Modeling and Automation of Industrial Processes

Modelação e Automação de Processos Industriais / MAPI

GRAFCET
(Sequential Function Chart, SFC) 3/3

http://www.isr.tecnico.ulisboa.pt/~jag/courses/mapi2223

Prof. José Gaspar, rev. 2022/2023

GRAFCET vs Ladder

GRAFCET/SFC can be converted directly to ladder logic

Memory variables:

Assign one Boolean variable to each step (s_i) and transition (t_j)

Code to run once:

1. Initialize steps and transitions

Code to run at **every scan cycle**:

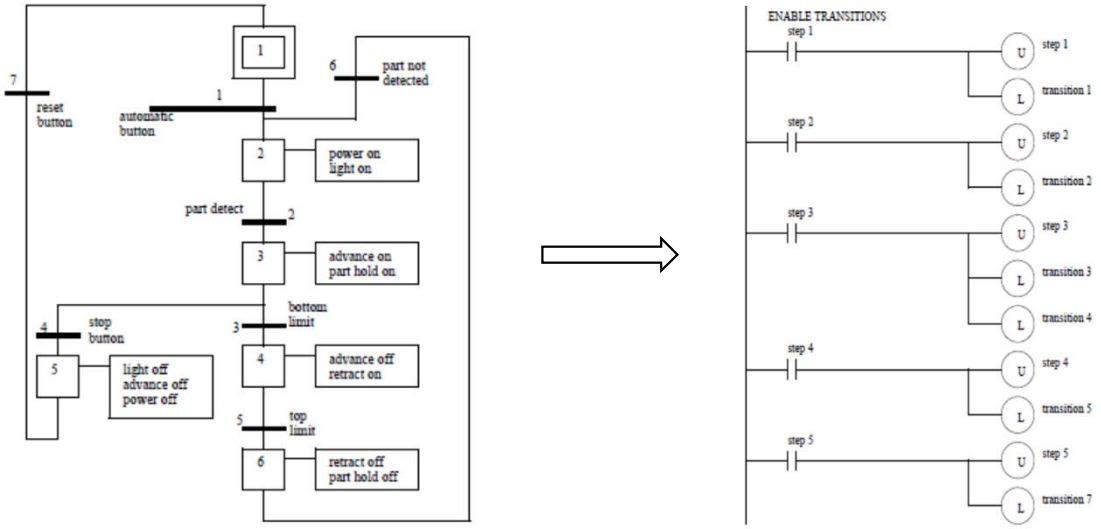
2. Check transitions and activate steps
3. Perform activities for steps
4. Enable transitions (jump to 2.)

Ref: [Hugh Jack 2008]

GRAFCET/SFC vs Ladder

GRAFCET/SFC can be converted directly to ladder logic

Ref: [Hugh Jack 2008]



Memory variables:

Assign one Boolean variable to each step (s_i) and transition (t_j).

Create memories to keep output values.

Code to run once:

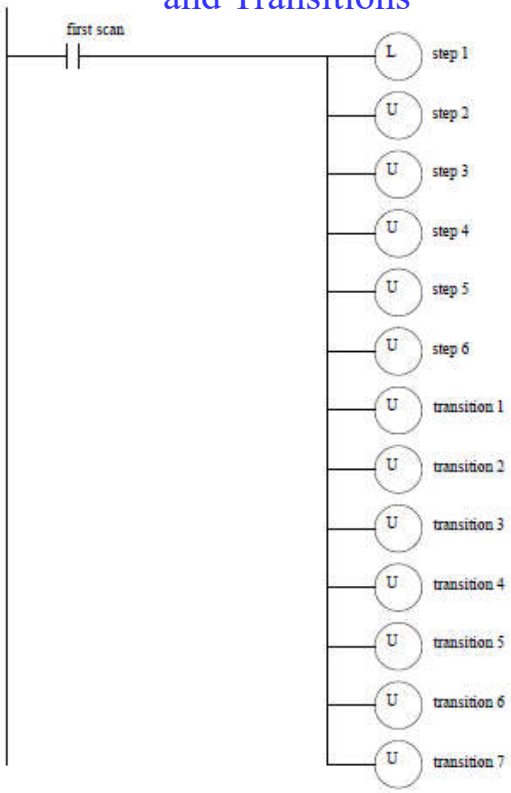
1. Initialize steps and transitions

Code to run at **every scan cycle**:

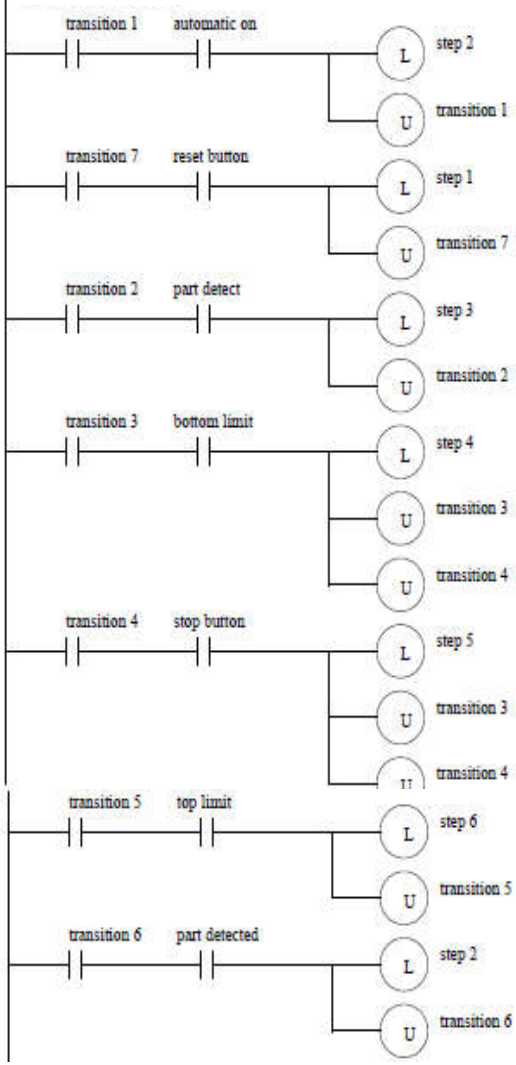
2. Check transitions and activate steps
3. Perform activities for steps
4. Enable transitions (jump to 2.)

The complete program, four sections *(to see separately in the next slides)*:

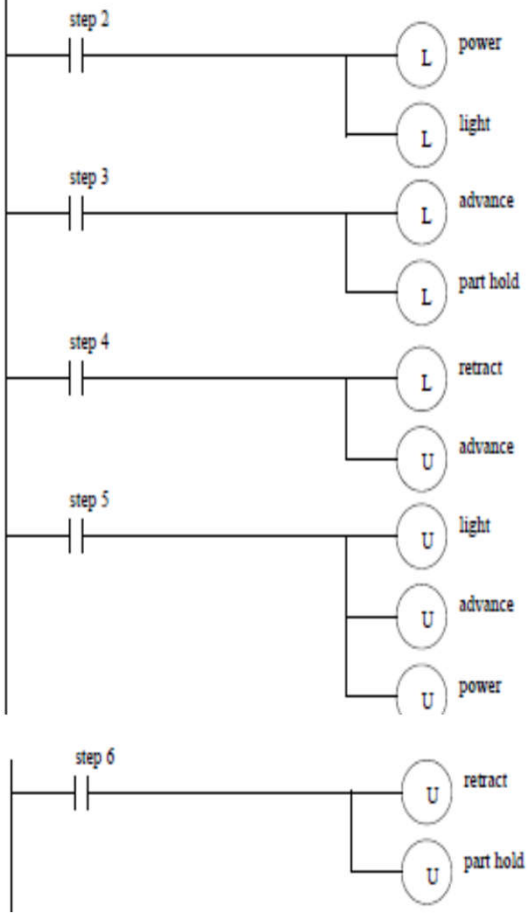
1. Initialize Steps and Transitions



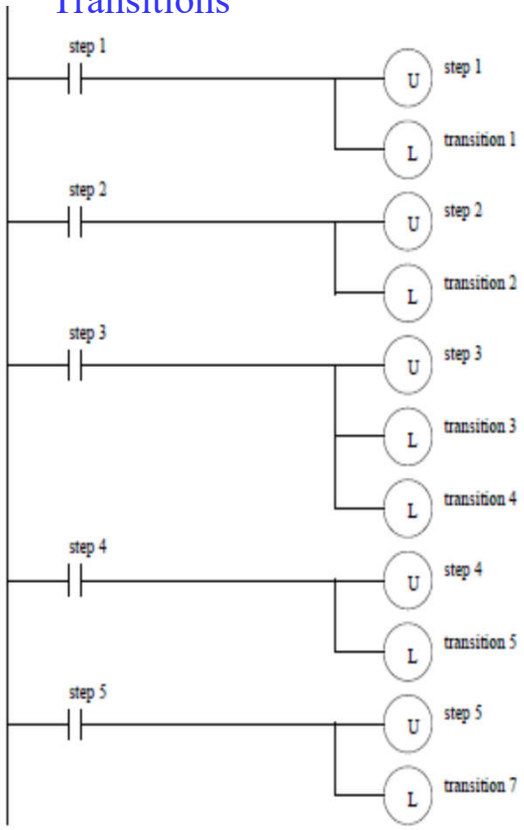
2. Check Transitions



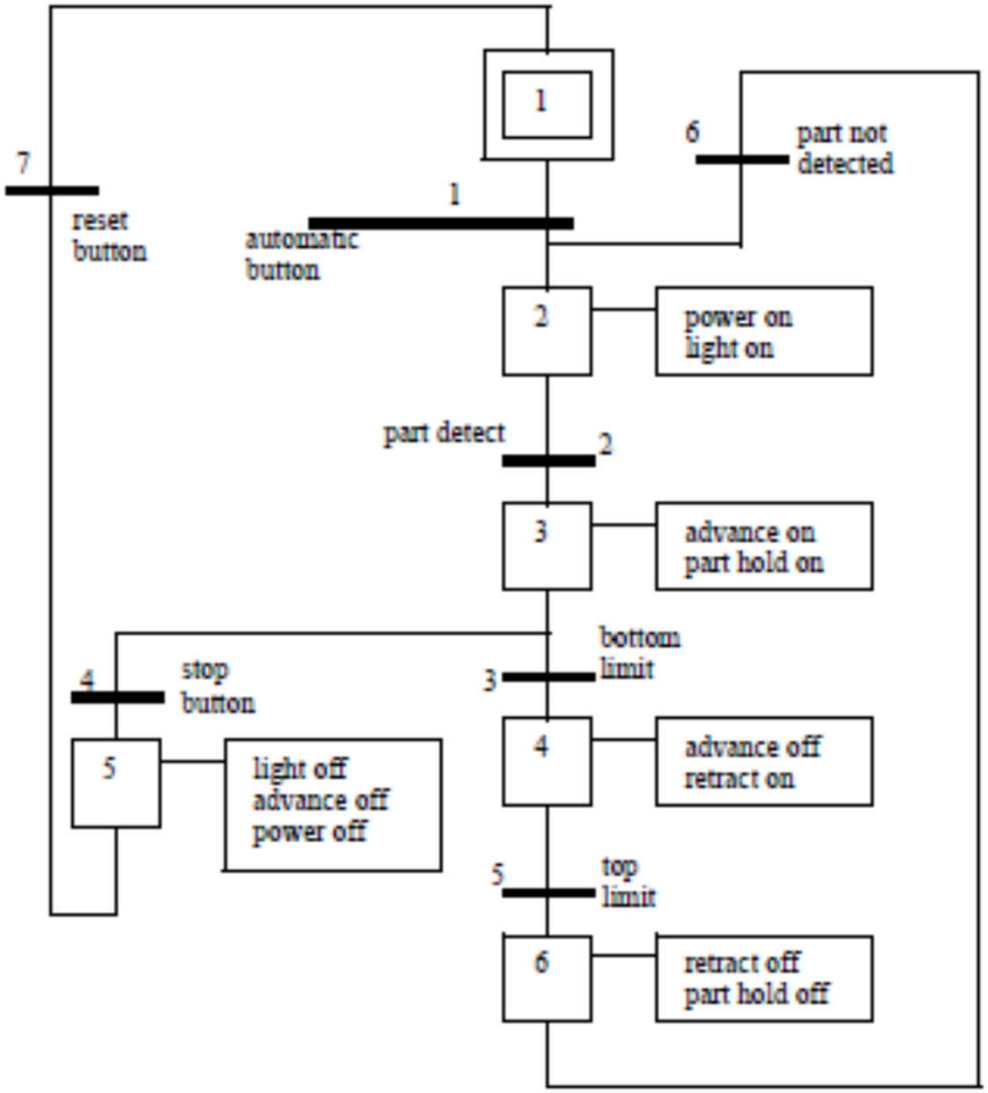
3. Perform Activities for Steps

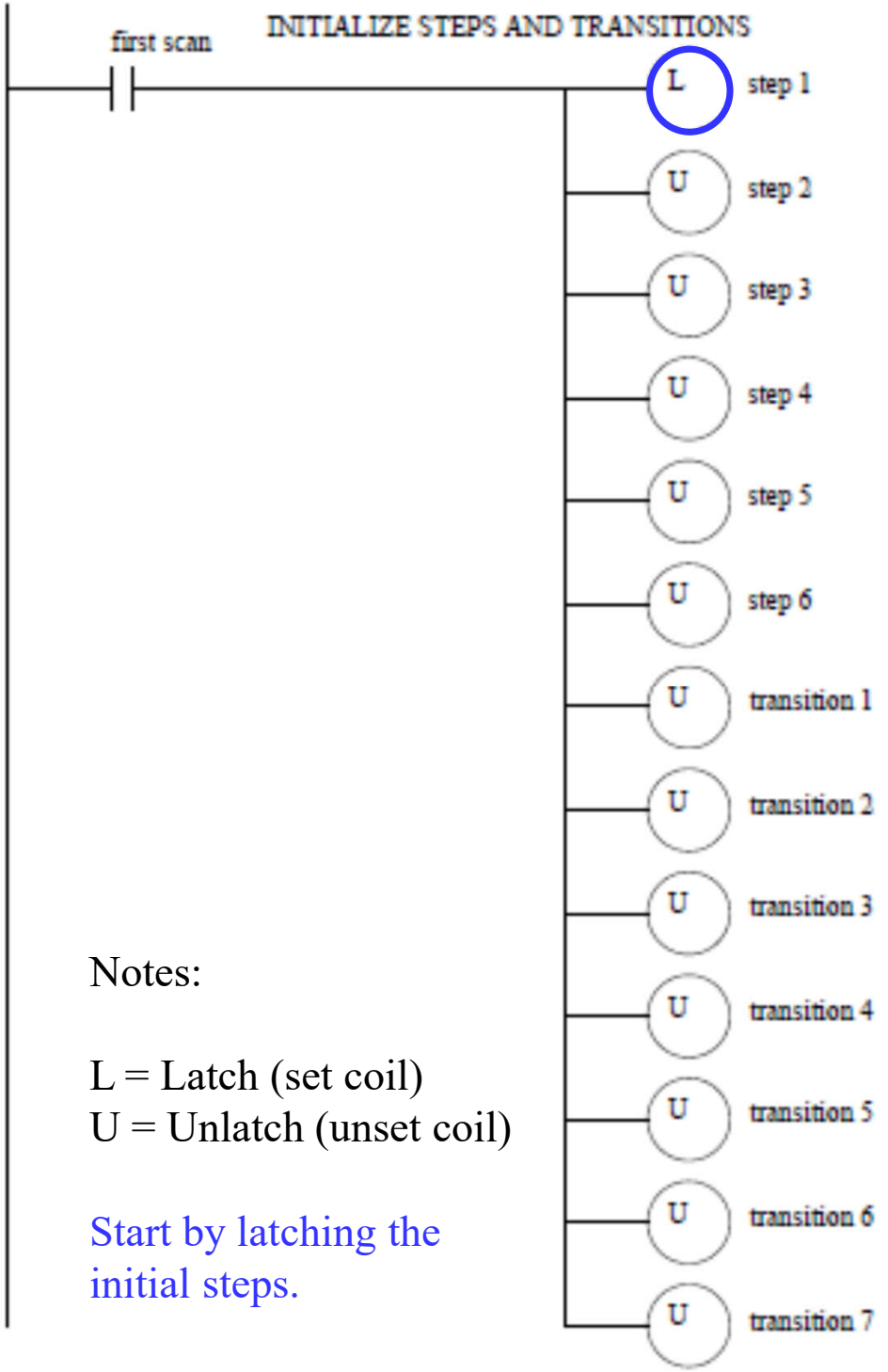


4. Enable Transitions



1. Initialize steps and transitions



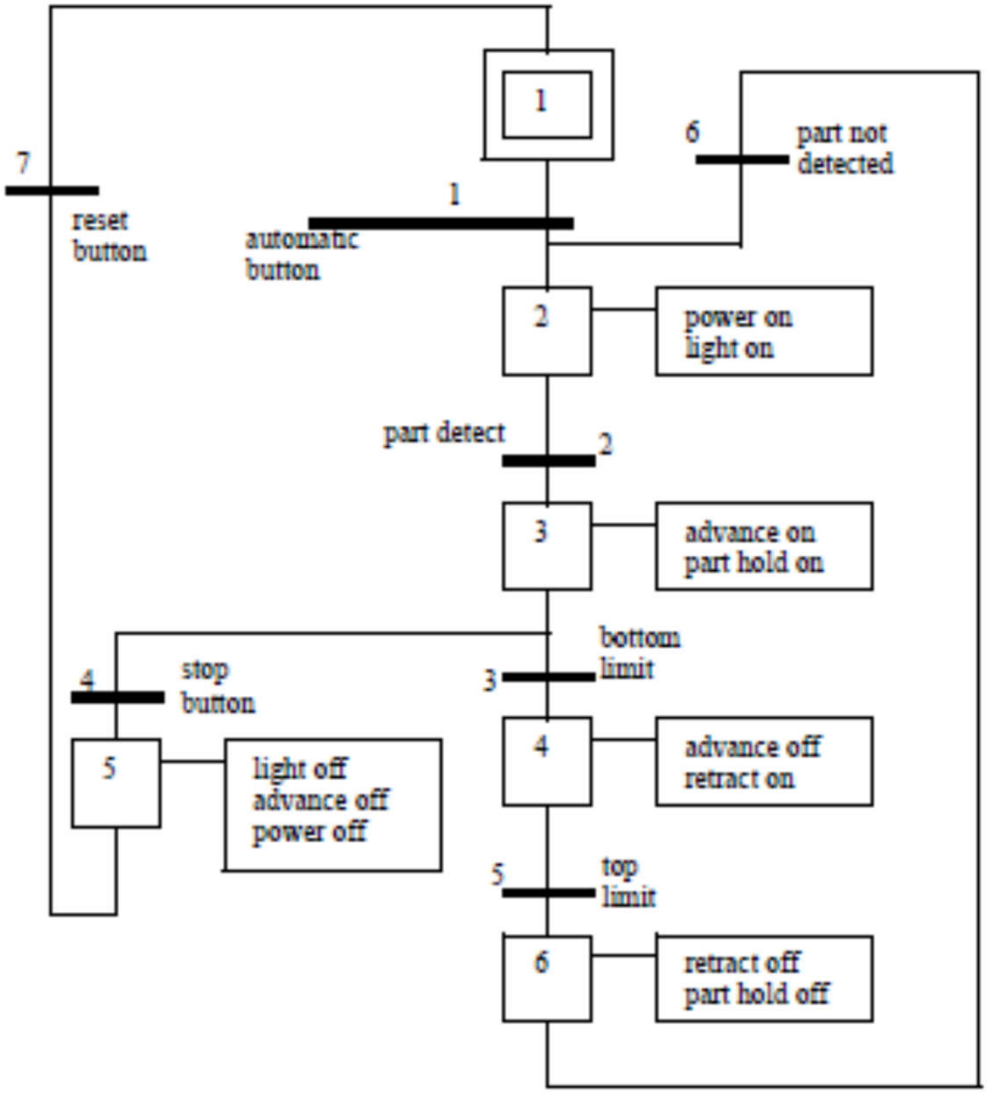


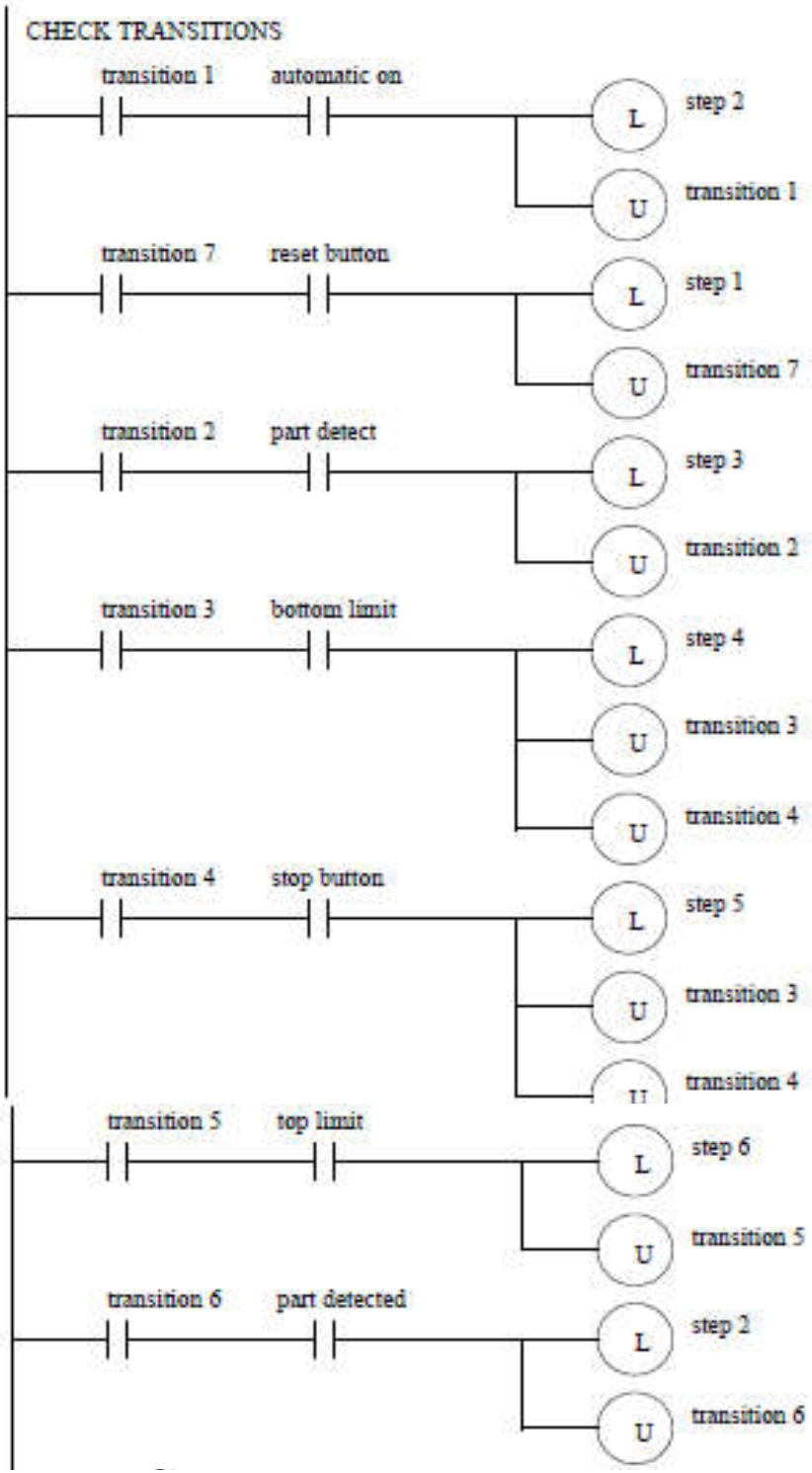
Notes:

L = Latch (set coil)
U = Unlatch (unset coil)

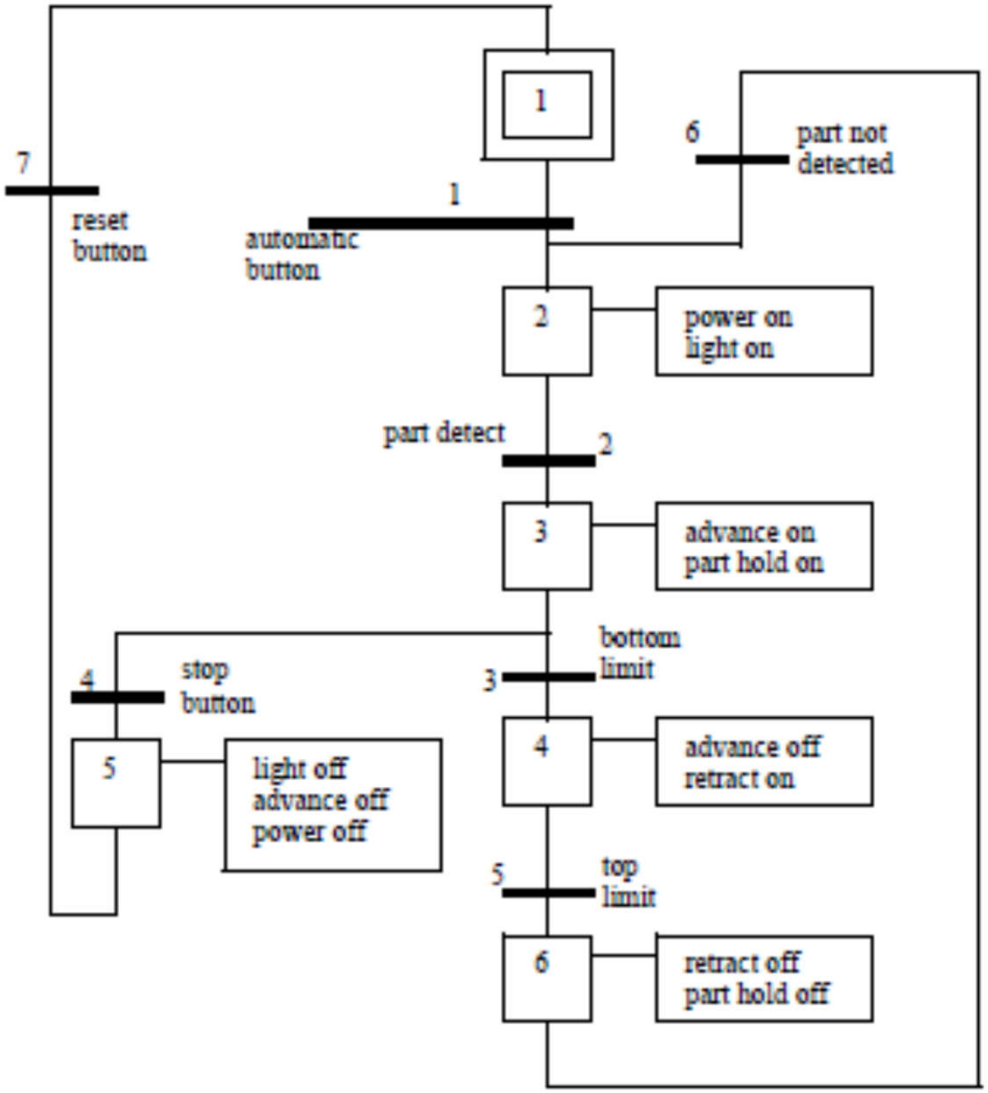
Start by latching the initial steps.

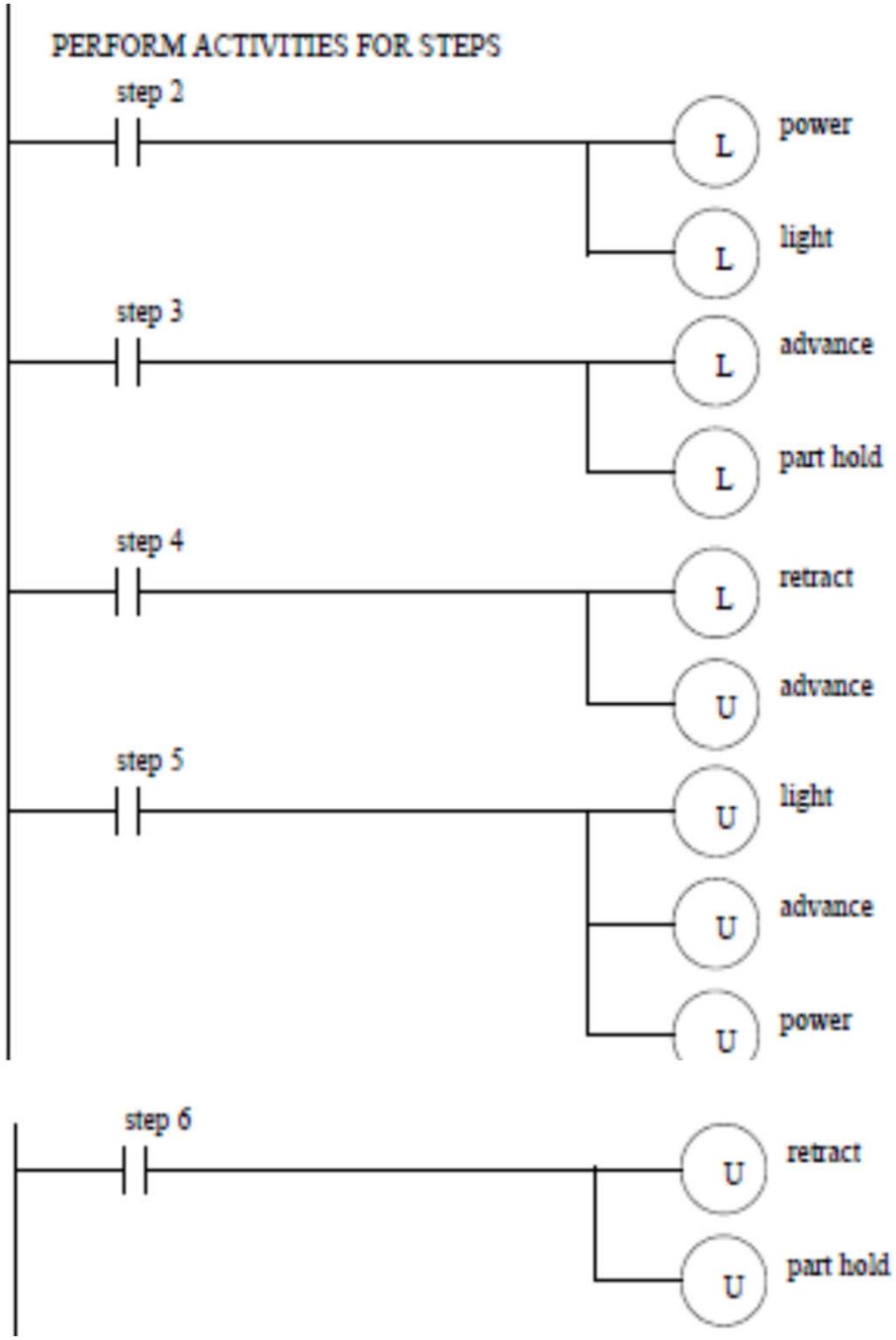
2. Check transitions & activate steps



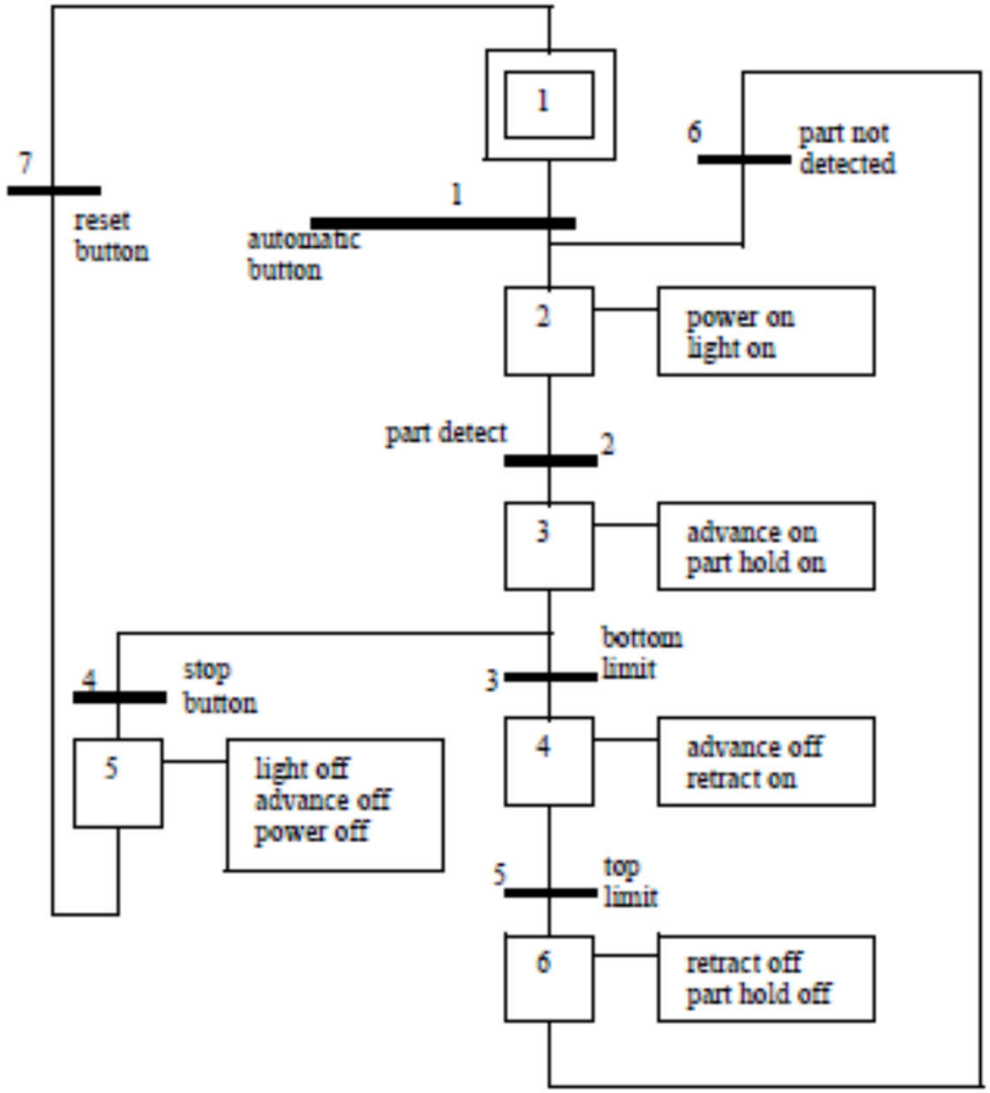


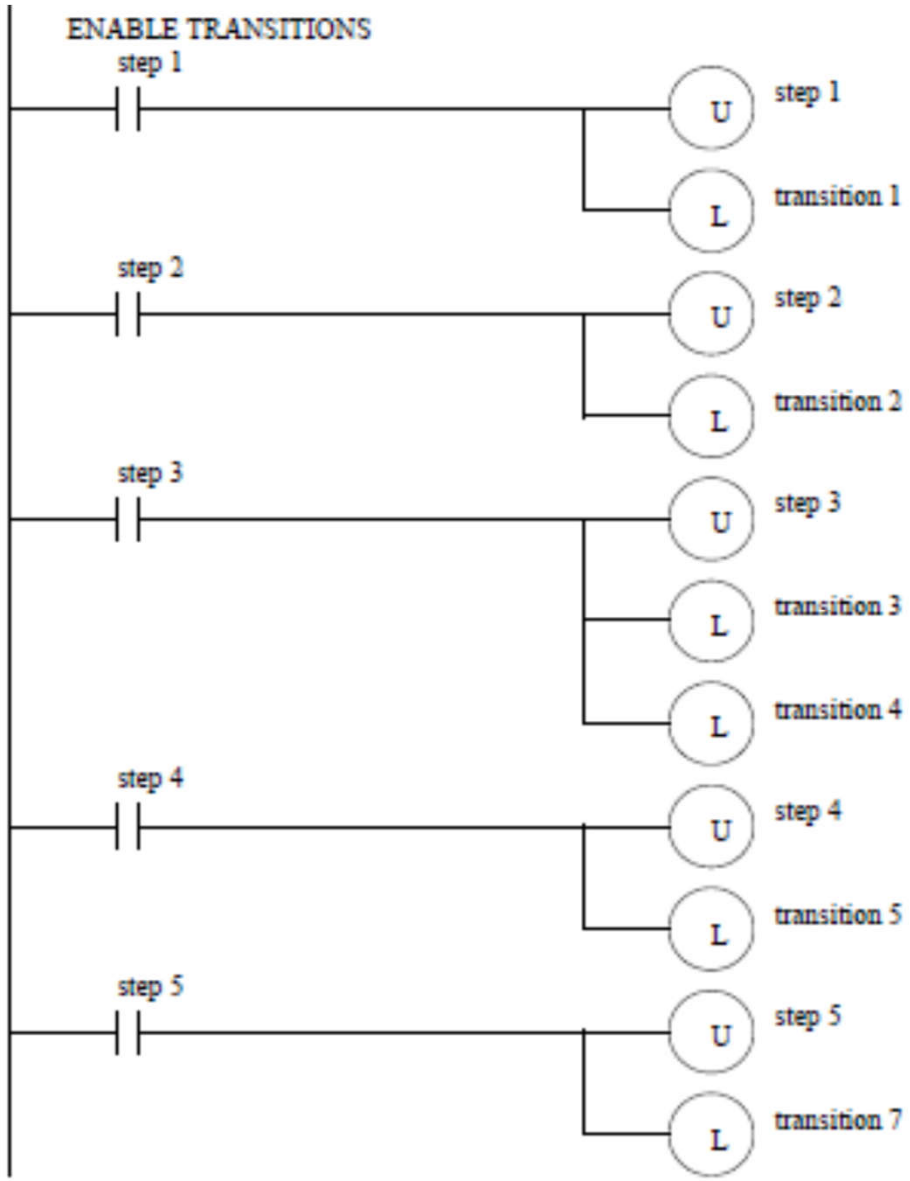
3. Perform activities for steps





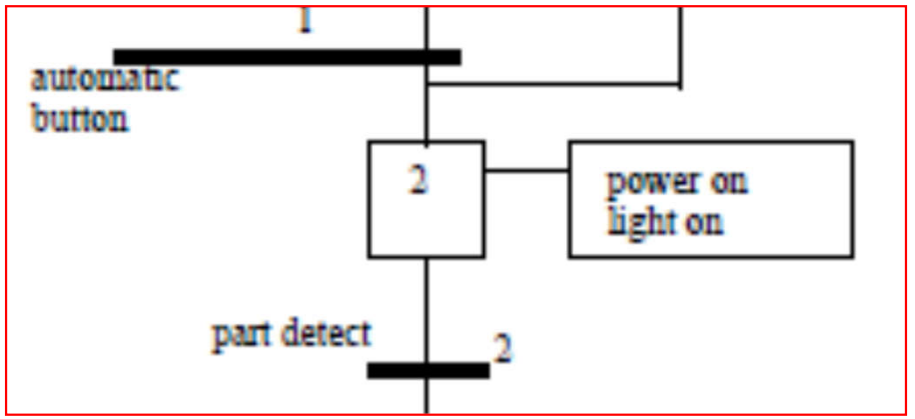
4. Enable transitions





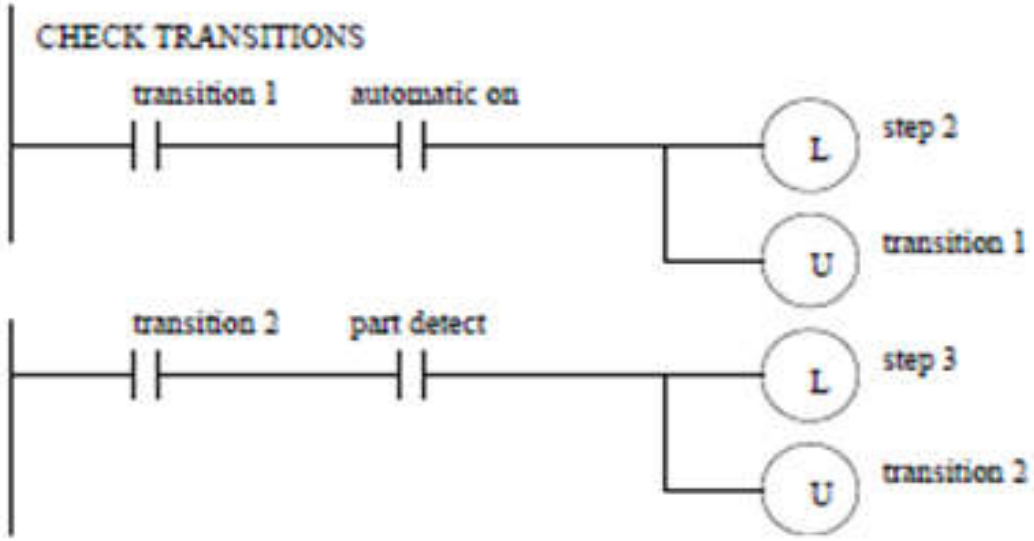
Note: all active steps are made inactive.

Discussion: not-keeping vs keeping steps active

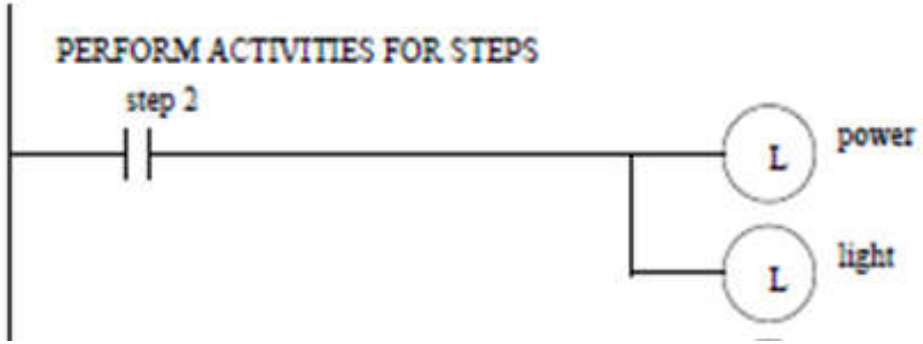


Small part of the Grafcet to analyse

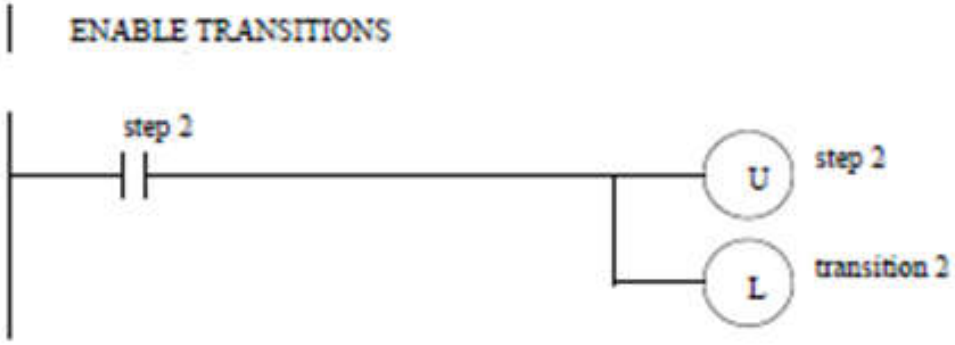
1)



2)



3)



*If step2 is **active in 1** then its work is done in 2 and it is going to be made **inactive (unlatched) in 3**.*

*Note: code parts 1, 2 and 3 run in a single scan cycle; **latched outputs imply they have no spikes**.*

*Note2: **Unity Pro** is not like this, step2 gets inactive only after transposing transitions2.*

Homework challenges:

1. Convert the ladder code shown in the previous slides to a structured text program.

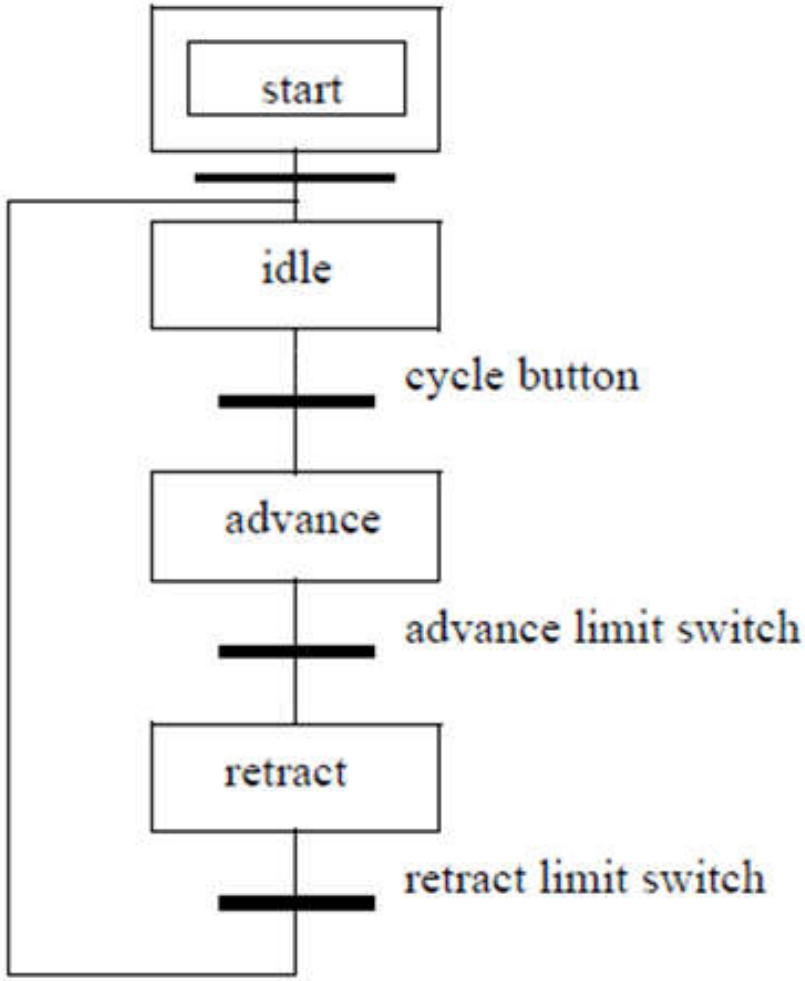
2. Consider simulating the ladder diagram, ladder instructions one-by-one, saving all variables:
- Steps (1..6)
- Transitions (1..6)
- Inputs (automatic button, part detect, …)
- Outputs (power, light, advance, …)

Confirm that:
- Step variables are active *at most one scan cycle*
- Outputs are set/unset (latched/unlatched) and therefore *do not need the steps being active all the time*.

GRAFCET **Practice Problem 1**

Draw **one SFC** for one stamping press that can **advance and retract** when a **cycle button** is pushed, and then stop until the button is pushed again. The press has **limit switches** indicating stop advancing and stop retracting.

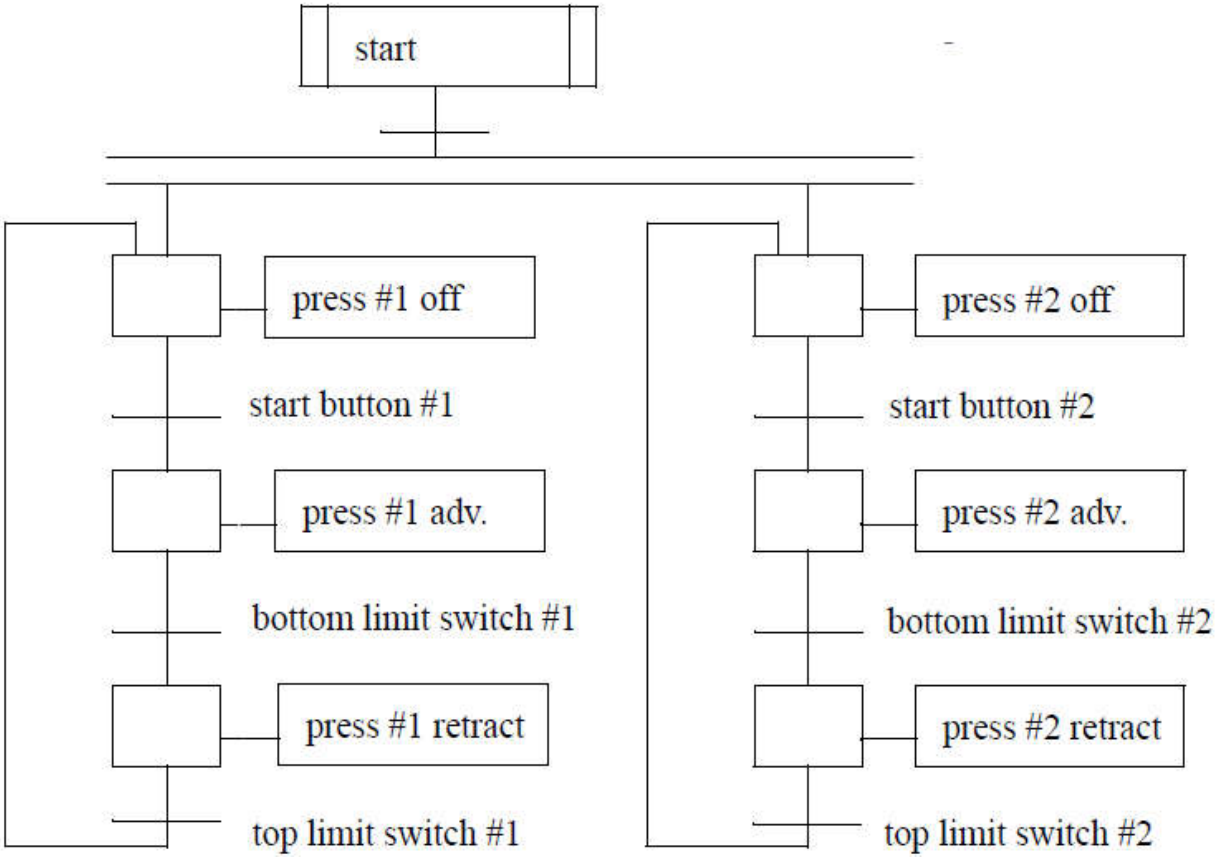
Further study: discuss the advantages of using SFC as compared with using Ladder in this problem.



From [Hugh Jack 2008]

GRAFCET **Practice Problem 2**

Develop **one SFC** for a two person assembly station. The station has **two presses** that may be used at the same time, **independently**. Each press has a cycle button that will start the advance of the press. A bottom limit switch will stop the advance, and the cylinder must then be retracted until a top limit switch is hit. The two presses are enabled only after a common starting procedure.



From [Hugh Jack 2008]

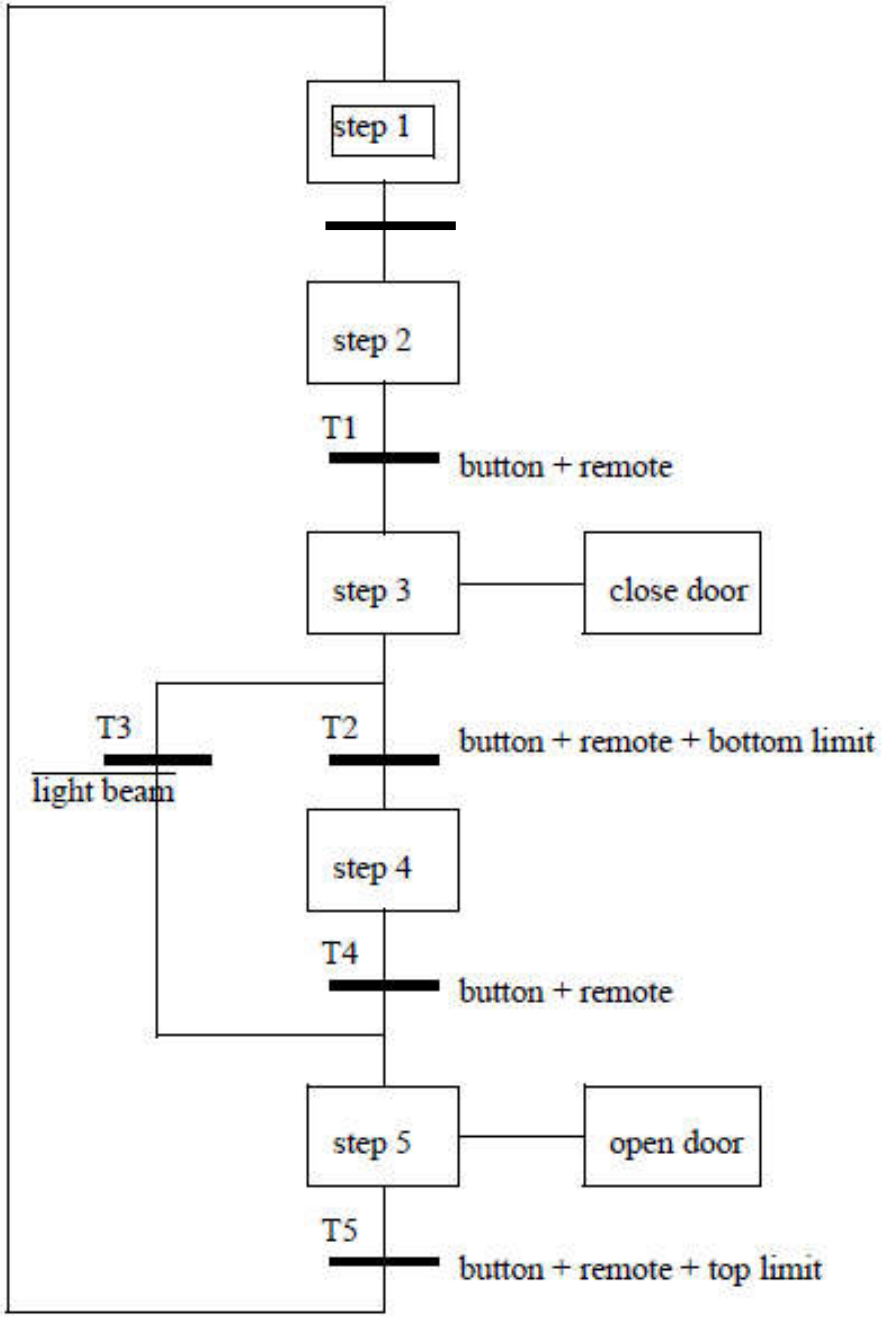
GRAFCET **Practice Problem 3**

Design a garage door controller using an SFC. The behavior of the garage door controller is as follows:

- There is a single button in the garage and a single button remote control. When the button is pushed the door will move up or down.
- There are top/bottom limit switches to stop the motion of the door.

- If the button is pushed once while moving, the door will stop. A second push will start motion again in the opposite direction.
- There is a light beam across the bottom of the door. If the beam is cut while the door is closing the door will stop and reverse.

- There is a garage light that will be on for 5 minutes after the door opens or closes.



From [Hugh Jack 2008]

Application

The conversion of Grafcet / SFT to Ladder, detailed in this chapter, can be mimicked for other sources and images.

Petri nets, a theory foundation of Grafcet / SFC [David95], will be introduced in a later chapter.

The conversion sketched in this chapter is explored to make Structured Text (ST) from Petri nets [www-Gaspar19] .

[David95] *Grafcet: a powerful tool for specification of logic controllers*, R. David, IEEE Trans. on Control Systems Tech., 1995 v3n3 pp253-268
https://ieeexplore.ieee.org/abstract/document/406973

[www-Gaspar19] *Petri net to PLC converting: Inputs and Outputs mapping*, J. Gaspar, 2017-2019, http://www.isr.tecnico.ulisboa.pt/~jag/course_utils/pn_to_plc/pn_to_plc.html