Workshop Basic Arduino Class 4 – I/O Table and Finite State Machines

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Contenidos

1. I/O Table.
2. Finite States Machines.

Input and Outputs Table (I/O Table)

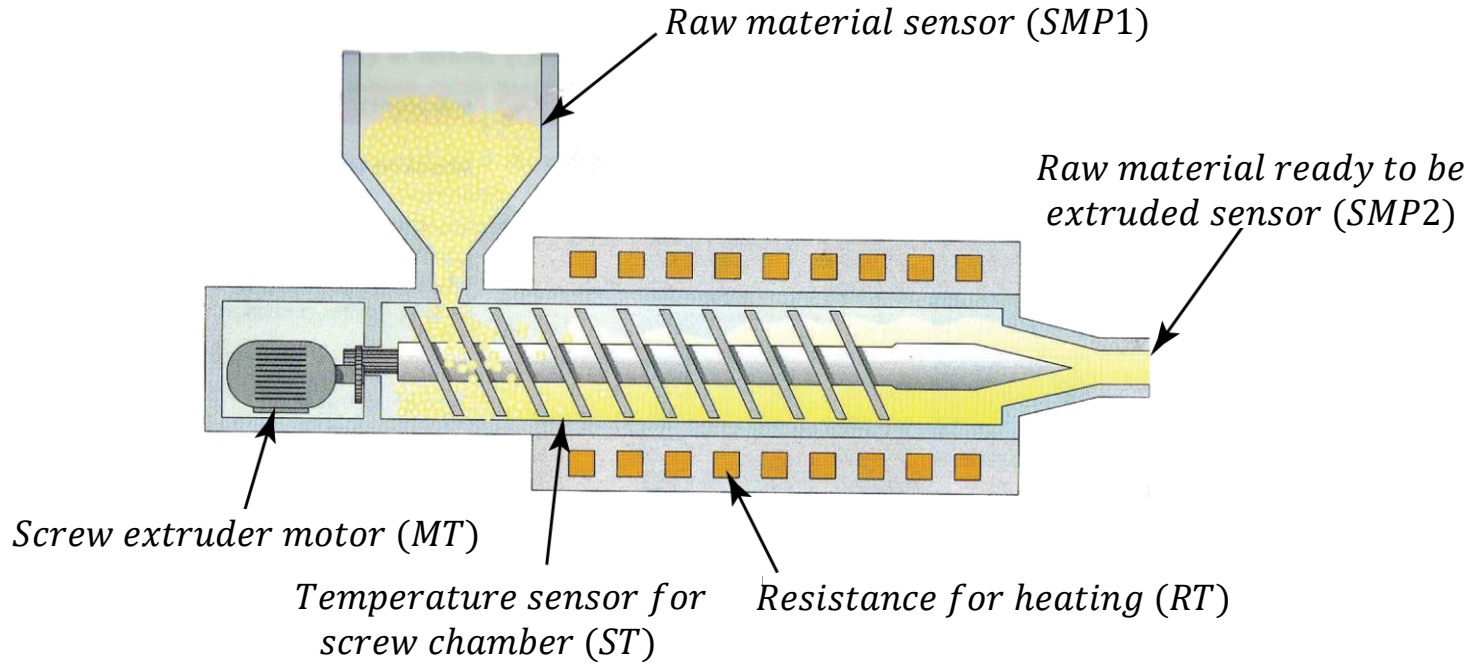
- Very usefull for **identifying** the **I/O** in an industrial process.
- Allows any user to clearly recognize a **variable** used in a Flowchart, Pseudocode, Finite State Machine or direct code.
- Is the **first step** when creating an **algorithm** that will be used over the **hardware**.

INPUTS			OUTPUTS		
Name	**Description**	**Type**	**Name**	**Description**	**Type**
$SL1$	Level Sensor (NO*)	Boolean (Digital) $(0V\ or\ 5V)$	$L1$	ON state LED indicator	Boolean (Digital) $(0V\ or\ 5V)$
$ST1$	Temperature Sensor	Analog $(0\ to\ 5V)$ $(0º\ to\ 40º)$	$T1$	Internal timer for heating time	Internal Variable
$BTNS$	Start Button (NC**)	Booleana (Digital) $(5V\ or\ 0V)$	$M1$	Output to mixer motor	Analog $(0\ to\ 12V)$ $(0\ to\ 1200\ rpm)$
			$C1$	Internal counter for agitation cycles	Internal Variable

*NO stands for Normally Open
**NC stands for Normally Closed

Example - I/O Table

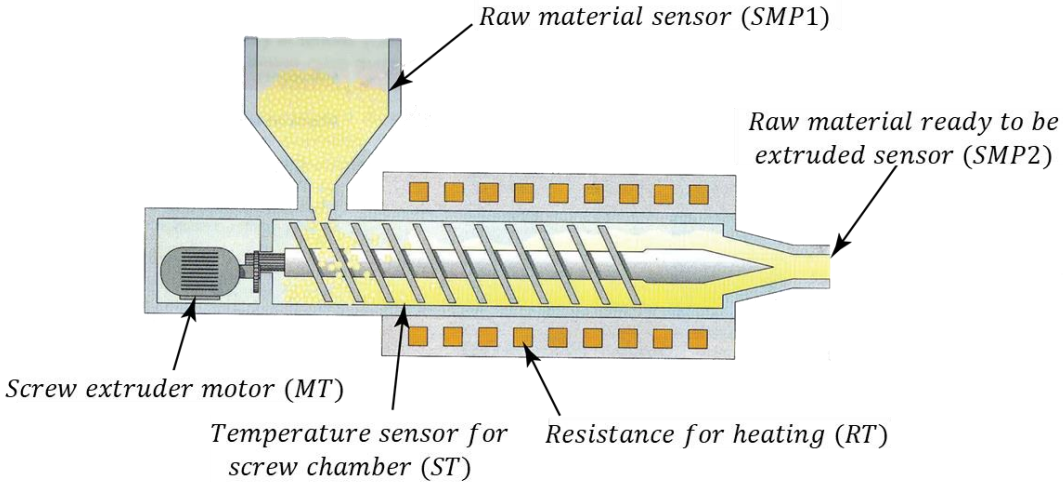
- Identify the I/O table of a plastic injector using the following description:



Start button (bSTART)NO

- The raw material sensor (***SMP1***) is a presence sensor indicating that the raw material reached the optimum level (it's normally open ***NO*** and it only has **two states**: **raw material at optimum level** or **not enough raw material**).
- The raw material to be extruded sensor (***SMP2***) works equal to the SMP1, the difference is that it allows to detect if the melted material already reached the end of the extruder.
- The screw extruder motor (***MT***) allows to rotate the screw extruder in order to deliver the material from the chute to its final part. It only has two states: **OFF** or **ON** and works with 12V.
- The tempearture sensor for screw chamber (***ST***) allows to monitor all the time the temperature of the screw. This sensor has a range from **0° C to 100° C** (0V to 5V voltage)
- The resistance (***RT***) allows to heat the raw material. It can only be in two states: **ON or OFF** and works with 110V AC.

Tabla de entradas y salidas - Ejemplo

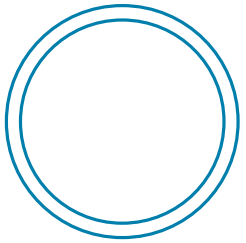
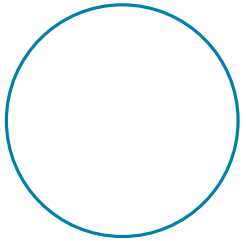


Start button (bSTART)NO

INPUTS			OUTPUTS		
Name	**Description**	**Type**	**Name**	**Description**	**Type**
$bSTART$	Start button (NO)	Boolean (Digital) (0V or 5V)	MT	Motor del tornillo extrusor	Booleana (Digital) (0 or 12V)
$SMP1$	Raw material level sensor (NO)	Boolean (Digital) (0V or 5V)	RT	Resistencia para calentar el tornillo extrusor	Booleana (Digital) (0 or 110 VAC)
$SMP2$	Raw material ready to be extruded sensor (NA)	Boolean (Digital) (0V or 5V)			
ST	Temperature sensor for screw chamber	Analog (0 to 5V) (0° a 100°C)			

Finite states machine for HW (FSM)

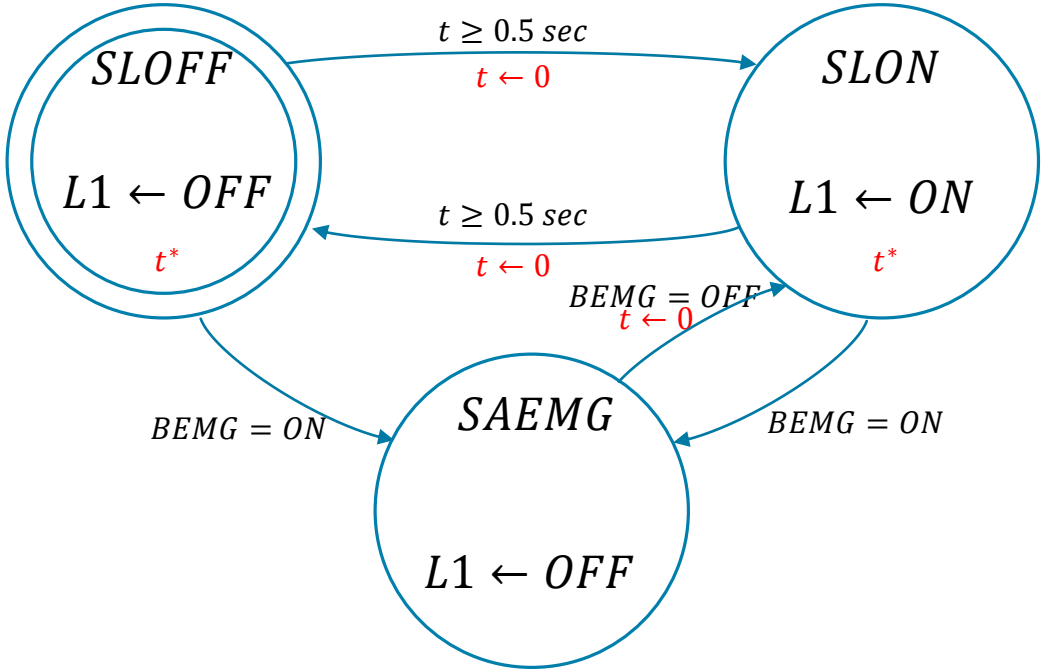
- Mathematical model of computation.
- **Abstract machine** that can be in **one** of a **finite number of states** at **any given time**.
- Can be represented using **state diagrams** to **provide a solution for an engineering problem**.
- It's mainly based in **states** and **transitions depending** to some **conditions** (**external inputs** or **variables changing**).
- In Hardware, it's recommended to **always modify the value of all physical outputs** inside the states to guarantee safety.

Symbol	Name	Description
	Initial state	State in where the program begins with certain initial values in the Outputs
	State	Any given state where some Outputs are assigned with certain value
	Transition	Condition to change from a state "A" to a state "B"

Example 1 - FSM + I/O Table

- Do a program that "blinks" a LED (***L1***) ½ sec ON and ½ sec OFF if the emergency switch (***NO***) has not been activated (***BEMG***). If BEMG is activated, the LED will stay OFF until this switch gets disactivated, where it will return to its normal blinking process.

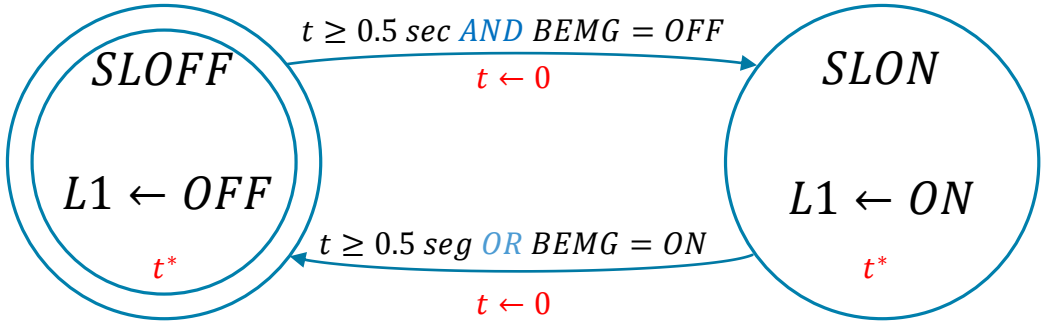
Solution 1



INPUTS			OUTPUTS		
Name	Description	Type	Name	Description	Type
BEMG	Emergency Switch NO	Boolean (Digital)	*L1*	LED	Boolean (Digital)
			t	Timer	Internal Variable

STATE	DESCRIPTION
SLOFF	State LED ON
SLON	State LED OFF
SAEMG	State Emergency Alarm

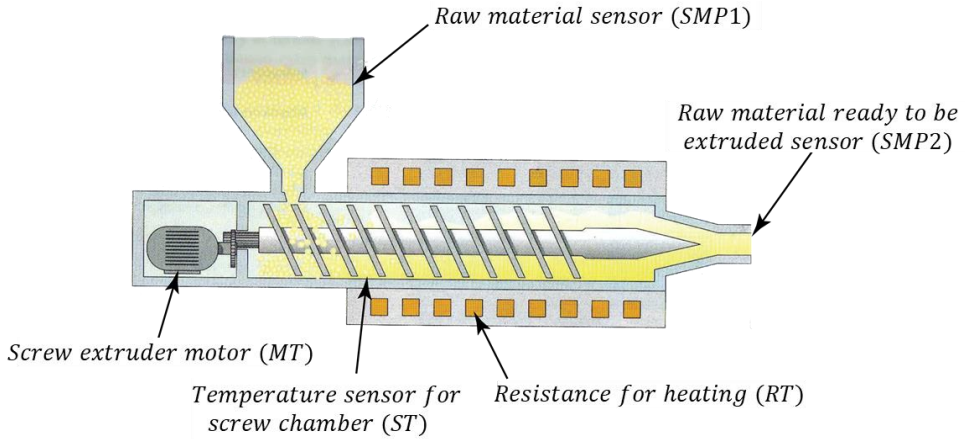
Solution 2



ESTADO	DESCRIPCIÓN
SLOFF	State LED ON
SLON	State LED OFF

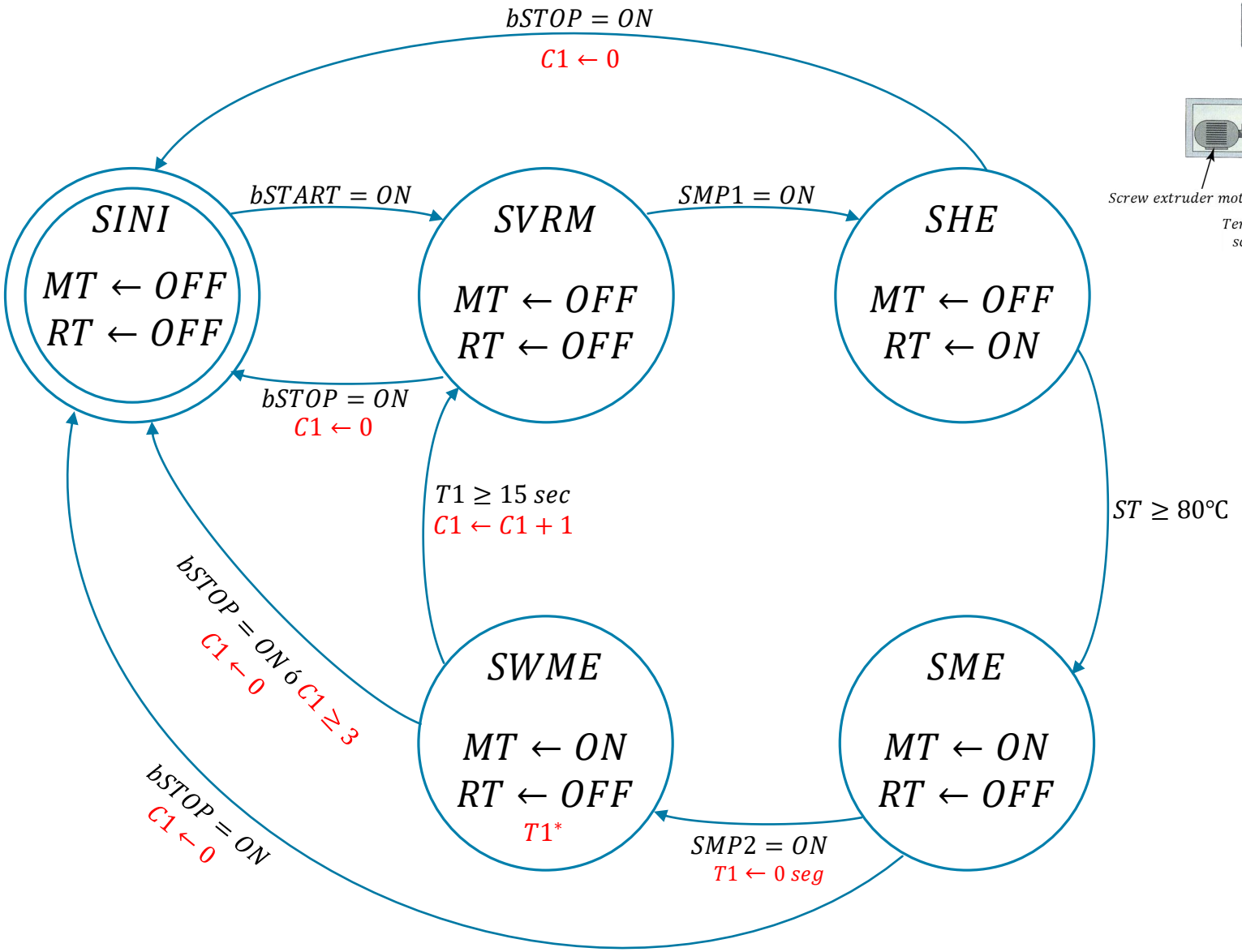
Example 2 – Advanced FSM

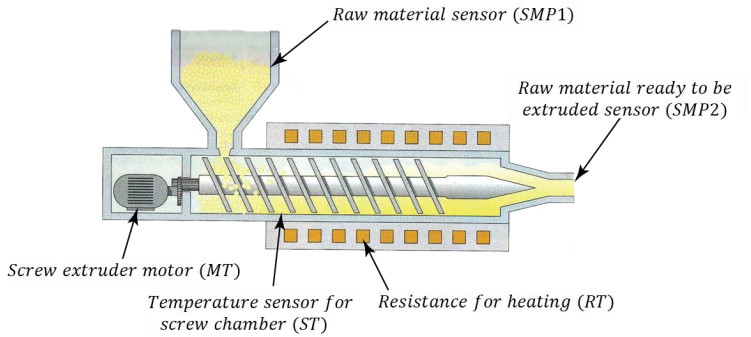
- Do a FSM that controls a basic plastic injector, having in mind the following operation:
  - The injector is completely OFF (***RT*** and ***MT*** OFF) at the beginning.
  - To start the injector, the ***bSTART*** button must be pressed.
  - First, the injector must check that the raw material is at the required level ($\boldsymbol{SMP1} = ON$).
  - Then, the extruder screw needs to be heated using the resistance ***RT*** until it reaches a temperature of $\boldsymbol{80°\ C}$ ($\boldsymbol{ST} \geq 80$)
  - Once the screw is at the required temperature, ***RT*** must be turned OFF and ***MT*** turned ON in order to transport the melted material until the end of the injector.
  - When the melted material reaches the end of the injector ($\boldsymbol{SMP2} = ON$), the injector must wait **15 seconds** and then turn OFF ***MT*** for starting a new injection cycle (from verifying raw material level step).
  - If in any moment the ***bSTOP*** button is pressed, the machine returns to the initial state.
  - Add a counter (***C1***, Internal Variable) to check if the injection process has compleated more than **3 injection cycles**. If this is true, then the machine must return to the initial state.



3 injected pieces

Example 2 – Advanced FSM





STATE	DESCRIPTION
SINI	Initial State
SVRM	State Verify Raw Material Level
SHE	State heat extruder screw
SME	State move extruder screw
SWME	State wait melted material to be extruded

Thanks!