Cabinet Mounting of the MICREX-NX

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1. Introduction

Control systems are often mounting in cabinets of the customers' desired dimensions in order to improve environmental resistance and ensure proper functionality and management range. So that devices enclosed within a limited volume can be configured and operated stably, the design of the cabinet must limit the rise in internal temperature and must be equipped to handle the assumed level of external noise at the site of the installation. In addition to incorporating these considerations, the cabinet for the MICREX-NX: new information and control system is also designed to use Euro terminal I/O modules to realize high-density mounting. Moreover, external terminals are replaced with the same ring terminal interface as in prior products to realize the same mounting efficiency as in the past. This paper presents an overview of the MICREX-NX cabinet mounting technology.

2. Necessity of Cabinets

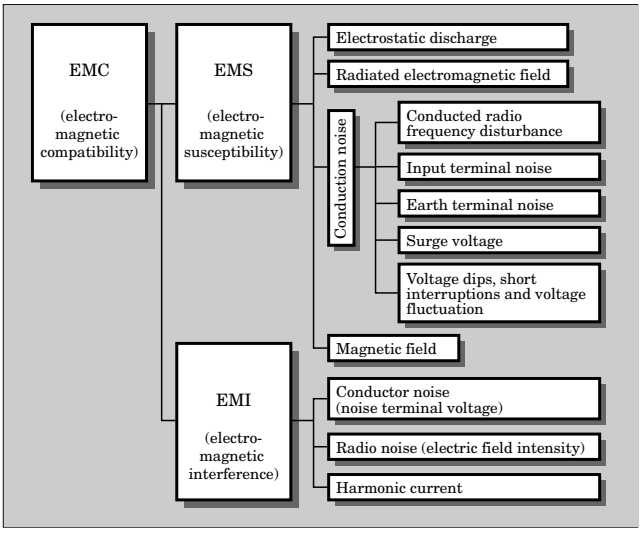
The main reasons for housing an industrial system inside a cabinet are given below.

(1) Management, operation and security consideration
  ① To clarify the system's responsibility of work and range of the contract
  ② To enable maintenance with a 1-to-1 relationship between the power supply distribution panel and the system
  ③ To clearly identify the manager and clarify his/her responsibility with lock and key management

(2) Environmental consideration
  ① Heat: To cool and/or heat the cabinet's internal ambient temperature to maintain the system at a suitable temperature
  ② Atmosphere: To protect the interior from corrosive gas and/or dust
  ③ Vibration: To protect the system from earthquakes and vibrations from large equipment
  ④ EMC: To realize EMC (electromagnetic compatibility), shown in Fig. 1, comprising both an EMS (electromagnetic susceptibility) level that is immune to external interference and an EMI (electromagnetic interference) level that does not disturb other equipment.

(3) Safety consideration
  ① To protect against bodily harm by preventing accidental contact with energized parts, heated parts, and moveable parts such as fans
  ② To prevent workers from accidentally touching the equipment (to prevent mistaken operation)

Fig.1 EMC classification



The MICREX-NX cabinet has been designed with the above considerations. The cabinet is described below with a focus on its thermal design, safety and EMC environment design, and Euro-to-ring terminal conversion.

3. Thermal Design

3.1 Cabinet cooling method

When mounted inside the enclosed space of a cabinet, the system will be adversely affected by heat. Thermal design is used to minimize this adverse effect. The thermal design also considers other conditions unrelated to heat and various cooling methods were designed.

Conditions unrelated to heat include the efficiency of mounting the system in the cabinet, protection against EMC, dust, corrosive gas and other environmental factors, and the tradeoff relation between these conditions and temperature rise.

The cooling methods shown in Fig. 2 are described below.

(1) Air cooling without a fan

In this method, heat is exhausted by natural convection through slits provided at the top and bottom of the cabinet. This method does not require any special equipment for cooling, and is advantageous in terms of cost and mounting efficiency.

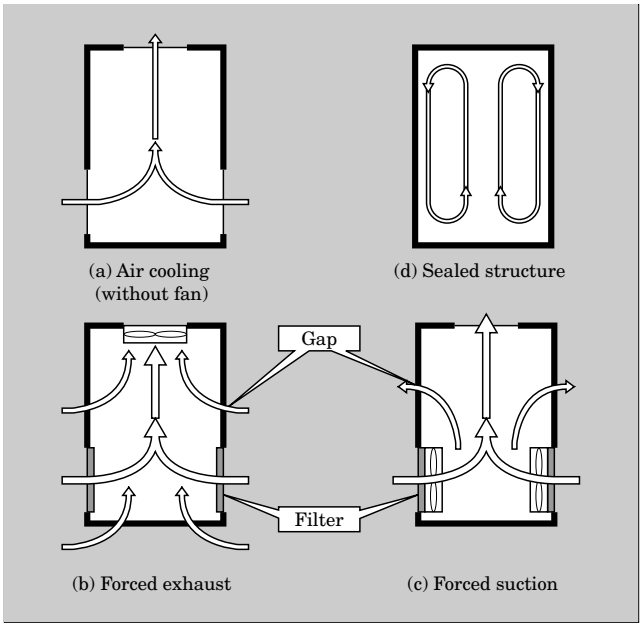
(2) Fan cooling

Forcible convection with a fan is used to exhaust heat.

① Forced exhaust
This method uses filters through which air passes at the cabinet bottom and a fan at the top of the cabinet to exhaust heat. The cabinet interior is negatively pressurized with respect to the external atmosphere and because gaps are also provided that allow the intake of small particles, this method is disadvantageous in providing protection from environmental factors such as dust and corrosive gas.

② Forced suction
This method uses filters through which air passes at the cabinet bottom and fans at the bottom of the cabinet to exhaust heat from the cabinet top by means of convection. Because the cabinet interior is positively pressurized with respect to the external atmosphere and the intake air must pass through a filter, this method provides excellent protection against the environment. However, because the filters and fans are concentrated at the bottom of the cabinet, the mounting efficiency is poor.

Fig.2 Cooling methods



(3) Sealed structure

In this method, the cabinet is completely sealed. Because no cooling fans or filters are used, and because there is no convection, this method provides ideal protection against dust and corrosive gas. However, the cooling efficient is poor since heat is exhausted solely by the radiation of heat from the cabinet surface. Another drawback is that corrosive gas may enter the cabinet when the door is opened and closed during maintenance.

In the case of forced cooling, this problem does not occur because external air that enters the cabinet is eventually replaced with filtered air.

3.2 MICREX-NX cabinet mounting

The MICREX-NX has been designed to enable mounting with any of the above cooling methods. The thermal design must be implemented such that the operating temperature of the mounted system does not exceed 60°C.

Figure 3 shows a drawing of the MICREX-NX controller cabinet mounting, and Fig. 4 shows the external appearance of that controller cabinet.

A redundant controller, control LAN communications device, power supply, power receiving and distribution equipment, and an alarm unit are mounted in the front panel. I/O devices for handling field signals and Euro-ring terminal conversion cables that connect to the field wiring are mounted in the back panel.

3.3 Actual thermal design

(1) Thermal balance

The mounting design basically organizes the system so that heat-generating devices are not arranged consecutively. As a result, heat does not become concentrated inside the cabinet and the temperature can be averaged.

In the cabinet's front panel, the controller and power supply, which are heat-generating source, are alternately mounted between low heat-generating equipment. In the rear panel, each I/O device is mounted so as to alternate with a Euro-ring terminal conversion cable, which generates no heat at all.

(2) Heat shielding and ventilation route

In order to prevent a rise in temperature, it is extremely important that the heat generated by equipment mounted in the cabinet does not affect any other equipment in that same cabinet. With the MICREX-NX cabinet mounting, a heat shield unit is used between each piece of equipment.

This heat shield unit exhausts the self-generated heat from the back top of the cabinet, without conveying that heat to upper stages, so that upper and lower equipment are shielded in heat. The heat shield unit is also provided with a function that supports the cables connected to each piece of equipment.

Fig.3 Mounting of controller cabinet

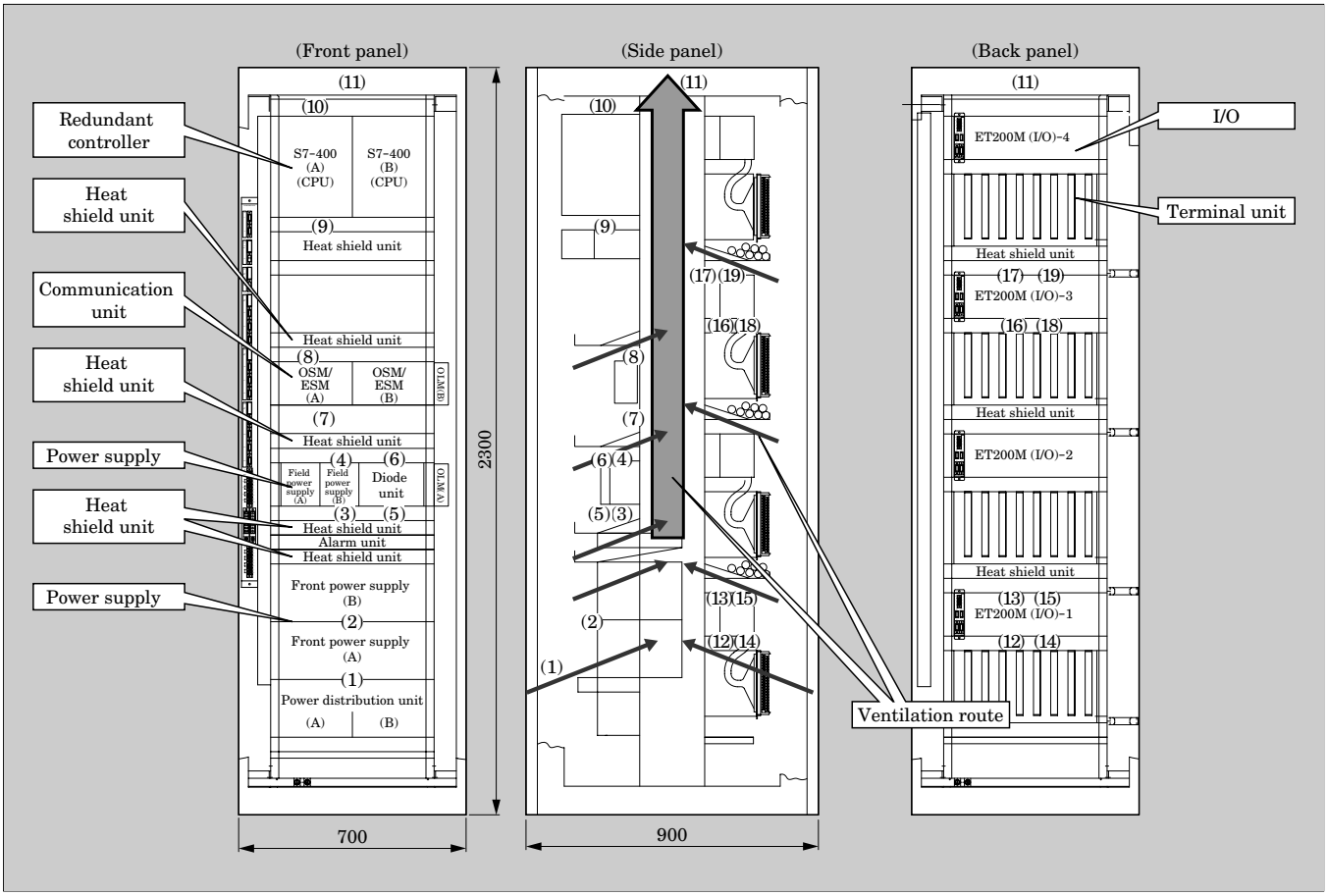


Fig.4 Appearance of the controller cabinet

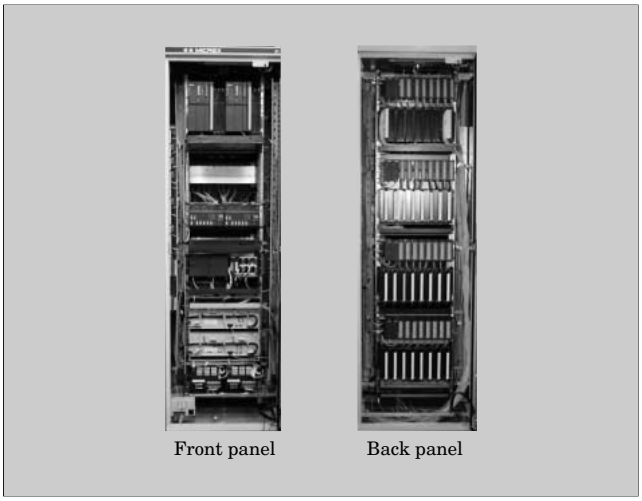
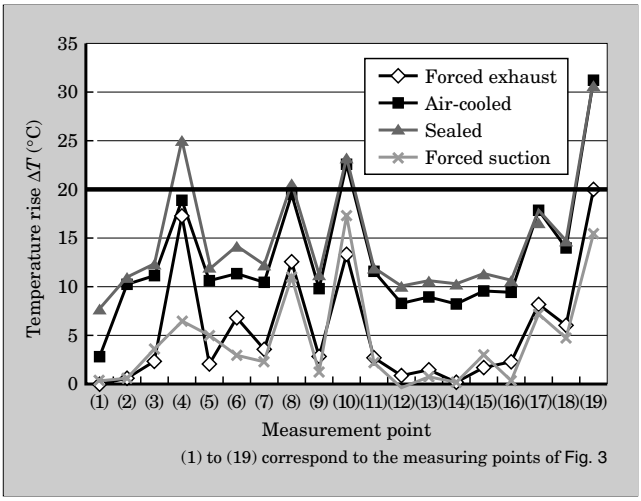


Fig.5 Temperature measurement results



In addition, the cabinet is designed such that heat exhausted from the rear passes through a chimney-like ventilation route provided in the center of the cabinet, to exhaust heat efficiently from the top of the cabinet.

(3) Actual measurement and evaluation of temperature distribution

For each of the cooling methods, the distribution of temperature inside a cabinet of the above design was measured and the suitability of the design was assessed. The results are shown in Fig. 5.

The operating temperature for each system must not exceed 60°C. Moreover, the maximum ambient temperature of the cabinet is 40°C, and the temperature rise at an air intake vent for the equipment mounted in the cabinet must not exceed 20°C.

A design tolerance of 5°C is maintained for these conditions, i.e., the cabinet must be designed such that the temperature rise at all air intake vents for a

system does not exceed 15°C. These results satisfy the design condition because temperature rises in excess of 20°C occur only at the exhaust vents.

Accordingly, the thermal design of the MICREX-NX cabinet enables mounting that is compatible with the cooling methods of air cooling without a fan, fan cooling with a fan, and sealed structure cooling, each of which has advantages and disadvantages with respect to mounting efficiency (cost) and resistance to the environment, i.e., protection from EMC, dust and corrosive gas.

4. Safety and EMC Environmental Design

Measures against heat and EMC are vital in ensuring the safe operation of the system. The layout of the power supply input unit and the power supply system is important because it forms a route along which disturbances and noise can travel. To realize the required specifications in a highly efficient manner, a front power supply method is adopted for the cabinet power supply input unit and the power supply system. The source power is received entirely at the front power supply, where it is then converted into a stable, low voltage of 24 V DC and delivered to each devices.

Because this front power supply has a noise-resistant design, EMC protection and the required cabinet specifications listed below are realized. Other internal devices and the cabinet layout are important because their design leads to better overall design quality, since the designers can concentrate on functional design and thermal design, without distraction from external requirements.

(1) Electrical shock prevention, insulation

100 V AC wiring is used only for connections between the power-receiving terminal and the front power supply. Insulation management is performed along this interval only.

(2) Noise resistance

There is less wiring for electric power within the cabinet and there is also less electromagnetic interference between electric power and signal wires.

(3) Harmonic current suppression function

Because the front power supply has functions for correcting the power factor and suppressing the harmonic current, there is no need to configure active filters for each devices.

(4) Input wide range power supply

Because the front power supply supports the input specifications of 100 to 220 V AC and 110 to 220 V DC, the internal devices can be standardized for an input of 24 V DC.

(5) Power supply line noise, surge voltage

The effective noise filter of the front power supply provides effective shielding from line noise and surge noise.

5. High-density Design and Euro-to-ring Terminal Conversion

The miniaturization of equipment and reduction in number of panels that accompany high-density mounting complies with requests for space savings and lower cost. By using a Euro ring-type I/O module, thermal design and a centralized power supply, MPU redundant systems with 1,536 (Euro terminals) and 1,024 (ring terminals) I/O points had been realized.

5.1 Euro terminal features and necessity for ring conversion

The characteristic feature of Euro terminals is that the exposed copper core of wire whose sheathing has been stripped off (or a cylinder-shaped pin attached to the wire) is inserted into the terminal and tightened with a screw to secure it. The two main advantages of Euro terminals are listed below.

(1) The space occupied per wire is less than for Japanese ring terminals, thus enabling higher mounting density.

(2) Wiring work is simpler and results in labor savings.

Direct application of the above advantages enables high-density mounting to be realized with up to 1,536 points, with reduced labor. In Japan, however, ring terminals are strongly requested and a mechanism for converting Euro terminals to ring terminals is available.

5.2 Design of Euro-to-ring terminal conversion

The Euro-to-ring terminal conversion method was designed in consideration of the I/O (IPU-Ⅱ) of the present MICREX-AX model, and in particular, a revision of its structure was considered.

As the result of this study, the Euro-to-ring-conversion cable, shown in Fig. 6, was developed. The advantages of this method are described below.

(1) More compact structure

The wiring is soldered directly onto the lead of ring terminal block. This results in a slimmer terminal conversion part and ensures the withstand voltage.

As a result, the number of I/O points could be increased from 768 to 1,024 in a single MPU redundant system cabinet.

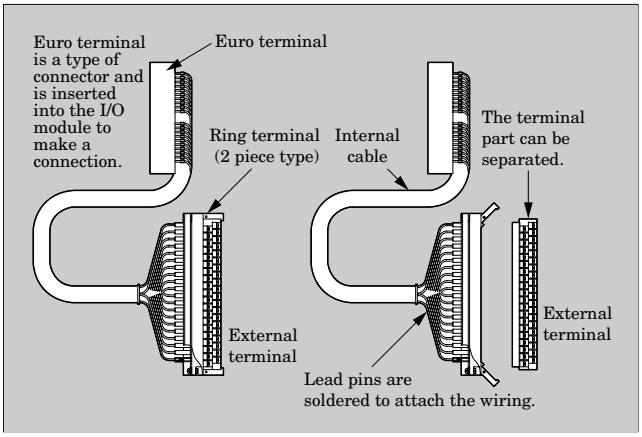
(2) Improved workability

A two-piece construction terminal block was adopted. Because the terminal block can be replaced to allow connection of the test equipment, the amount of labor involved in the testing was reduced.

(3) Cable wire as a component

In the cabinet layout, an external wiring terminal block is located directly beneath each I/O module, and the length of the cable for Euro-ring conversion is fixed. Thus, the wiring for the terminal is no longer dependent on the customer's specification. These parts

Fig.6 Conversion of Euro terminal to ring terminal



are available as cable assembly components, which are produced in advance and can be stocked.

6. Conclusion

The thermal design, safety and EMC environmental design, and the Euro-ring terminal conversion of the MICREX-NX cabinet have been described. In addition to these functions, there are also recent requests for environmentally conscious design.

The Fuji Electric Group has declared its intention to promote the reuse and recycling of constituent materials for cabinets, and to design cabinets that have low impact on the environment throughout their entire product lifecycle, from material procurement to structuring, transportation, usage, and finally, to disposal.

In terms of reuse and recycling, the design has changed to adopt labeling of the raw materials in the various components and to use rivets instead of angle welding construction for easier disassembly.

To reduce environmental impact, the Fuji Electric Group is working to improve technology for environmentally-conscious design and is involved in various efforts to reduce environmental impact, such as acquiring a type Ⅲ environmental label as established by Japan Environmental Management Association for Industry (JEMAI), for the first time in Japan in the control system field. (Refer to the “Low-voltage motor control center,” described on the JEMAI website (http://www.jemai.or.jp/).)

In the future, Fuji Electric intends not only to enhance system features and performance further, but also to maintain the highest level of environmentally conscious design and to continue to provide solutions to the marketplace and contribute positively to society.