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Research on Industry Parallel-Control System Based on Siemens PLC

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Abstract: An industry parallel-control system framework for Siemens S7-200 PLC series is researched in this study. By analysis of PLC hardware features and operation modes, communication and information automation network, a multi-task system framework model which can improve PLC control efficiency in the use process and solve program chaos problem has been established. Multi-task system completes the programming system fault tolerance function and strengthens the system robustness.

Key words: Siemens PLC, parallel-control system, sequence logical scanning, fault tolerance

INTRODUCTION

Programmable Logic Controller (PLC) is the most important component in industrial automation and it has become one of the three pillars (robots, PLC and CAD/CAM) of the modern industrial control technology (Liao, 2007). Its high reliability, convenient use and other advantages are well known by engineers. After more than 40 years development, the PLC has become the most important, reliable, widespread industrial control microcomputer. While PLC is difficult to make system functions fully used and ensure the system fault tolerance function, system program chaos problem, the poor adaptability problem and so on have been concerned in use process (Li *et al*., 2006). Based on Siemens S7-200 series PLC, a PLC multi-task system framework model improve parallel control ability and ensure the stability of the system and guarantee the system fault tolerance function and the portability of the system at the same time.

FEASIBILITY ANALYSIS OF PLC MULTI-TASK SYSTEM

Industrial control characteristics: In modern industrial production control system, industrial task is often multi-tasks, multi-stages and multi-process steps, this requires the controller's control functions are fully used; In the factory production line, considering industrial safety and worker safety, the system should have good fault tolerance, monitoring and self-test function (Xu and Ye, 2001); In industrial control applications, system program should be easy to maintain and can adapt to the flexible production needs which requires the control system have the adaptability and rational. Concerned about all this, multi-task system structure should has a good ability of improving system efficiency and adapting process changes and fault self-checking. To establish a better PLC system framework which is stable and easy to maintenance should first analyze the controller characteristics from the following aspects (1) Scan cycle feature during the execution phase, (2) PLC communication during the message-processing phase and (3) PLC memories feature. According to the hardware characteristic and the industrial production requires we establish PLC multi-task system structure (Zheng and Tang, 1992).

PLC execution feature: The S7-200 PLC executes a series of tasks repetitively. When PLC is RUN mode, its work state is shown in Fig. 1. This cyclical execution of tasks is called the scan cycle (Li *et al*., 2006). That is, a logical coil is switched on or off, all the contacts of the coil are not

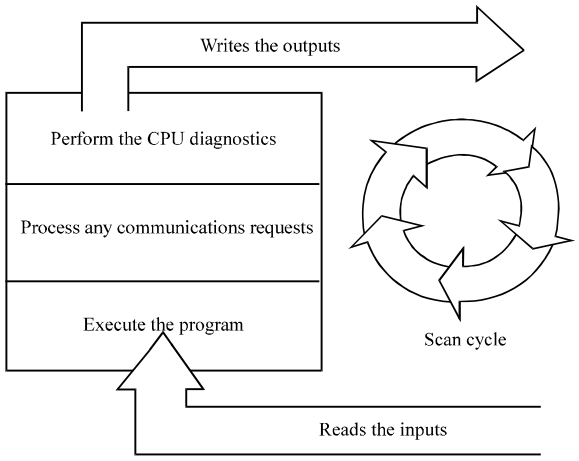

Fig. 1: PLC scan cycle

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immediately actuated until the S7-200 writes the values stored in the process-image output register to the digital outputs at the end of every scan cycle. In the scan cycle, control system and program execution phases are closely related. In the user program execution phase, PLC instructions execution speed, the user program, jump instructions, timer instructions directly influences the scan cycle. A reasonable multi-task system framework and strictly control of the scan cycle will make full use of PLC control function; Blocking system task and process steps make system logic clear and easy to maintenance.

PLC communication and information automation: The S7-200 supports many different types of communication networks so that establishing information automation network conveniently. In the processing any communications requests phase, PLC sends or receives data to be processed by different methods. In the field of industrial control network, The PROFIBUS protocol is designed for high-speed communications with distributed I/O devices which can achieve flexible manufacturing. In the remote monitoring network, TCP/IP Ethernet communication can maintains production units with Internet. Adding communication handler program in the multi-tasks framework systems will make system have portability and universality.

PLC storage characteristics: Siemens S7-200 series PLC stores information in different memory locations (memories, accumulators and registers) that have unique addresses. In the writing to the digital outputs phase, values in the process-image input register is unchanged until the S7-200 writes the values stored in the process-image output register to the digital outputs at the end of every scan cycle. Process-image registers make system operation stable and provides different ways to achieve fault tolerant control and self-test diagnosis function. In the programming execution phase, you can explicitly identify the memory address that you want to access. Then access data in most memory areas (V, I, Q, M, S, L and SM) as bytes, words, or double words by using the byte-address format. Some memories have specific features (Li *et al*., 2007). Interrupt program can interrupt normal scan cycle and complete the monitoring function.

STRUCTURE OF PLC MULTI-TASK SYSTEM

System control function can be improved in two main ways: temporal parallelism and spatial parallelism. Time parallelism refers that scheduling process and operating program at the same time or period of time. In this way, it will make full use of computing horsepower of PLC internal processor, so as to enhance the parallel degree and reliability of the system. Spatial parallelism refers to setting multiple independent operating units in the internal processor which makes these operating components synchronous or asynchronous work. According to the hardware characteristic we set up a reasonable time parallel system structure to improve the PLC control function.

Multi-task system model: The PLC multi-task system is divided into many unrelated subtasks, each subtask will be implemented independently (Fig. 2). The framework system consists of various function modules. Apart from the specific functional modules, other modules decided by process steps. When multi-task system is running, independence of subtask protect them completing respective process steps. In this way, multi-task system not only short system execution time greatly but also strengthen capability and adaptability of system structure and make it easy to maintain in flexible production.

Estimation of parallel process number: Within certain limits, due to PLC high scan frequency, program segment be executed in a short period time can be regarded as execution at a same time (in most non-polar strict requirements industrial scene). Number of task unit executing at the same time is the parallel process number. According to Table 1 PLC instructions execution speed, in the premise of inputs pulse width must be greater than

Table 1: PLC instructions execution speed

Parameters	Speed (μsec per instruction)
Boolean execution speed (T_{bool})	0.37
Timer/counter execution speed ($T_{t/c}$)	50-64
Single precision execution speed (T_{single})	46
Double precision execution speed (T_{double})	100-400
Movement execution speed (T_{move})	34

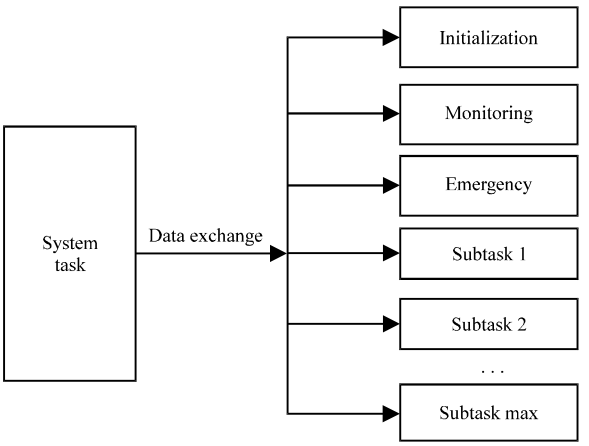

Fig. 2: Prallel system structure

scan cycle, estimating parallel process number under the conditions of all inputs pulse width are greater than 100ms, each instruction execution equivalent, communication and PLC self diagnosis time of the scan cycle time 1/2, uncertain factors coefficient is 10:

$$T = nS \approx \frac{T_{min} - T_{selftest} - T_{communication}}{T_{T/C} + T_{bool} + T_{move} + T_{single} + T_{double}}$$

Among them, S represents the uncertain factors coefficient, T_{min} represents the minimum scan cycle, $T_{self\text{-}check}$ represents controller self-diagnosis time and $T_{communication}$ represents controller communication time. N is the parallel system process number and its value is between 9 and 21. Generally, the main system task is divided into 10-15 process control tasks to complete.

Multi-task system unit and the cycle peak: PLC multi-task system has two main control units: Linear-flow task and nonlinear-flow task. Linear-flow tasks will be executed in proper sequence during the program execution phase and each function unit is called only one time; Nonlinear-flow tasks are not executed entirely in turn, some function units will be called repetitively or make a loop call, as shown in Fig. 3.

In practical application, the main system task is separated gradually. There must be a scan cycle peak of the largest task, complex operation process. In order to guarantee that the PLC controller can stabilize the multi-task system, the cycle peak must be continuously monitored. Adding the monitoring module in the system structure, we get scan cycle peak through the special mark area. Multi-task system initialization module is executed only once, to complete the system task preparation. Emergency module and monitoring module is associated with system task process. Generally, the multi-task system monitoring can be completed by monitoring Watchdog Reset instruction (WDR). Function unit need reasonable combination based on the specific production process so that avoiding cycle peak.

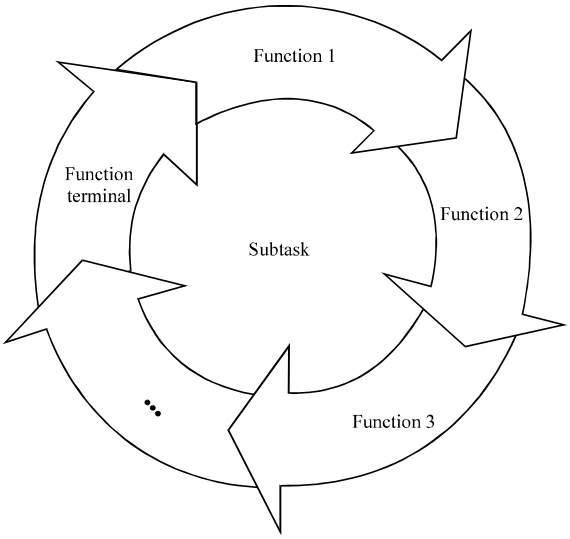

Fig. 3: Function loop

CONCLUSION

The Siemens S7-200 series PLC Multi-task system model and its realization points are introduced in this study. PLC Multi-task system achieves parallel control function and improves the Multi-task structure and solves the procedure chaos problems including large number of digital signals complex control problem and so on. By monitoring process, data exchange and other methods ensure the stability of Multi-task system. Since, Multi-task system used in production line station (I 120, Q 113, the total number of I/O has reached more than 200), Equipment operates stable and system performances its high reliability, self-diagnosis and adaptation process capability. Multi-task system structure makes it easy to monitor and repair, not only reduce the production cost but also improve production efficiency. PLC Multi-task system is a reference model in modern industrial production.

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