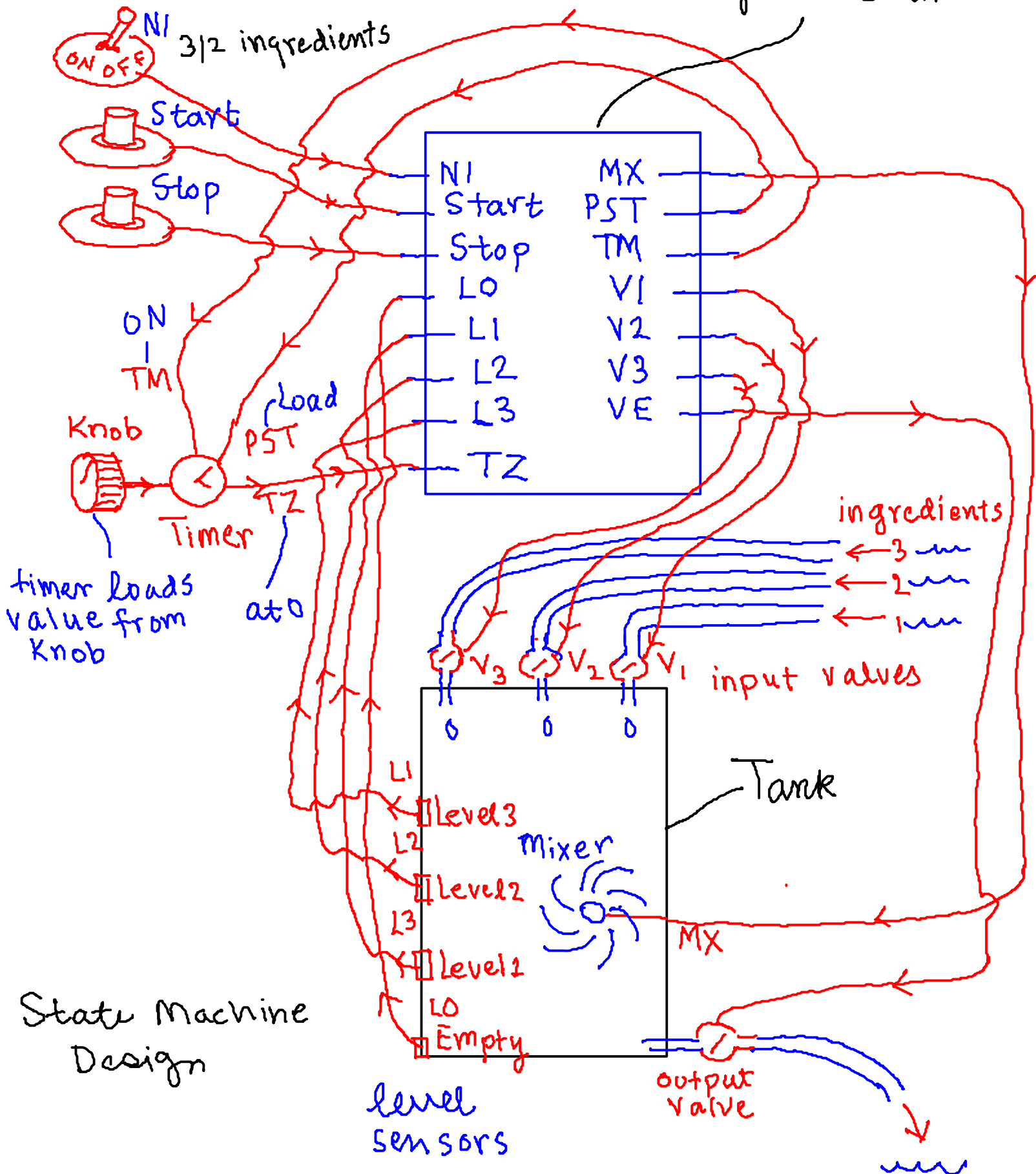


Batch Mixing System Control

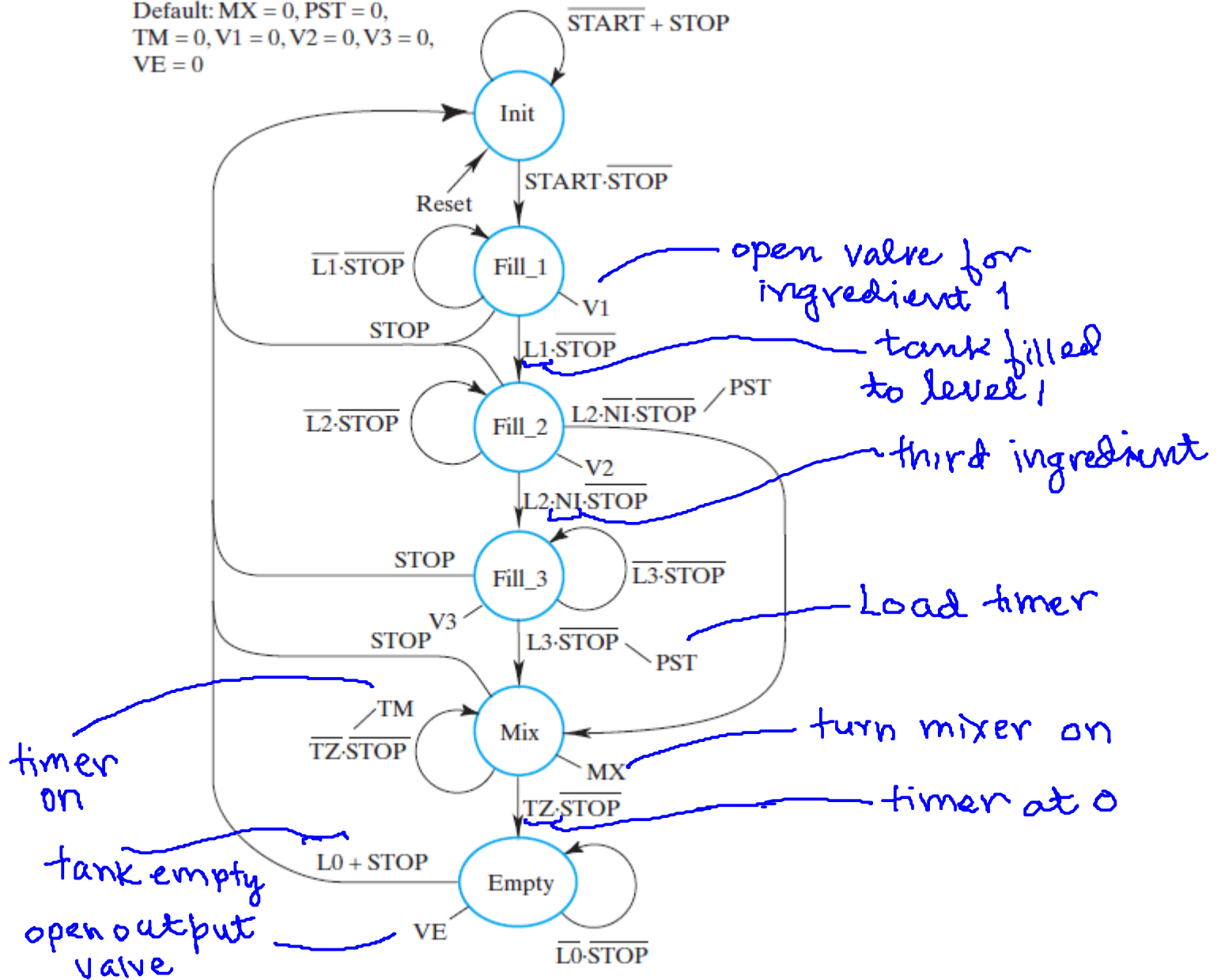


Input and Output Variables for the Batch Mixing System

Input	Meaning for Value 1	Meaning for Value 0*
NI	Three ingredients	Two ingredients
Start	Start a batch cycle	No action
Stop	Stop an on-going batch cycle	No action
L0	Tank empty	Tank not empty
L1	Tank filled to level 1	Tank not filled to level 1
L2	Tank filled to level 2	Tank not filled to level 2
L3	Tank filled to level 3	Tank not filled to level 3
TZ	Timer at value 0	Timer not at value 0

Output	Meaning for Value 1	Meaning for Value 0
MX	Mixer on	Mixer off
PST	Load timer with value from D	No action
TM	Timer on	Timer off
V1	Valve open for ingredient 1	Valve closed for ingredient 1
V2	Valve open for ingredient 2	Valve closed for ingredient 2
V3	Valve open for ingredient 3	Valve closed for ingredient 3
VE	Output valve open	Output valve closed

Default: $MX = 0, PST = 0,$
 $TM = 0, V1 = 0, V2 = 0, V3 = 0,$
 $VE = 0$



State Machine Diagram

State	State Code	Transition Condition	Next State	State Code	Non-zero Outputs Including Mealy Outputs Using TCs*	
Init	100000	$\overline{\text{START}} + \text{STOP}$	Init	100000		
		$\text{START} \cdot \overline{\text{STOP}}$	Fill_1	010000		
Fill_1	010000	STOP	Init	100000	V1	
		$\overline{\text{L1}} \cdot \overline{\text{STOP}}$	Fill_1	010000		
		$\text{L1} \cdot \overline{\text{STOP}}$	Fill_2	001000		
Fill_2	001000	STOP	Init	100000	V2	
		$\overline{\text{L2}} \cdot \overline{\text{STOP}}$	Fill_2	001000		
		$\text{L2} \cdot \overline{\text{NI}} \cdot \overline{\text{STOP}}$	Mix	000010		PST*
		$\text{L2} \cdot \text{NI} \cdot \overline{\text{STOP}}$	Fill_3	000100		
Fill_3	000100	STOP	Init	100000	V3	
		$\overline{\text{L3}} \cdot \overline{\text{STOP}}$	Fill_3	000100		
		$\text{L3} \cdot \overline{\text{STOP}}$	Mix	000010		PST*
Mix	000010	STOP	Init	100000	MX	
		$\overline{\text{TZ}} \cdot \overline{\text{STOP}}$	Mix	000010		TM*
		$\text{TZ} \cdot \overline{\text{STOP}}$	Empty	000001		
Empty	000001	$\overline{\text{LO}} \cdot \overline{\text{STOP}}$	Empty	000001	VE	
		$\text{LO} + \text{STOP}$	Init	100000		

FF input equations:

$$\begin{aligned}
 \text{Init}^+ &= \text{Init} \cdot \overline{\text{START}} + \text{Init} \text{ STOP} \\
 &+ \text{Fill}_1 \cdot \text{STOP} \\
 &+ \text{Fill}_2 \text{ STOP} \\
 &+ \text{Fill}_3 \text{ STOP} \\
 &+ \text{Mix} \text{ STOP} \\
 &+ \text{Empty} \cdot \text{LO} + \text{Empty} \text{ STOP}
 \end{aligned}$$

$$\underbrace{\text{Init} + \text{Fill}_1 + \text{Fill}_2 + \text{Fill}_3 + \text{Mix} + \text{Empty}} = 1$$

system has to be in some state

$$\text{Init}^+ = \text{Init} \cdot \overline{\text{START}} + \text{STOP} + \text{Empty} \cdot \text{LO}$$

$$\text{Fill}_1^+ = \text{Init} \cdot \text{START} \cdot \overline{\text{STOP}} + \text{Fill}_1 \cdot \overline{\text{L1}} \cdot \overline{\text{STOP}}$$

$$\text{Fill}_2^+ = \text{Fill}_1 \cdot \text{L1} \cdot \overline{\text{STOP}} + \text{Fill}_2 \cdot \overline{\text{L2}} \cdot \overline{\text{STOP}}$$

$$\text{Fill}_3^+ = \text{Fill}_2 \cdot \text{L2} \cdot \overline{\text{N1}} \cdot \overline{\text{STOP}} + \text{Fill}_3 \cdot \overline{\text{L3}} \cdot \overline{\text{STOP}}$$

$$\text{Mix}^+ = \text{Fill}_2 \cdot \text{L2} \cdot \overline{\text{N1}} \cdot \overline{\text{STOP}} + \text{Fill}_3 \cdot \text{L3} \cdot \overline{\text{STOP}} + \text{Mix} \cdot \overline{\text{TZ}} \cdot \overline{\text{STOP}}$$

$$\text{Empty}^+ = \text{Mix} \text{ TZ} \cdot \overline{\text{STOP}} + \text{Empty} \cdot \overline{\text{LO}} \cdot \overline{\text{STOP}}$$

output equations

$$V1 = \text{Fill}_1$$

$$V2 = \text{Fill}_2$$

$$V3 = \text{Fill}_3$$

$$PST = \text{Fill}_2 \cdot L2 \cdot \overline{N1} \cdot \overline{STOP} + \text{Fill}_3 \cdot L3 \cdot \overline{STOP} \quad X_1$$

$$MX = \text{Mix}$$

$$TM = \text{Mix} \cdot TZ \cdot \overline{STOP} \quad X_2$$

Exercise: Draw the circuit