

# Study on the Embedded SPC System Based on LAN

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## ABSTRACT

Statistical Process Control (SPC) is recognized as one of the most important tool of quality control (QC), and is one research focus in order to implement SPC quickly and effectively using computer technology and network environments. This paper proposes the principle and topology of embedded SPC based on the Internet/Intranet, emphatically discusses the embedded data sampling block, embedded network interface and SPC strategy. An example of application is given.

**Key Word:** SPC, Embedded system, Network environments, Internet, Intranet, LAN

## 1. Introduction

SPC is noted as the most popular tool of quality control (QC) by QC engineers. It provides people with dynamic information about manufacturing process stability and variation of production quality. Using control charts, one can detect unstable processes and find out reasons of the problem, then take proper measures to avoid or reduce the yield of unacceptable product, so as to ensure the quality in manufacturing processes.

But it is onerous to do statistical calculations and draw control charts manually. In order to improve efficiency computers were first applied in 1950. With the development of computer technology, more and more companies have done SPC analysis and diagnosis by computer aid. Statistical calculations, drawing, and analysis can be completed with software much more efficiently. But for many companies it is a bottle-neck to input massive data into computers. Although it can be solved by CAI (Computer Aided Inspection), CAI technology is limited by costly equipment and various application environments. The embedded system based on network offers an approach to resolve this problem

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Embedded system is a computer system that is embedded in other equipment or applying production based computer technology. These systems have characteristics of small code high intelligent and quick response. The development of trend embedded system is to combine measuring equipment with the Internet. This paper, in view of the trend, introduced the principle and proposed a topology of embedded SPC system. It also discusses the embedded data sampling block, the embedded net interface and SPC strategy and gave an example of their application.

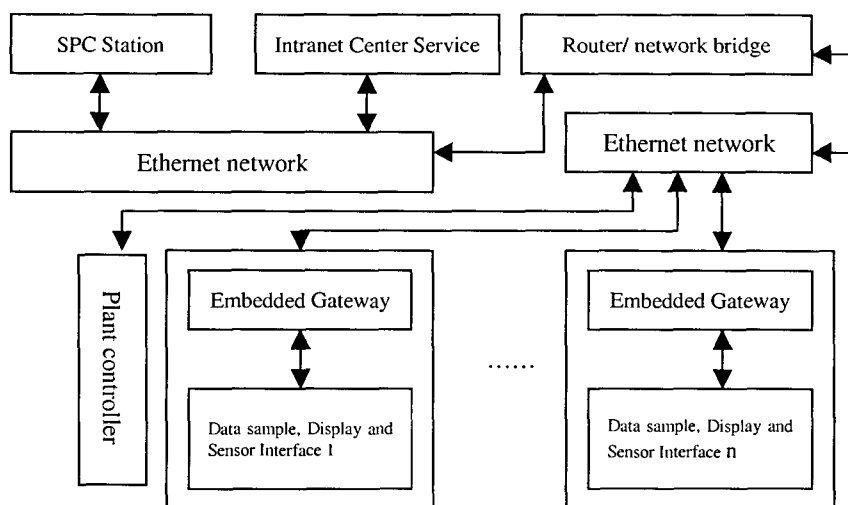


Figure 1. The system diagram of embedded SPC system based on LAN

## 2. The Frame of Embedded SPC System Based on Intranet

A network platform is the important resource for modern manufacturing companies, It is the fundamental platform to implement co-operative management of multi-hierarchy and multi-tasks, and to support knowledge sharing. It is a trend that SPC task is implemented using this resource during the manufacturing process. Especially in low volume, multi-production manufacturing area, it is complicated to realize more efficient QC, it needs quality guarantee systems which are of explicit responsibility, cooperating and supervising each other. To combine SPC with network and database technology is the result of this requirement. It provides the company with a solution of systemic quality assurance during its manufacturing processes.

The system diagram shows the embedded SPC system based on LAN in figure1. Every spot point of measuring and controlling has an embedded system of data sampling. After the value of quality character is sampled, a real time signal is given to show whether the value

is eligible and then the value is sent to the Intranet Center Service through the network. The SPC service controls this work procedure point using strategy, and advice of adjustment is sent to the embedded system of data sampling to inform the operator.

### 3. Embedded Data Sampling Block

Embedded data sampling is one core block of the system, while quality requirements and measure methods are various in manufacturing sites, therefore embedded data sampling blocks are developed for various objects. As an example, we discussed the principle of embedded data sampling blocks for precision control of general dimensions in a machining process.

#### 3.1 Principle of embedded data sampling system in the face of dimension precision control.

The input part of embedded data sampling block receives an electronic signal with a change of dimension. Then through the signal process A/D converter, a digital signal is calculated and saved in the memory by microchip, then a digital signal is send to the center server through COMM converter (RS232 or RS232/RS485) and embedded gateway by microchip at the same time. For example, the sensor is a high precision LVDT in the embedded data sampling block as shown in figure 2.

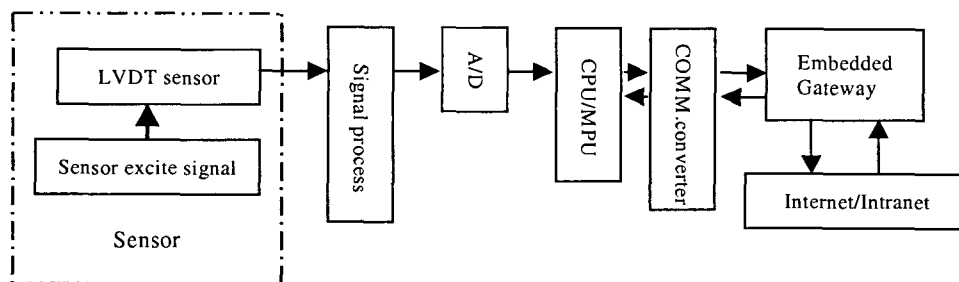


Figure 2. The principle of embedded system of data sampling

#### 3.2 Implementation of an embedded data sampling system

A system structure is proposed according to the principle of embedded system of data sampling and requirements of quality control during manufacturing, as shown in figure 3.

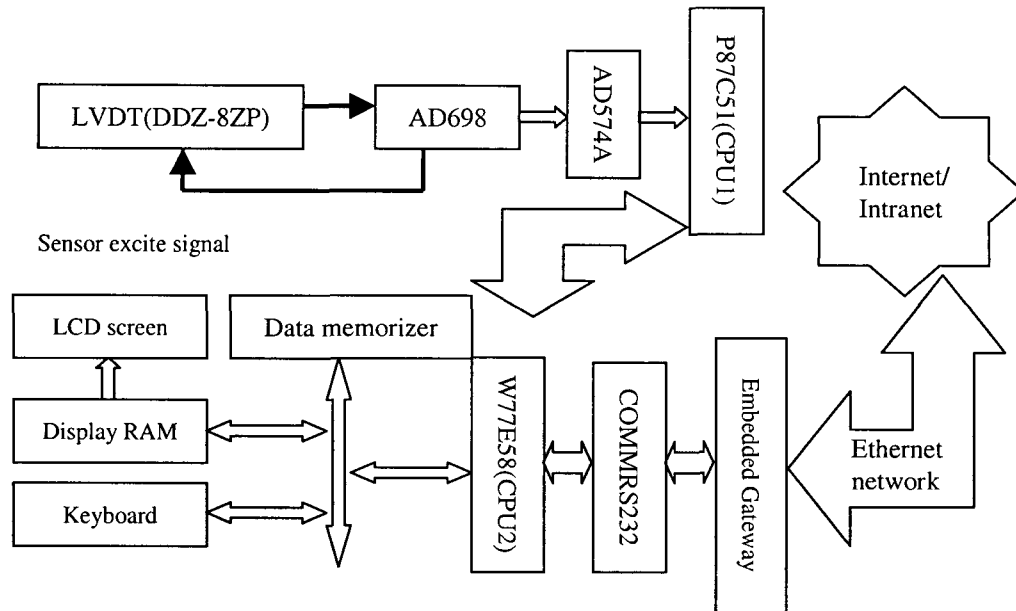


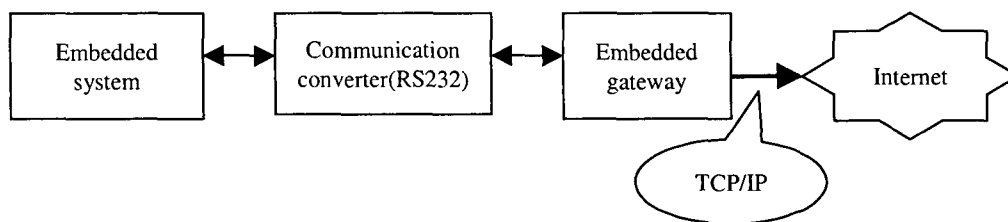
Figure 3. System structure of embedded data sampling

This system has two parallel process MPUs which incorporates displacement signal sampling judgment, a dynamic measuring network, an information process keyboard and display process etc. Embedded Gateway includes physical layer, protocol layer, network data interface and user data interface etc.

To determine an effective measuring value is very difficult for quick measurement in the measuring area. For example, in measuring a bearing, grads criteria of dynamic measurement based digital filter is set up, according to the character of dynamic measurement. Let observation value be  $x_n$  after digital filter, the start point of calculation grad be  $x_i$ , the number of grad sum be  $k$ , then the judgment criteria of effective observation value of start point will be  $\sum_{n=i}^{i+k} (x_n - x_i) < c_1$ ; and the end point be  $\sum_{n=i+1}^{i+k} (x_n - x_i) > c_2$ , where  $c_1$  is the threshold value of judgment at the start point, and  $c_2$  is the threshold value of the end point, the value of  $c_1$  and  $c_2$  can be adjusted.

#### 4. Embedded Lan Interface

Presently, Embedded network access systems are of two types. The first type/scheme is to realize TCP/IP protocol using 16/32bit microprocessor. This scheme is flexible, but the requirement of system resource and CPU is very high, so that it is difficult to realize using an MCS-51 microprocessor. The second scheme is implemented using an embedded gateway, where all embedded systems communicate with gateway, and then the embedded system connects with the Internet/Intranet through a gateway, shown in figure 4.



**Figure 4.** Topology structure of the embedded network access system

The user interface of an embedded Gateway is a channel for data transmission between the embedded system of data sampling system and Internet/Intranet, the protocol of data transmission is decided by a data package and RS232 protocol, the format of data package is:

Package head	Data length	Order word	Effective data	Package end	Data package verify
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### 5. Strategy of Embedded SPC System

From the system point of view, the control software of the embedded SPC system based on LAN consists of two parts: (1) SPC analysis software based Server or PC. (2) SPC analysis software in the embedded SPC system (It is in fact the frame of Server/Client). The control & analysis software based Server or PC has been developed in the environments of Network database (for example SQL Service). It is reliable now and there are many successful applications in place. As long as the software with same communication protocol is designed, the information can be exchanged between the embedded SPC system and the center Server by Internet/Intranet. Hence, how to realize the software in the embedded SPC system is discussed next.

Besides the output control chart and analysis results, the control software of embedded SPC system includes quality data sampling and saving, selecting of the control chart and control object, sending data to the center server or consulting center server and so on. Figure 5 outlines the procedure of an embedded SPC system.

The control object is a representative of the main quality target during the manufacturing process; it has a relation to the measuring values, and it is an important factor in the selection of the control chart. The output graph of the control chart can be of various types to meet the request of users.

The stability of a working-procedure can be judged through observing the arranged character of the points in the control chart. If it is satisfied to the same rules of judging abnormality, and the process of manufacturing continues, probably soon a deterioration of quality product will appear. This will result in waste of material and efficient of production will decrease. So, when the possible out-of-control of working procedure is detected, embedded SPC system will compare with out-of-control modes saved in the embedded SPC system, give the reason of out-of-control; if embedded SPC system can't find the reason, it will ask center server.

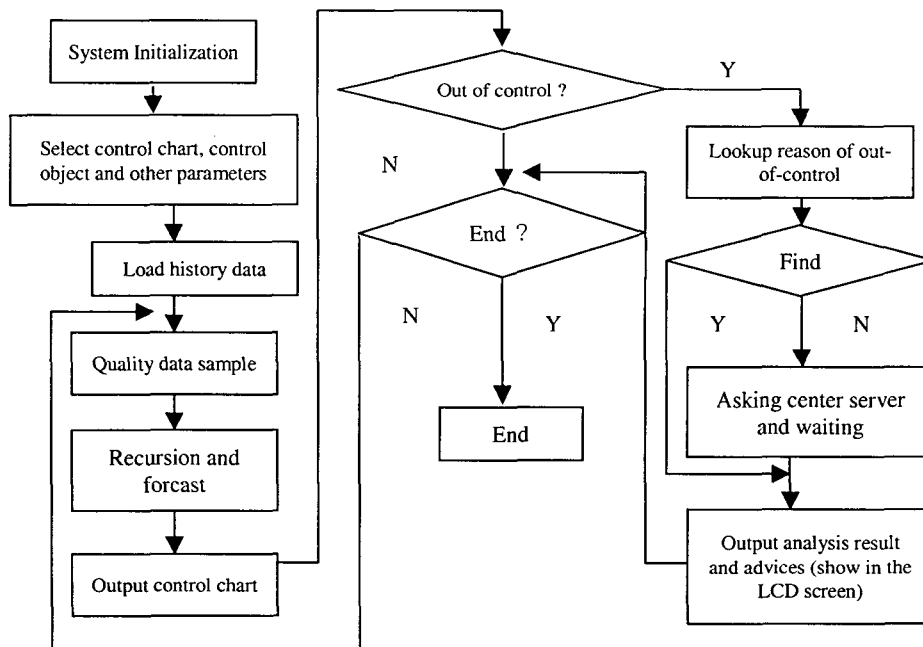


Figure 5. Flowchart of embedded SPC system software

## 6. Applying Embedded System of Data Sampling to Network SPC

Based on the above mentioned embedded system of data sampling and use of a CEWMA (Cluster EWMA) control chart of embedded SPC, an application is realized in the bearing manufacturing operation with obvious effective results.

## 7. Conclusion

An embedded SPC system based on LAN combined data sampling, industrial ethernet and SPC, solved the difficulty of data sample in implementing SPC, and assured randomization of sample data. Furthermore it extended the SPC implementation from information managed layer to equipment guidance layer. Real-time network SPC is established based on company Intranet. Co-operative management of multi-hierarchy is realized. The system acts as a solid foundation for implementing full-scale QC in any company.

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