General-Purpose Inverters Meeting Global Standards "FRENIC-HVAC/AQUA Series" and "FRENIC-Ace Series"

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ABSTRACT

In recent years, general-purpose inverters have been required to be multi-functional. Even in the areas where dedicated controllers or specialized variable speed drives were conventionally used, in an increasing number of cases customized general-purpose inverters are being adopted. The demand for product globalization is also increasing. To satisfy these needs, Fuji Electric has developed the "FRENIC-HVAC/AQUA Series" and "FRENIC-Ace Series" general-purpose inverters that meet global standards. These products are supporting our globalization by featuring a customized logic function as standard and introducing multi-language support and region codes. They also comply with international standards regarding noise immunity and functional safety.

1. Introduction

General-purpose inverters are utilized for a wide range of applications including energy saving in fans and pumps, and power saving and automating industrial machines. Fuji Electric offers a diverse line-up including a simple variable-speed series, with little load fluctuation suitable for fans and pumps, and a series equipped with high-performance vector control ideal for up-down conveyors.

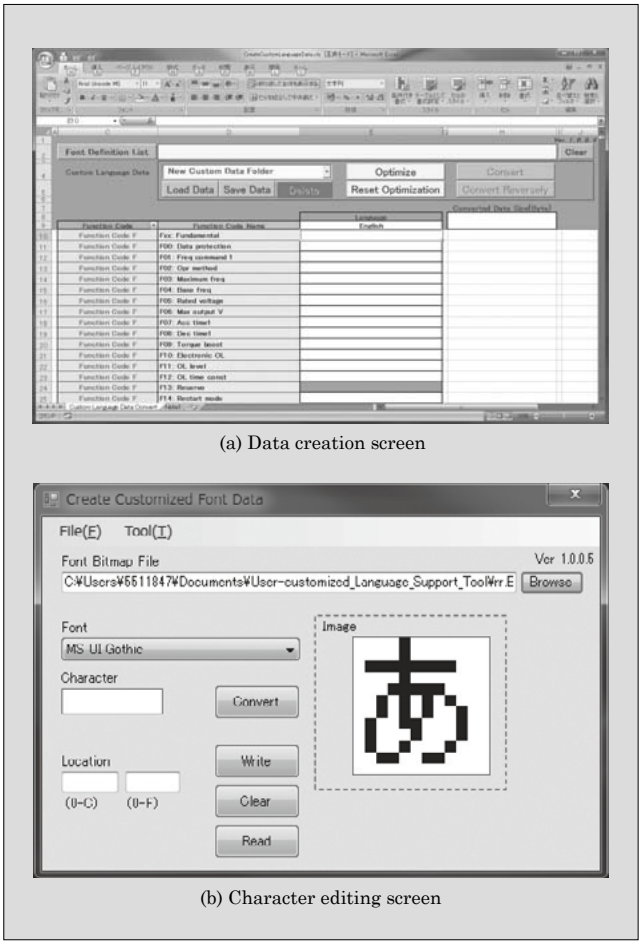
The newly developed "FRENIC-HVAC/AQUA Series" and "FRENIC-Ace Series" have been designed for global market and standards but also conformed to the international standards that are applied to the end products to which the inverters are to be built. This paper describes these inverters.

2. Expansion of Features for Global Market

2.1 Multi-language support function

One function required for globalization is to have a multi-language display. For users, being able to see indications in their own language when they want to verify inverter information such as function codes leads to a reduction in the number of accidents caused by misconfiguration or wrong understanding, and also makes it easier to read the display.

Traditionally, Fuji Electric's inverter series has provided interfaces in basically 6 languages including Japanese for customers in different regions. The number of languages available for the FRENIC-HVAC/AQUA Series has been increased to 19 to lower the language barrier. The 19 languages are as follows: Japanese, English, German, French, Spanish, Italian, Chinese, Russian, Greek, Turkish, Polish, Czech, Swedish, Portuguese, Dutch, Malay, Vietnamese, Thai and Indonesian.



(a) Data creation screen

(b) Character editing screen

Fig.1 Editing screen of User-Customized Language Support Tool

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2.2 User-Customized Language Support Tool

Characters to represent these 19 languages may also be used for languages other than the 19 but many languages require unique characters. In addition, terms may vary even in the same English-speaking world and the representations normally used by Fuji Electric may not always be easy for users to understand.

To address this problem, we have developed User-Customized Language Support Tool that meets all character-display needs. Figure 1 shows an example of the editing screen of this tool. The data creation screen shown in Fig. 1 (a) allows the user to set subtle linguistic expressions. Characters created by using the character editing screen shown in Fig. 1 (b) can be saved as character data, which makes them available for languages other than the 19 previously mentioned.

2.3 Introduction of regions codes

Fuji Electric's inverters have previously offered 7 models with different language and power supply specification (voltage and frequency) settings and terminal shapes and specifications for different regions of Japan, Asia, China, Taiwan, Europe, North America and Korea.

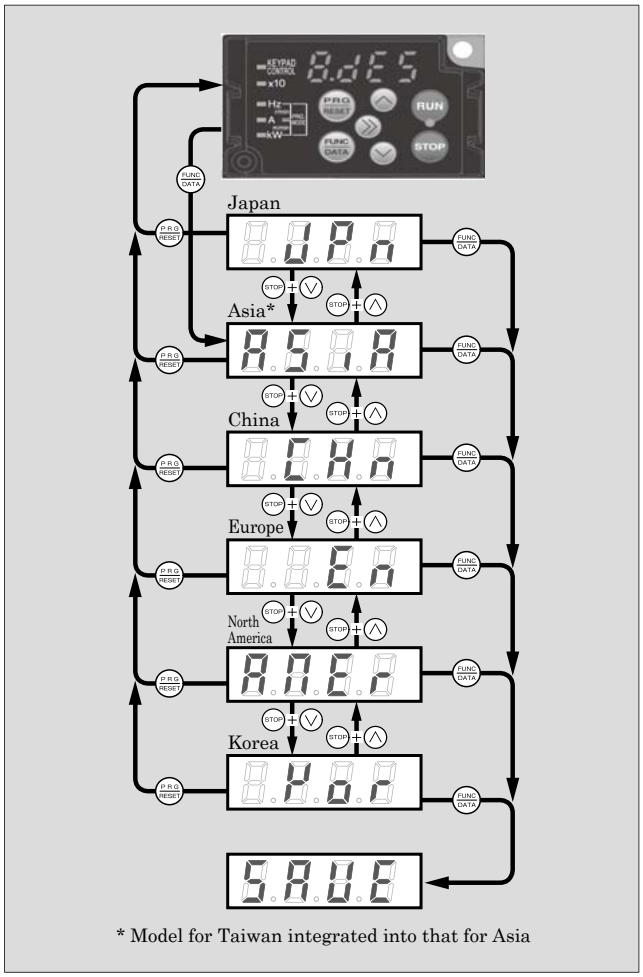


Fig.2 Region code setting

However, inverters shipped to various regions may be installed on users' machinery and equipment, and then often shipped in turn to other regions. This generated problems such as a difficulty in procuring products with the same specifications in the end-destination regions, and different terminal shapes and specifications puzzled operators and users, who have called for easier local procurement and standardization of specifications.

To deal with these challenges, we have prepared global models, in which hardware configurations of the existing products for the global market are integrated and standardized. The language and power supply specification (voltage and frequency) settings, which were traditionally factory-configured for different models for different regions, have been simplified to an automatic setting that the user can set merely by selecting a region code at the time of use, as shown in Fig. 2.

This integration and standardization have achieved a significant reduction in the number of models for the global market to one-third of the conventional models and streamlined the user's global procurement and inventory management while simplifying the setup operation.

2.4 Customized logic function enhanced and provided as standard feature

With the FRENIC-Ace Series, the significantly-enhanced customized logic function is provided as a standard feature (see Fig. 3).

Traditionally, end users' needs have been difficult to meet with standard inverter models, and specialized features demanded by manufacturers of assembled products have been served by using special products with the enhanced software functions of the inverters themselves and external control devices. The FRENIC-Ace Series, with the extended customized logic function provided as a standard feature, is capable of supporting these applications simply in standard inverter models (see Fig. 4). This has made it possible for engineering departments of sales hubs in various parts of the world, system integrators, machine builders and end users to program themselves.

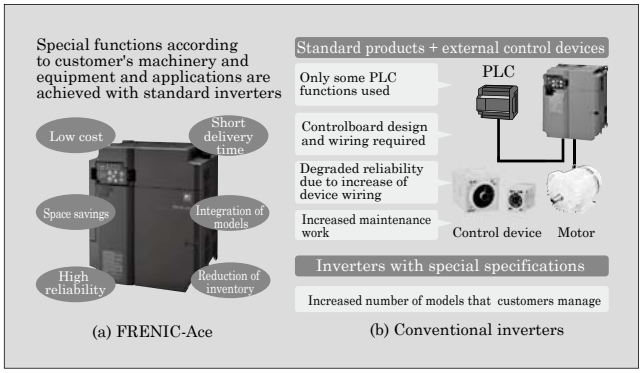


Fig.3 Customized logic function

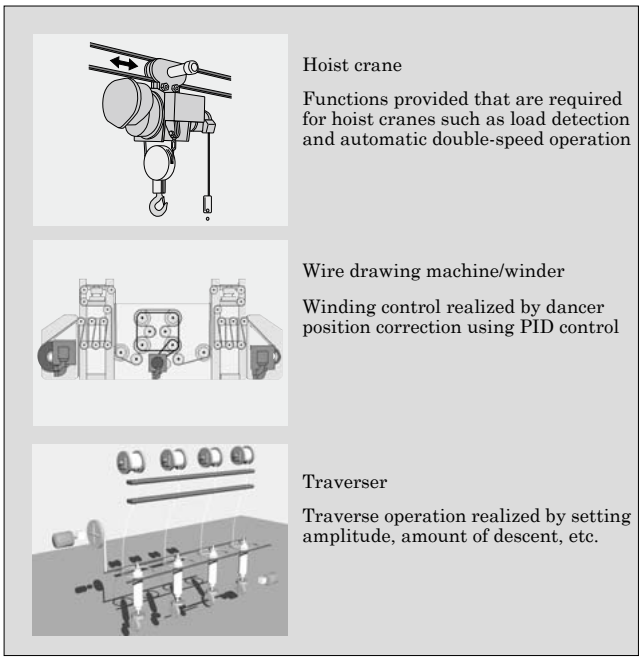
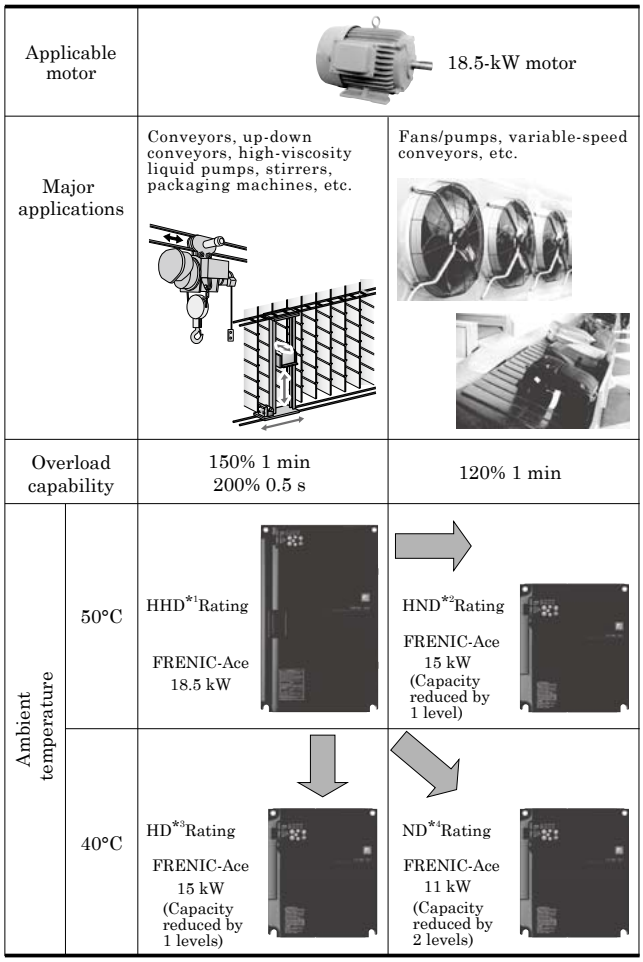


Fig.4 Examples of application of customized logic function



*1 HHD: High carrier frequency heady duty
*2 HND: High carrier frequency normal duty
*3 HD: Heavy duty
*4 ND: Normal duty

Fig.5 4 types of overload capacity

2.5 4 types of overload capacity

The FRENIC-Ace Series offers 2 options for "overload capacity" types, a high carrier frequency heavy duty rating (HHD rating) and high carrier frequency normal duty rating (HND rating), selectable according to the machines and devices used. It also offers 2 types of "temperature rating," 40 °C and 50 °C, as the upper limit of ambient temperature at the inverter installation location. This has made it possible for one model to support a total of 4 types of ratings (see Fig. 5).

The high carrier frequency heavy duty rating is suited for up-down conveyors that repeatedly start up and stop at high frequencies in multilevel warehouses, and stirrers for viscous materials and crushers in food processing machines and material processing. The high carrier frequency normal duty rating is suited for applications not requiring much overload capability such as moderate acceleration/deceleration and continuous rotation of fans and pumps, centrifuges, and conveyors. With the high carrier frequency normal duty rating, it is possible to adopt an inverter of one level smaller in capacity than that with the high carrier frequency heavy duty rating to drive the motor of the same output rating. Moreover, in an environment with an ambient temperature of 40 °C, an inverter of 2-level smaller in capacity (ND rating) can be adopted. This makes it easier to use the inverters for fan and pump applications and utility applications, the market of which is globally large.

3. Conformity to International Standards

3.1 International standards for inverters

When exporting inverters, it is essential to conform to the standards of the destination region. For example, conformity to EN61800-3 and EN61800-5-1 for Europe and to UL508C for North America is required. In regions with no original standards such as Asia, conformity to the EN and/or UL standards is a condition of tenders. The FRENIC-HVAC/AQUA Series and FRENIC-Ace Series conform to these standards. Recently, along with the more stringent requirements of standards, conformity to conditions according to the environment of the inverter installation location has come to be required, and the Series have achieved this.

3.2 Conformity to standards according to installation environment

Table 1 shows the standards to which the FRENIC-HVAC/AQUA Series and FRENIC-Ace Series conform.

The FRENIC-HVAC/AQUA Series provides inverters used for fan and pump applications, and the environment of installation locations extend to buildings, stores, stations and other commercial facilities in addition to factories. For installation in factories, it is desirable for the inverter to support longer motor cables. For commercial facilities, the generated noise must be suppressed to satisfy more stringent limit values. For

Table 1 Conformed standards

Series name	Standard	Standard name/condition
FRENIC-HVAC/AQUA Series	EMC*1	EN61800-3*3 C1: Motor cable 10 m C2: Motor cable 75 m/150 m C2/C3: Motor cable 30 m EN50121-5
	Momentary power failure tolerance	SEMI F47-0706
	Safety	EN61800-5-1 UL508C
	Functional safety	–
FRENIC-Ace Series	EMC*2	EN61800-3*3 C2: Motor cable 10 m
	Safety	EN61800-5-1 UL508C
	Functional safety	ISO13849-1 EN61508-1 to 7 EN61800-5-2

*1 Built-in Filter
*2 External EMC filter
*3 10 m: for general industries
75 m/150 m: for fans and pumps
30 m: for equipment using an earth leakage circuit breaker
C1: for residential and commercial areas
C2: for residential and commercial areas (installed under supervision of an expert)
C3: for industrial environment

installation in stations, compliance with EMC standards for railroad equipment may be required. The products have undergone an assessment to check their conformity to the standards shown in Table 1, which have been selected based on the requirements according to the installation environment.

The FRENIC-Ace Series, intended for machine tools and plant applications, also comply with the functional safety.

When selecting an inverter, users compare the standards that are required for their equipment with the standards that the inverter meets. However, manufacturer's specified conditions based on the EMC standards may differ from user's use conditions. When their conditions do not agree, the user is obliged to prove conformity, and this sometimes placed a significant burden on the user. Recently, manufacturers tend to acquire the certification of inverters intended for fan and pump applications with a representative installation environment. Individual user no longer needs to conduct tests for a conformity assessment, manufacturers, however, need to acquire the certifications with more conditions.

3.3 Design of EMI filter

To ensure one type of inverter conforms to multiple EMC standards, design of an EMI filter is essential. An example of an EMI filter circuit is shown in Fig. 6.

Inverter-generated noise has frequency characteristics with a peak at the LC resonance frequency generated by the self-inductance and capacitance of

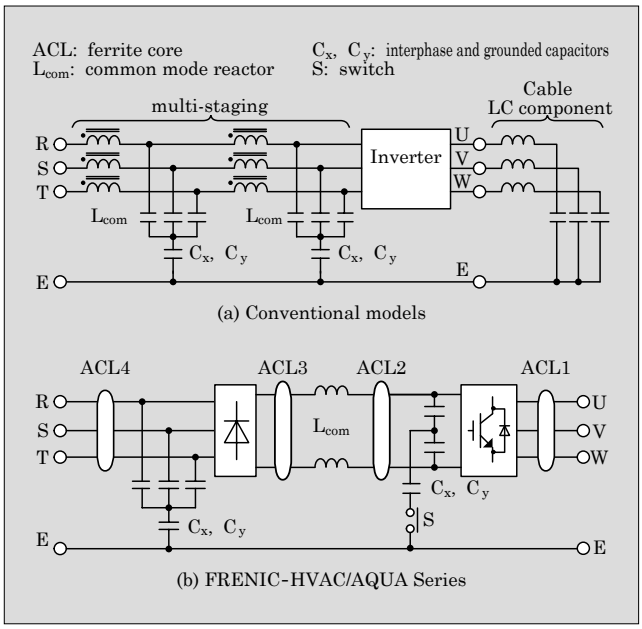


Fig.6 Example of EMI filter circuit

the motor cable. One known design technique for noise filters is to match the frequency that maximizes the attenuation characteristic of the filter with the peak of the noise, thereby allowing for a reduction in the size of the filter. Meanwhile, when the resonance frequency of the inverter-generated noise may vary depending on the cable length, the filter is, conventionally, designed to have high attenuation characteristics over the entire frequency region. One representative example of this is a 2-stage filter as shown in Fig. 6 (a). This design does not readily allow for a size reduction or built-in installation of the filter and may cause excessive attenuation depending on the frequency, and this has been a challenge. In order to solve it, we have made a fundamental revision for the FRENIC-HVAC/AQUA Series and adopted the EMI filter circuit shown in Fig. 6 (b).

In the conventional 2-stage filter, the part that hinders a size reduction is the common mode reactors. The common mode reactor is a cased ferrite core with a winding and its volume and cost account for 70% of the filter, which means that providing 2 stages requires twice as much volume and cost as that of an EMI filter. Accordingly, the FRENIC-HVAC/AQUA Series has not employed the 2-stage filter and has adopted distributed ferrite cores in various parts of the circuit to adjust the impedance of the filter. The ferrite core can be mounted simply by securing naked cores in the existing internal wiring, which makes them a very inexpensive component. In addition, the space in the vicinity of the internal wiring is often empty and addition of ferrite cores hardly increases the volume of the filter. As a result of adjusting the impedance with the ferrite cores, a noise attenuation equivalent to that with a 2-stage filter has been achieved with a volume and cost close to those of a one-stage filter.

The most important point in adjusting the impedance is to select appropriate ferrite cores. For the FRENIC-HVAC/AQUA Series, 30 types of ferrite cores with combinations of different core materials and sizes were prepared as candidates, and one of them has been selected to achieve the required impedance with the smallest possible size at each location. By changing the combination of material and size, attenuation can be adjusted without changing the circuit configuration. The built-in EMI filter that allows one inverter to meet multiple cable conditions has been realized for all capacity specifications of the FRENIC-HVAC/AQUA Series.

3.4 Conducted emission

Figure 7 shows the result of measuring conduct emission of the FRENIC-HVAC/AQUA Series. The noise peak frequencies greatly differ between both standards because of the different motor cables. However, both are shown to be lower than or equal to the limit values of their respective standards. There was almost no frequency band with an overdesign in reference to the standard value. For the waveforms in Fig. 7, switch S in Fig. 6 (b) is in the ON state and connecting a large-capacity grounded capacitor provides the high attenuation characteristics required for conforming to the C1 and C2 standards. However, this large-capacity grounding capacitor increases the leakage current of the power supply and may cause failures such as a malfunction of the earth leakage circuit breaker provided on the primary power supply side. Accordingly, for users not requiring support for the C1 standard or long-distance motor cables, opening switch S in Fig. 6 (b) makes it possible to reduce the leakage current and use the inverter with an earth leakage circuit breaker while satisfying the standard.

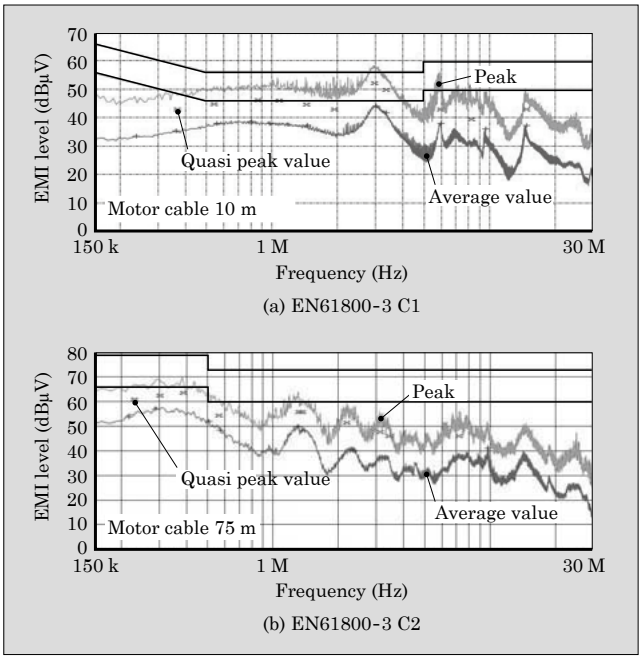


Fig.7 Conduct emission of "FRENIC-HVAC/AQUA Series"

4. Postscript

This paper has presented Fuji Electric's "FRENIC-HVAC/AQUA Series" and "FRENIC-Ace Series," general-purpose inverters that meet the global standards. The trends of multi-functionalization and globalization for meeting customer needs are expected to continue in the future. We intend to quickly grasp the trends and work to create truly global products.