STUDY ON CAD OF ELECTRO-PNEUMATIC SEQUENCIAL CIRCUIT

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ABSTRACT

Electro-Pneumatic sequential circuit (EPSC), which controlled by PLC takes as important role in all kinds of production lines. An easy method to design this kind of EPSC is put forward in this paper. Based on this method, a CAD software for EPSC, named PneuCAD that allows users to design, simulate and animate circuits consisting of electro-pneumatic sequential systems. PneuCAD is the ideal CAD and simulation tool for teachers, students and engineers who specialized in pneumatics.

KEY WORDS

Electro-Pneumatic sequential circuit, PLC, CAD, Simulation

INTRODUCTION

Pneumatic driving system is widely used in plenty of automation fields today for its well-known advantages. Especially, Electro-Pneumatic sequential circuit (EPSC) which controlled by PLC holds more and more important position in mechatronic fields[1]. To design this kind of EPSC, the conventional solution is firstly to calculate pneumatic circuit and choose pneumatic components needed and build up the actual pneumatic system, then according to how many control points needed to select corresponding PLC, link PLC I/O units into solenoid valve, magnetic switches and so on. After constructing EPSC, next step is to write PLC ladder logic program in some kind of software which presented by PLC corporation and download it to PLC for verifying ladder logic program. Usually, these processes have to repeat many times until getting a satisfied result. It is obvious that conventional solution has to cost much money purchasing real devices before an ideal plan come into being. How to get rid of these troubles? Much efforts focused on this purpose give us invigorative approaches and very successful applications[2,3]. For example, Automation Studio is a completely integrated software package that allows users to design, simulate and animate circuits consisting of various automation technologies including pneumatics, hydraulics, PLCs, Grafcet and electrical controls. It also supports an optional I/O interface Kit that can be connected to real external devices. Therefore, we can use Automation Studio as a SoftPLC trainer to control real devices such as pneumatic or electric power trainers. With the I/O interface Kit, students can design and simulate any process controlled by a real PLC using elements of the libraries such as pneumatics, hydraulics, electrical, motor controls, etc. and turn Automation Studio into a
complete virtual factory[4].

PneuCAD, mentioned in this paper, is a CAD software package for pneumatic system which integrates following five main functions: pneumatic circuit drawing, pneumatic driving design, electro-pneumatic sequential circuit design, dynamic performance simulation and pneumatic components selection. PneuCAD adopts a specific component library, a set of powerful edition functions and these features result in a rapid and convenient pneumatic circuit drawing method. The module of driving circuit design can draw system circuit, calculate dynamic responses and choose out proper pneumatic components automatically adapting to user’s requirements. The EPSC module can either gives out system control ladder according to user’s requirement or animates the sequential motions according to a specified ladder logic program. The simulation module can recognize pneumatic circuit automatically, extract parameters and set up mathematic model which based on bond graph theory, finally give out pressure and movement characteristics curves. Component selection module implements a pneumatic components selection system based on Client/Server. The structure of PneuCAD is shown as figure 1. The details about pneumatic driving system designing, dynamic performances simulating and pneumatic components selecting based on Client/Server are illustrated in some other papers. In this paper, designing for electro-pneumatic sequential circuit which controlled by PLC is our discussing topic and an easy method to design, simulate and animate EPSC is put forward.

Figure 1 The structure of PneuCAD

INTRODUCTION TO PNEUMATIC CIRCUIT

Drawing pneumatic circuit is the foundation of PneuCAD, it acts as the key links to any other modules. It has two main functions: rapid constructing pneumatic system circuit, simulating pneumatic sequential circuit’s motion. The module of drawing pneumatic circuit is written in Delphi completely, no other third part software tool is used and results in flowing features:

1. Special drawing method No additional burden required user to remember any drawing command like AutoCAD, what user do is only dragging the component symbol from component panel and placing them in workspace, and then connecting them by mouse dragging.

2. Specific Component Libraries The “component” in PneuCAD is not real symbol of pneumatic components, and the libraries also don’t exist in fact. The component libraries are the set of some arithmetic which drawing some real pneumatic component symbol. That’s to say that it has no any component symbol displayed on workspace until you click the icon corresponding pneumatic component. To some extent, we can call this component library is “soft” library or virtual pneumatic components.

3. Object-oriented Component In PneuCAD, all “components” are instances of Tblock class, and they inherited the same properties and same operation methods from their parents. Of course, every component block own their dedicated properties and especial operation methods to know from other brotherhood blocks.

4. Powerful Edit Instructions Kinds of editing instructions help you implement editing operations, such as selecting, moving, copying, cutting components. These instructions enhances drawing efficiency greatly and also make great strides on pneumatic circuit drawing.

5. Recognize Automatically After “components” are created dynamically and connected manually, PneuCAD can abstract all components’ properties and linking information. Moreover, all information can be updated automatically while “components” being copied, cut, or moved again.

6. Animate simulation Animation technology used in PneuCAD makes pneumatic circuit is not a static figure any more. The direction valve and cylinder’s motion is clear at a glance during simulation process.

7. Pneumatic circuit saved as TXT file Format PneuCAD can change the pneumatic circuit from bitmap into TXT file. The size of TXT file is smaller than figure file and more convenient to be used.

8. Convenient Interfaces PneuCAD can save pneumatic circuit as picture for other application. Figure 2 shows the main interface of PneuCAD. PneuCAD is a standard windows application, with it help, there is no need for additional editing software, it provides editing toolbars and pull-down menus that are easy to learn and use. Most generic pneumatic components are embedded in PneuCAD components palette. PneuCAD allows user to click mouse on components palette to create component or drag mouse to allocate component on the work space. Powerful editing tools allows user to selecte, zoom, move, copy and paste components conveniently.
The most important function of EPSC module is to give out the PLC ladder program automatically according to user’s requirements to EPSC. We know that programming is a creative job and different programmer has different idea, habit and absolute different program. How can computer give out a program facing so many EPSCs? The following ideas are the answer.

1. In spite of how the working sequence of pneumatic system defines, what’s current state of machine stay, each air cylinder must stay in some exclusive state, it must be extending, retracting or be in static state. After the pneumatic circuit is confirmed, the cylinder’s motion lies on solenoid valve.

2. The principle of PLC which adopting itinerancy scan and creating mapping area of I/O indicates that output relay’s output state lies on logic operation result, and its output state is exclusive in current scan period.

3. The above similarities give us an inspiration that if we link PLC’s output relay with solenoid valve, the logic conditions of this output relay will determine cylinder’s state and further determine the machine’s state. Another inspiration is that the necessity, repellency and sufficiency of PLC relay’s output conditions are electro-pneumatic control system’s marrow.

4. The fact of existing obstruction signal in X-D method warns acting period of working steps must be controlled strictly during control processing. If we use the bits of PLC shifting relay record the sequence number of machine’s working and the sequence number will shift a step after completing each step, PLC shifting relay indicates the next step automatically, and these bits of relay become one of the conditions of determining valve being ON or OFF, then we will avoid complex jobs of getting rid of obstruction signal.

5. During the working period, the bit state of PLC shifting relay has not allowed shifting until the current step ending condition is coming, generally, this condition is cylinder reaching the end, timer turns ON and any other situations.

CONCLUSION

PneuCAD was originally designed for pneumatic corporations help them selecting components and simulating the dynamic performance of pneumatic driving system. When we introduced EPSC design into PneuCAD, it is now can also be used for training application. PneuCAD will simplifies the teacher’s job. With PneuCAD, students will spend their energies learning pneumatic and PLC technologies, instead of learning interface itself. On the other hand, It is also a cost effective solution. PneuCAD virtually gives you access to all the components you need to create.
electro-pneumatic circuit. There is no need to purchase additional components such as cylinders, valves, relays or PLCs when you need them. Creating circuits on a PC is a safe and economical way for students to learn troubleshooting techniques. You do not need to worry about dangerous and costly mishaps.

Though PneuCAD has a very bright future, there are many works to perfect its functions. Firstly, we need to expand its component libraries, such as adding hydraulic, electrical controls and so on. Secondly, we need to study more practicable program methods as we can to face all kinds of applications. At last, we much develop some general interfaces for PneuCAD to link with kinds of hardware devices.

REFERENCES

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