# I-7000 Series Modules Applied in Computer-based Remote Dispatching System for Thermoelectric Plant

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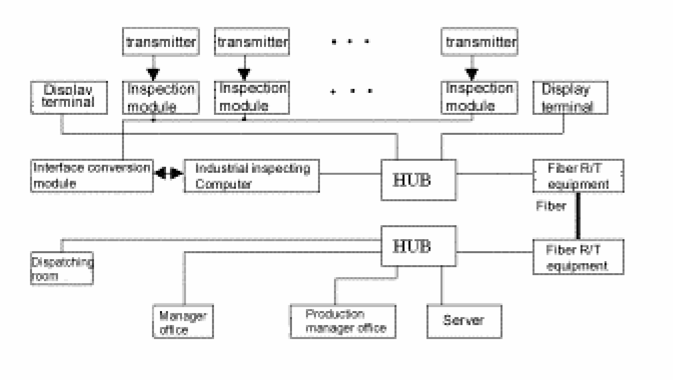
A group power plant, which is a heating power plant that utilizes a steam turbo-alternator to generate electricity, consists of four power boilers, three generator systems and two common systems. With so many huge facilities and a number of associated and distributed parameters that require monitoring, it is very difficult for these plants to coordinate these operating parameters in order to make the whole system run efficiently and safely. The nine facility operation rooms of the system are in a distribution spacing them tens to hundreds of meters apart and the central dispatching room of the power plant is 500 meters away from the field. The command and dispatching of the whole production can only employ a telephone system rather than field monitoring (which would be much more ideal), resulting in false operation data, concealed failure and lack of obedience to dispatched instructions. As a result, the system always operates with low efficiency and many accidents.

In order to improve production efficiency and reduce cost by enhancing dispatching and management we implemented I-7000 series remote measurement modules network and developed a computer-based remote dispatching system with a LAN platform for this plant. It is a computer-based industrial monitor and communication network including complicated systems and functions with high real-time features. This paper only discusses some important issues involving the use of I-7000 series modules in the lower layer of the monitoring network.



## 1 Introduction to the System Architecture

As shown in figure 1, each facility in the nine-facility operation rooms has several parameters that need to be monitored, such as pressure, temperature, flux and liquid level, etc. Nine I-7017 modules distributed within each instrument panel monitor 69 parameters processed and transmitted by the computer. These parameters are converted into standard signals by the transmitter and sent to a I-7017 module. After being processed by the modules' built-in chips the data is transmitted to the computer used for monitoring via an industrial half-duplex serial data bus (RS-485). An industrial computer communicates with all modules via I-7520 RS485/RS232 converter and stores all inspected parameters in the computer. Then the computer will initiate a series of actions such as data processing, measurement conversion and complicated compensation computing for 20 instantaneous flux parameters to get an accumulated quantity of heat. After that 63 inspected values and 40 worked-out values will be transmitted through the computer network.

Because of the long distance between the field and dispatching room and the harsh environment in the power plant, the media used to transmit the upward data from the inspector to the server is optical fiber. In order for the important posts in the field to get enough system information to coordinate the production, both the dispatching room and the executive's office should be able to access data regarding operation conditions of the whole system. Additionally, in the main workshops are installed some display terminals.

## 2 Issues in designing real-time monitor system using I-7017

The remote dispatching system in a thermoelectric plant usually operates under harsh environmental conditions with severe interference and scattered parameters; therefore, the monitor system must be reliable with robust real-time performance. I-7017 is an 8-channel A/D converter with various input modes. During the designing and debugging phase of the system we learned through industrial real-time testing and controlling of systems using the module that it displayed reliability, strong protection against interference, precision and easy-of-use regarding establishing remote networks using the RS-485 bus, etc. System monitoring based on the modules can completely satisfy the requirements of reliability and real-time performance. But only when several key factors in the system-designing phase are implemented wisely can the module be taken full advantage of.

### 2.1 Common issues existing in original and computer-based monitoring system

During the technical reconstruction of an old-industry system it is necessary to retain some of the old instrument monitoring system and extract some important monitoring signals from that old system. Although I-7000 modules involve a full range of input signal series it is more feasible to build a new system by acquiring signals from the existing system than by adding sensors, transmitters and monitoring lines to the old facilities. Some signals such as pressure, flux and liquid level which are transferred to the instrument panel by transmitter can be inspected by both instruments and modules simultaneously when the current input circuit of modules is series-connected to the current output circuit of transmitter. But for temperature signals, which are input through thermocouple or heat resistance, we adopted an all-in-one temperature transmitter that can be directly mounted in an armored junction box of sensors in the field. The transmitter and the module can inspect the temperature signal simultaneously by performing the following steps: First: change the old line connecting field to instrument panel into supplying power and signal output circuit of the temperature transmitter. Second: convert the input circuit of the temperature instrument into a standard current signal input. Finally, series-connect the input circuit of the temperature instrument and modules to the output circuit of the transmitter.

**2.2 Issues regarding how to protect input circuit of modules**

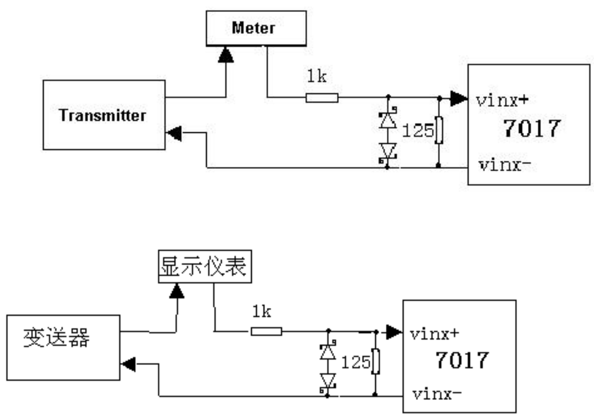



Figure 2

Protection circuit diagram for module input circuit

It is difficult to furnish an internal input circuit with protection system because the I-7017 module features various input modes. Also, in an industrial monitoring field sometimes the monitoring input circuit of the module series-connected with an old instrument circuit can experience serious alternating interference and even direct current interference can easily be introduced into the circuit. This is especially true in the case of a pressure transmitter II which can product higher reversal voltage when the power of the transmitter is cut down. The reversal voltage will destroy the input circuit of the module. However, the field application needs a maintenance overhaul for some circuits without cutting the power. So it is necessary to design a circuit that doesn't interfere with the monitoring of the module and will provide protection for the input circuit of the module when abnormally high voltage is generated. A circuit with two reversals of 5V zener in parallel with the both sides at 125ohm resistance can be used for sampling current to form the current input circuit of the module. The wiring diagram is shown in figure 18 in which series connection of 1K and 125ohm resistances can reduce alternation and direct current interference at the input end of the module to a tenth of the signal normally monitored. Series connection of 1K resistance and two reversal of zener can provide limitation protect for the voltage of the module terminal under abnormal situations. It is apparent that 2.5V（20mA×125） is specified as the maxim voltage of the module terminal when used for current input, but the voltage of the zener should be higher than 2.5V. Testing performed by graphic instruments can guarantee that the reversal of zener doesn't generate leakage current under 2.5V voltage thus affecting the monitoring precision of the module.

**2.3 Issues on system real-time and reliability**

As an industrial real-time monitoring system the system naturally requires high reliability and robust real-time monitoring performance. This is even more the case given the industrial monitoring computer is a central component of the system undertaking the work of acquiring and processing data from sources distributed throughout the system. Both the hardware and software of the system ensure its reliability. The hardware aspect of the industrial control computer features strong protection against interference, watchdogs and a flash disk rather than a harddisk. The software is developed in DOS BORLAND C 3.1 which can execute operations directly on interfaces and set watchdog timers based on the motherboard of an industrial PC. The software should be so real-time that it can work out accumulating flux every 5 seconds depending on data which involves 20 instantaneous flux parameters inspected by the system and has been compensated for temperature and pressure. For the advantage of high operating efficiency and making the most of system resources, the C programming language is completely up to the task. The operating time including communication, data acquisition and time handled by the program is less than 3 seconds not exceeding 5 seconds cycle. An examination of the operating results of the system has proved the setup feasible and correct. The industrial monitoring computer has been placed in an operating room with a generator that has been operating successfully since March '99 without any failure even when a facilities failure generates a serious interference signal.

**2.4 Issues on reliability of the module communication program**

The lower-level monitoring network composed of modules and a monitoring computer is a host-guest communication system in which the computer will inspect and communicate with each module in sequence. The program by which the computer can communicate with monitoring modules through RS-485 introduced BIOS INT14 to drive hardware. The C language can guarantee the reliability of the communicating program but we also found that the program will abort when the monitoring modules are powered-off randomly. More work is needed to avoid this situation. When the host is communicating with one of modules and at that time the module is powered-off, the ensuing long wait also causes the host to abort. The solution is to open a timer at the beginning of the communication. If the time that the host waiting for the answer of a module is more than 0.2s the waiting program will be stopped. The host won't communicate with other modules until it receives the answer of the module after continuously trying to communicate with the module for three times. Then the operating status of the module, which is power-off, will be displayed in the screen. Use of this method can also avoid instantaneous communication interrupt failure caused by interference. It has been proven an effective solution in practice.

## 3 System operating results

The system has been operating successfully since March ‘99. Not only can all of the important parameters be monitored and controlled by production scheduling departments but also the system has the features of history inquire, parameter offset record and parameter operating curve, which greatly improve the quality of production management and production efficiency. In comparison with the same period of ‘98, the quantity of generation is more than 4,000,000 KWH of ’98, the consumption of standard coal has reduced 20,000 tons and the increase in production value is about RMB 10 million. All of these inspiring indications are attributable to modern testing and control technology.