DEVELOPMENT OF AUTOMATISM PRACTICAL WORKS

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Abstract: This article provides information and instructions for preparing practical’s aim to teaching students how to program a Programmable Logic Controller in Grafcet. After describing the goals and the presentation this paper shall be a digression on the GRAFCET before defining the content of educational documents created with the design associated Grafcet.

Key words: Grafcet, model-based test, sequential, logic controllers

1. Introduction

This paper presents a programming model using software PL7_2, soft that will order two Télémécanique TSX17 controllers of the Aldiance Linatec conveyor. PL7_2 software programming allows programming the transfer line with the SFC language.

The SFC (Sequential Function Chart) from the Grafcet is the graphic language used. It cannot be considered as a real programming language because there are no notations in SFC to program logical treatments associated with the GRAFCET. Thus, the transition conditions and actions are written in another programming language: the Ladder Diagrams (LD).

The Ladder Diagram is a succession of contact networks, conveying logical information, executed sequentially, it can integrate function blocks of automatism (tempo, counter, countdown timer) blocks comparison, and its graphical representation is close to that of a wiring diagram.

The GRAFCET (GRAphique Fonctionnel de Commande Etapes / Transitions) is used to represent the functioning of a sequential automation device graphically and in a structured way, that is to say, decomposable into steps. This description is done using simple graphic symbols, Figure 1. [1, 2, 8, 9]. This language represents the functioning of an automatism assembly by:

- steps (active or inactive) and associated actions;
- transitions between steps with associated transition conditions: the receptivity (true or false). A receptivity is a logical condition that distinguishes among all combinations of information available which is likely to get the system upstream step to step downstream;
- oriented links between steps and transitions, traversed by default top to bottom.

Figure 1: Grafcet: graphical elements.

To reach those goals, we followed the method below (Figure 2) chronologically.

Figure 2: Overall method of solving [3, 5].
2. Main paper objects

The laboratory transfer line Aldiance Linatec consists of:

- 3 Transept band conveyors set in motion by 3 asynchronous motors;
- 5 aluminum pallets provided with guides for wooden and steel blocks. The pallets are set in motion by conveyors;
- 1 two-axis manipulator arm with a gripper for cubes;
- 2 controllers Télémécanique TSX17;
- Many actuators and sensors;
- An input warehouse;
- An output warehouse.

To control a process, a PLC is necessary. A Programmable Logic Controller sends commands to actuators (operative part) from the input data (sensors), the set points and a computer program. This computer program is generated by the programming PL7_2 software (Figure 3).

Syntax rule: the alternation step-transition must be respected. Two steps should never be connected directly and neither should two transitions.

Evolution rules: the crossing of a transition: a transition is either validated or not validated. It is validated when all immediately previous steps are active. A transition can be fired only when: the transition is validated and the associated receptivity is true. A crossable transition is necessarily crossed.

The evolution of active steps: The crossing of a transition leads to the activation of all the steps coming right after, and the deactivation of all immediately preceding steps.

We decided to produce six documents: the first two are designed to a first theoretical approach while the following are practical works on the transfer line preceded by a short theoretical part.

The first document must contain the basics of programming in GRAFCET. It contains the notion of PLC, an introduction to the GRAFCET and the basic programming in PL7_2.

Also we decided to include an application example amid the previous section to understand the theoretical aspect better. It is a flash animation showing the evolution of the operative part and the control part (Grafccet) simultaneously.

The first practical must include the basics of practice programming on PL7_2 with all associated procedures. It leads to the programming of a single sequence and the test of the program on the PLC.

Another document, available next to the test post, guides students to transfer the program to the PLC and test it. It must contain all the necessary procedures.
The second practical work allows studying a new notion: the multiple sequences (Figure 5). A sequence is a succession of steps to be executed one after another.

**Figure 5: A several sequences GRAFCET**

The third and final practical work uses the same principle as the second; it is dedicated to the automatism functions that are present in the GRAFCET programming. Function blocks are represented as a rectangle, each block has inputs to control it and outputs which can actuate coils or words associated with specific values. Two widely used functions in automatism are studied: timers and counters (figure 6).

**Figure 6: Function blocks: counter (left) and timer (right) [6,7]**

Once the educational content defined, we could devote the design of GRAFCET in each of the three practical works.

**Graf cet design**

We applied the following approach (Figure 7) for the design of Graf cet. Once the solution found, step 6 of modification is usually longer and more difficult.

**Figure 7: Graf cet design method.[4].**

**Practical work 1**

The first station is that of loading. It is within the latter that a cube of wood or metal is deposited on an empty pallet. The loading is done via the manipulator arm, which carries the cubes of the entrance warehouse to the empty pallets in the immobilization station. An immobilizer raises and blocks pallets for loading.

The objective of this unique sequence is to program the next cycle as soon as a pallet arrives in the loading station:

- immobilization of the pallet ;
- loading a cube on the pallet via the manipulator arm ;
- liberation of the pallet to the sorting station.

**Practical work 2**

Once loaded, the pallets move towards the next station: the sorting station (Figure 8).

This post sorts the pallets according to their materials via an inductive sensor. Pallets with a metal cube (sensor true) through the sorting area on the main conveyor while those with wooden blocks (sensor false) are moving in the derivation (Figure 9).

The purpose of this “OR” sequence is to program the previous cycle as soon as a pallet, one by one, is present in the sorting station. Once this area crossed, pallet cubes fall into the output warehouse before returning to the first station.
Practical work 3

The aim of this third practical work, through two Grafcet, is to program the following cycle once a pallet is present in the sorting station:

- to sort the cubes according to their materials, as in the second practical.
- until there are no wooden cubes in the sorting station, metal cubes cross all the sorting area.
- once a wooden cube is present in the waiting area of the derivation (figure 9), the access to the second east switch blocks cubes of metal, the wooden cube waits for 4s (timer, the time for any metal cube to get out of the second bifurcation) and the wooden cube gets out of the sorting area.
- as soon as two wooden cubes are present in the derivation, the derivation entrance to any wooden cubes at the sorting station is blocked. As soon as a place becomes available, the wooden cube on hold is allowed to join the derivation (counter).
- the corresponding programs on PL7_2. We also drafted the practical works with the associated theoretical courses.

Conclusion

We appreciate that the methodology and language Grafcet are very useful in programming works on automatic equipments.

In this article we have tried to explain how to resolve concrete problems in programming an automatic transfer line equipped with proximity and recognition sensors and it is working in tandem with an industrial robot.

Applications exposed in the article have been made in didactical and research laboratory in order to be subsequently transferred to an industrial manufacturer in the region.

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