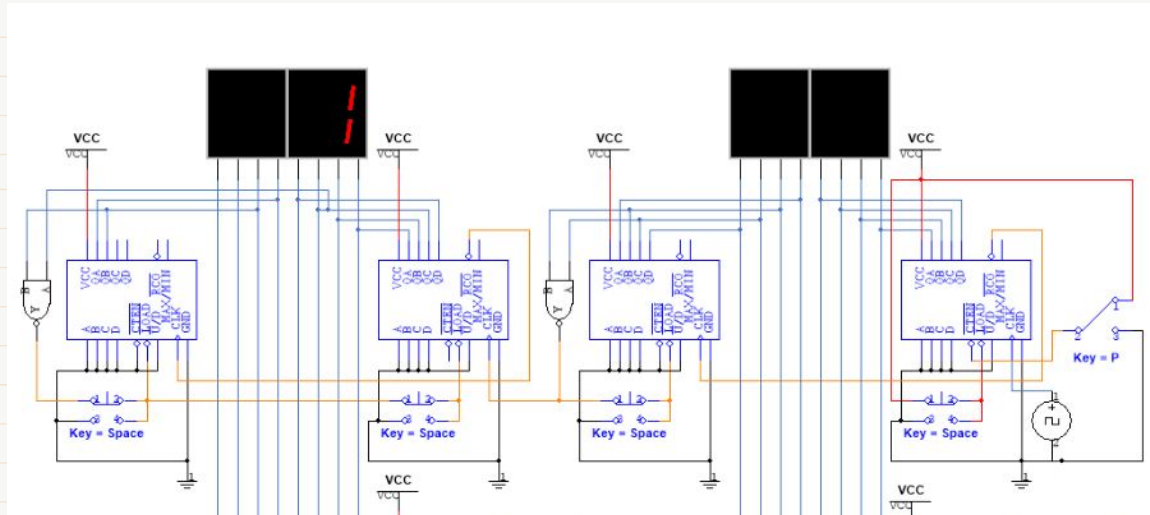
Time Comparator

Clock Circuit: 24 hour clock

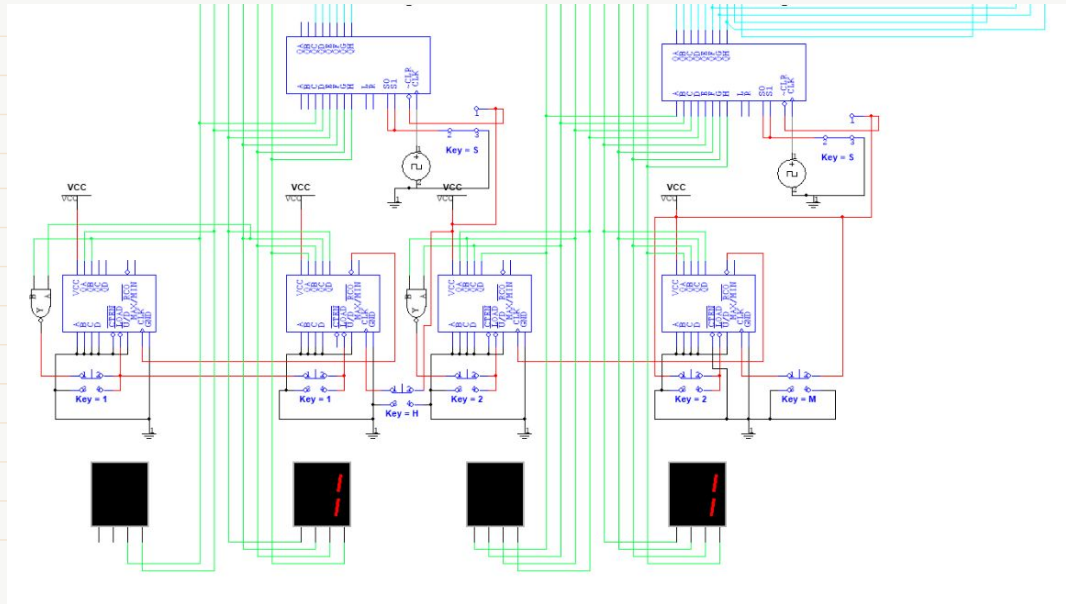
User Input Circuit: Stores the two user set times for the system to trigger

Comparator Network: Compare the user set time with the current time

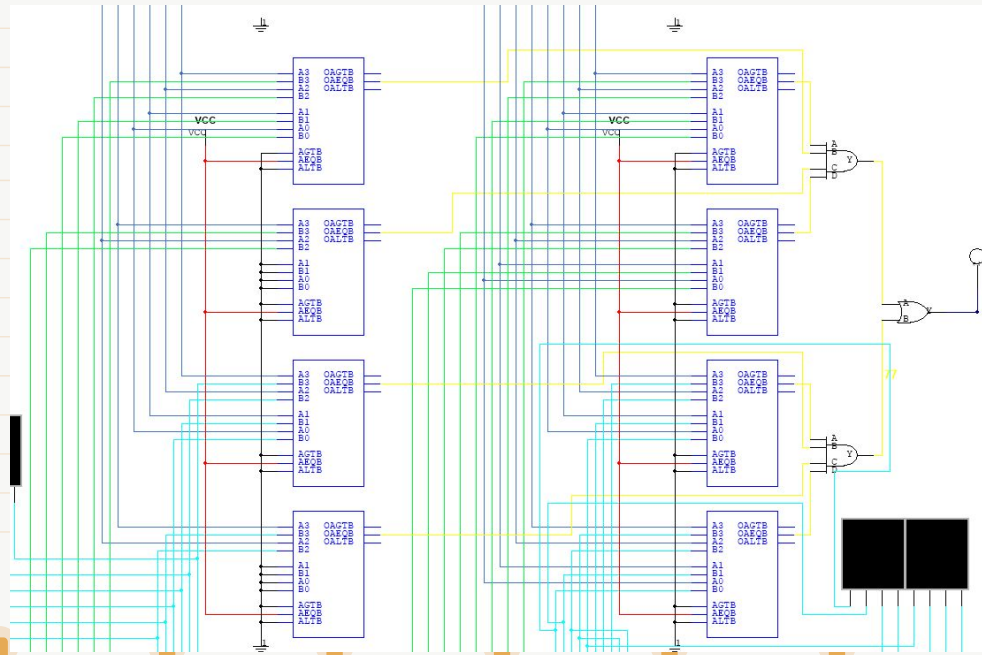
Clock Circuit



User Input Circuit



Comparator Network



XNOR Truth Table

Inputs		Output
A	B	Q
0	0	1
0	1	0
1	0	0
1	1	1

A dark brown rectangular title card with the text "Rain Checker" in a white serif font. The card is placed on a white notepad with horizontal lines. Two yellow sticky notes are attached to the card: one at the top-left corner and one at the bottom-right corner. The notepad is framed by a thick dark blue border. At the bottom of the notepad, there are eight yellow binder rings.

Rain Checker

Turns on when it rains, resets when it's a
new day (00:00)

Rain Checker Transition Table

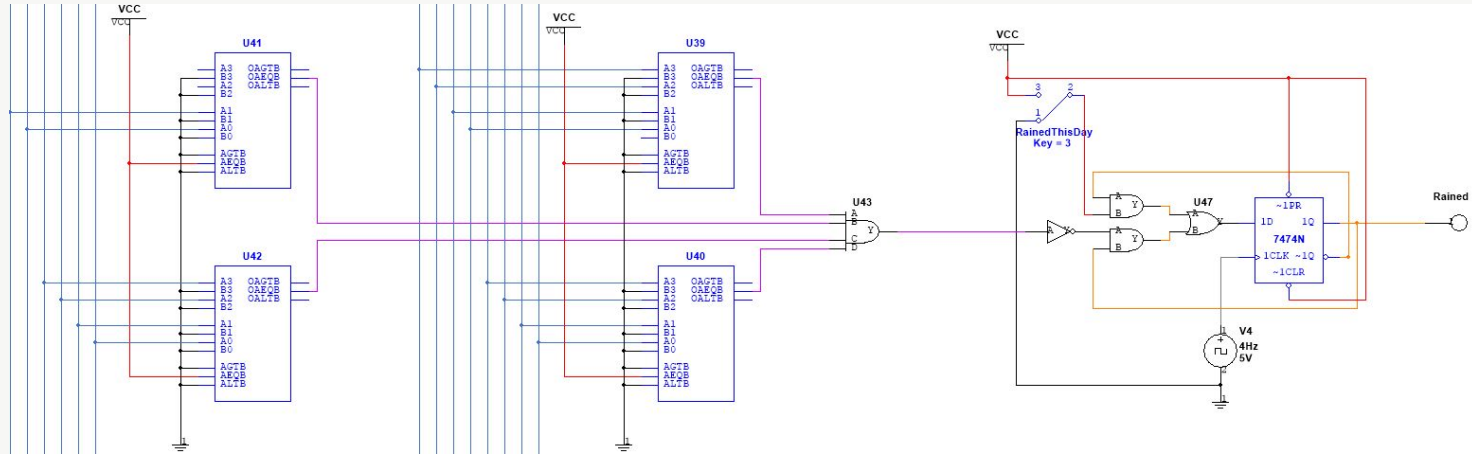
Present State	Inputs		Next State	Flip-Flop Inputs		
	Rained this day?	New Day? (00:00)		D	J	K
L	M	N		D	J	K
0	0	x	0	0	0	x
0	1	x	1	1	1	x
1	x	0	1	1	x	0
1	x	1	0	0	x	1

K-Map for the D Input in the Rain Checker Component

		<i>MN</i>			
		00	01	11	10
<i>L</i>	0	0	0	1	1
	1	1	0	0	1

$$D_{\text{RainChecker}} = L'M + LN'$$

D Flip-Flop Implementation of the Rain Checker Component



K-Map for the J Input in the Rain Checker Component

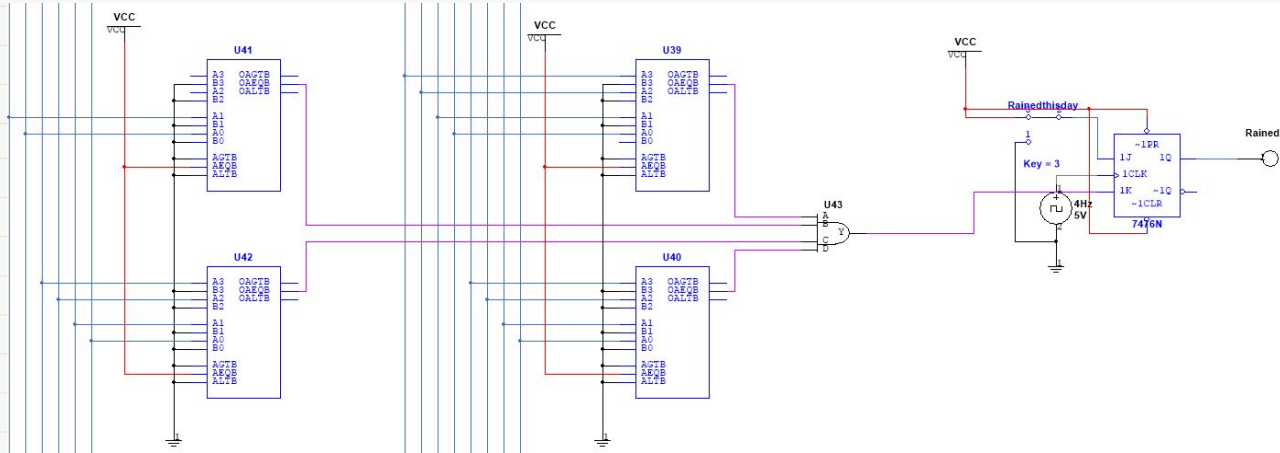
		MN			
		00	01	11	10
L	0	0	0	1	1
	1	X	X	X	X

$$J_{\text{RainChecker}} = M$$

K-Map for the K Input in the Rain Checker Component

		MN			
		00	01	11	10
L	0	X	X	X	X
	1	0	1	1	0

$$K_{\text{RainChecker}} = N$$





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Summary of Components Used

List of Components Used

D Flip-Flop Implementation:

- 47 Components
- 37 Maximum ICs*

JK Flip-Flop Implementation:

- 42 Components
- 35 Maximum ICs*

*Can be reduced if unused pins from the same logic ICs are utilized





D Flip-Flop vs. JK Flip-Flop

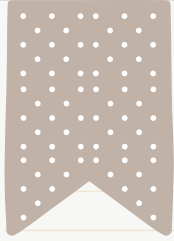
D Flip-Flop: Single input, more logic gates

JK Flip-Flop: Dual inputs, less logic gates

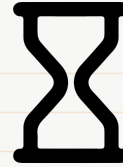
Demo

Please access through this link:

https://drive.google.com/open?id=1vpk_BQwCoJVbskxiH2nn7gVLiqg-VNsp&authuser=andreas.diaz%40obf.ateneo.edu&usp=drive_fs



Recommendations for Improvement



**User-Settable
Countdown System**



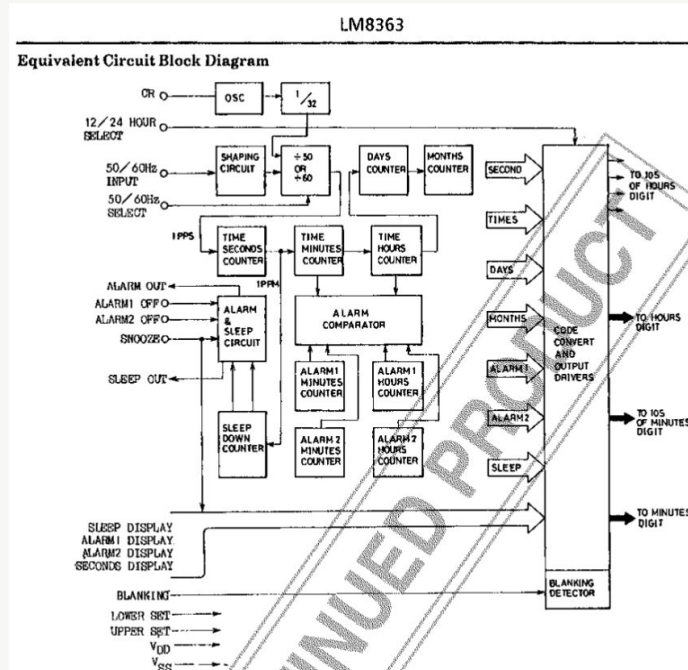
**5-Second Wait for
Manual Override**



**Use an Alarm
Clock IC**

If available*

LM8363D - Dual Alarm Clock IC





Thank You!