FVR-C11S/S11S Series, the Compact Inverters

Kazuhiko Imamura
Takao Ichihara
Osamu Shiokawa

1. Introduction

General-purpose inverters are becoming widely used in the fields of energy saving fan-pumps, labor-saving or automation applications for industrial machines and consumer-related products. The low-capacity fan or mini-conveyor markets, characterized by light loads and variable speeds, which had been slow to adopt the general-purpose inverter because of its cost and size, has begun to use the inverters, to standardize the specifications of 50/60Hz machines and to replace magnetic contactors with contact-less devices in the main circuit. Consequently, new demand for these inverters has appeared.

In recent years, the way of dealing with environmental protection has become important. Therefore, higher harmonic reducing measures and the realization of low-noise are becoming more important for the tasks of general-purpose inverters. In order to respond to these needs, Fuji Electric has developed this new FVR-C11S/S11S series of compact type inverters.

2. Special Features and Specifications

An external view of the FVR-C11S series is shown in Fig. 1, and the FVR-S11S series is shown in Fig. 2.

2.1 Common features and specifications of the FVR-C11S/S11S series

2.1.1 Introduction of separate input and output wiring of the main terminals

For purposes of compatibility with the installation and operation of the conventional FVR-C9S series, the same attaching dimensions are employed, the separate wiring style of the main terminal as shown in Fig. 3 is utilized, and a terminal for the power factor correcting DC reactor and two ground terminals (main power supply side, motor side) are equipped as standard features. With this equipment, the wiring arrangement of upper-input and lower-output can be employed, therefore making the wiring work easier and simpler.

Further, in order to realize greater convenience for installation in cubicles, a rail-mounting base is optionally equipped on devices rated at lower than 0.75kW. Consequently the device can be fixed or loosened on the 35mm IEC compliance rails with a simple one-touch operation.

2.1.2 Consideration of the environment

In consideration of the environment, the following items have been adopted.

(1) Realization of low noise

IGBTs (insulated gate bipolar transistors), a source of noise, shall be controlled by soft-switching control which has a voltage change rate (dv/dt) less than 5kV/μs, and consequently the noise shall be limited. Further, for the FVR-C11S series, a quasi-resonance

Fig.1 External view of FVR-C11S series

Fig.2 External view of FVR-S11S series

Fig.3 Main circuit terminal of FVR-C11S/S11S series

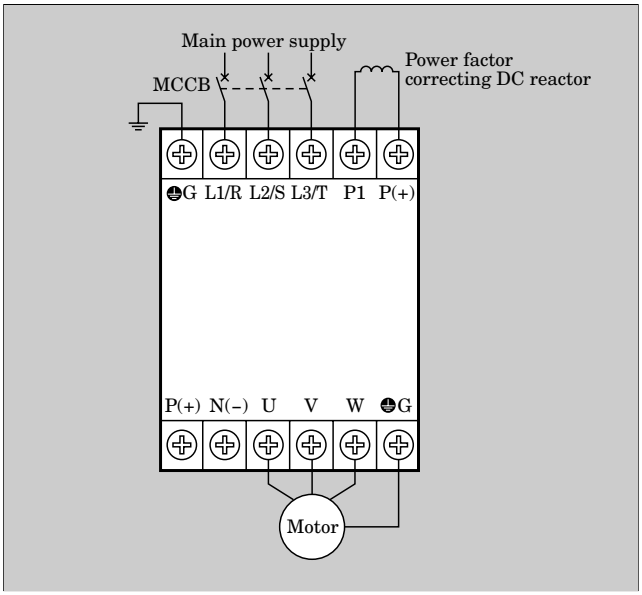
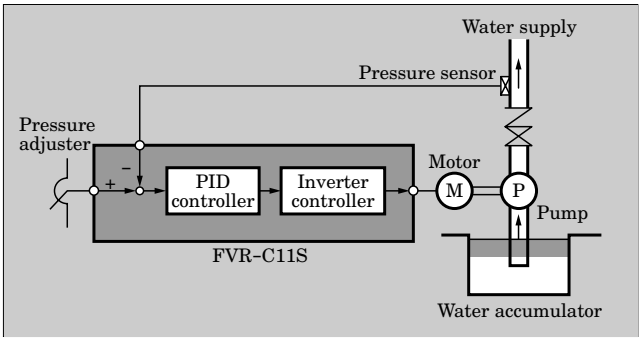


Fig.4 Application of FVR to pump system



type switching IC is utilized in the DC-DC converter, and the generated noise shall be minimized by aligning the switching-timing with the instant of minimum voltage between the drain and source of the switching MOSFET (metal-oxide-semiconductor field-effect transistor). Thus, the noise-influence to surrounding devices such as sensors is decreased drastically.

(2) Easy classified disposal

As environmental protection measures, lightweight products (max. 10% less than conventional products) are realized and the number of parts (max. 20% less than conventional products) is minimized. Further, the metal-insert molding in plastics is discarded, and thus, the construction was designed with consideration for ease of classified disposal.

2.1.3 Worldwide compatibility

In order to cope with foreign markets or indirect exports attached to some equipment, it is necessary for the inverter to comply with foreign safety standards or the like. For that purpose, the standard models of this series conform to the UL/cUL standard and the EN standard (CE marking).

2.2 Features and specifications of the FVR-C11S series

Compared with the conventional FVR-C9S series, the new FVR-C11S series is enhanced with the additions of a PID (proportional, integral, derivative) control function, accumulated operating time display for maintenance, on-off control of the cooling fan, and increased functionality adopting programmable input terminal. In addition, operation by serial communication (RS-485) is possible as an option. Furthermore, the function codes are standardized within the 11 series and improved for easier understanding.

We would like to introduce here some additions and improvements compared to the conventional FVR-C9S series.

2.2.1 PID control function

For fans and pumps, the most suitable PID-control is adopted in order to maintain a smooth and stable rate of flow in accordance with the variation of pressure. In the case of the FVR-C11S series, this function is installed in the inverter as a standard so that the feedback signal from the sensor can be input directly to the inverter. In this manner, the external PID-controller required by the conventional inverter has become unnecessary, and consequently this new inverter is more economical.

Figure 4 shows an example of a constant pressure control system that utilizes an inverter. Pressure in the water supply system is detected by a sensor, and that pressure is controlled by means of inverter control of the pump speed to always be constant, regardless of variations in the supply pressure. In the low rotating speed range where water supply is less, the pump load becomes small and a big energy-saving effect is obtained.

2.2.2 Accumulated operating time

By indicating the accumulated operating time of the inverter, the time for replacing electrolytic capacitors and other components that wear out can easily be estimated and consequently maintenance ability improved.

2.2.3 ON/OFF control of cooling fan

Based on the relation between the heat sink temperature and operating state of the inverter, an ON/OFF control was employed in which a cooling-fan rotates only when necessary. In this manner, the life of the cooling fan was prolonged, noise decreased and greater energy saving was realized.

2.2.4 Terminal function can be selected for increased functionality

The number of control circuit terminals in a small-size inverter such as the FVR-C11S series is limited by size constraints. On the other hand, a wide variety of terminal functions are requested by the user. Therefore, if limited to fixed functions, the general-purpose usefulness will be lost. For this reason, the X1, X2, X3-terminals of the FVR-C11S have multiple functions and many functions can be selected from a few terminals. A total of eight terminal functions such as

Fig.5 External view of Power Module

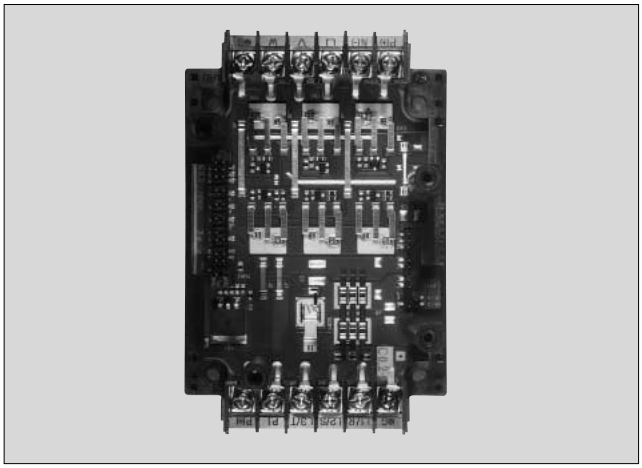
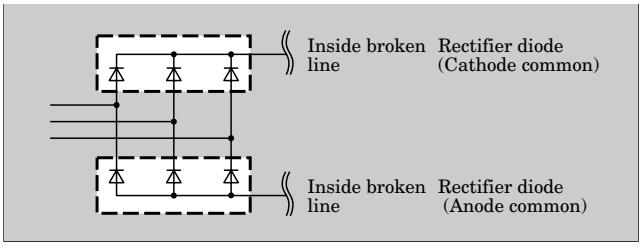


Fig.6 Circuit configuration of converter in FVR-C11S/S11S



coast-to-stop command, external alarm, alarm reset, multi-step frequency, etc. can be selected.

2.2.5 Rush current reducing circuit is equipped on all types

In order to prevent the welding of contacts in a magnetic contactor by rush current at the moment of power circuit closing, a rush current reducing circuit is equipped on all inverters in this series as a standard. As a result, inverters thus equipped can utilize smaller magnetic contactors, compared to unequipped inverters.

2.3 Features and specifications of the FVR-S11S series

2.3.1 Three types of inverters are available for different applications

Although functions of the FVR-S11S series are limited, the following three inverter types are available according to user requests. Consequently, supply of a low cost and optimally suitable inverter is possible.

(1) A volume type inverter (FVR-S11S-V) that sets the frequency by adjusting the volume on the inverter front and operates with turning · reversing · stopping switches.
(2) A terminal type inverter (FVR-S11S-S) that sets the frequency by an external 0 to 5V input and operates according to the ON/OFF input of the control terminal.
(3) A serial communication type inverter (FVR-S11S-C) that operates according to RS-485.

2.3.2 Simple setting of functions

This inverter series can set the following: high carrier frequency and low carrier frequency switching, torque boost, acceleration/deceleration time, base frequency, and maximum frequency including electronic thermal overload relay which protects the overload of motor. In the case of V and S type inverters, these functions can be set easily with a switch or by adjusting the volume. In the case of the C type inverter, these items can be set directly from a personal computer or programmable controller via RS-485 communication.

3. New Technology Adopted in the FVR-C11S/S11S Series

3.1 Connection without aluminum wire bonding

The parts of a semiconductor chip such as transistors or diodes of the main circuit have been electrically connected hitherto by aluminum wire bonding technology to comprise the circuit. With this method, the substrate can be freely designed however there is a limit on how much the production time can be decreased. Therefore, Fuji Electric developed an original chip with an electrode that can be soldered, different from conventional bonded chip.

Figure 5 shows an external view of a power module in which the chip has been soldered to a metal bar directly. By adopting this new method, production time has been decreased and bonding that is more reliable than the conventional one has been realized.

3.2 Development of the diode chip rectifier

The general-purpose inverter has a converter in which alternative current is once converted into direct current. In the case of 3-phase input as shown in Fig. 6, this inverter is comprised of 6 diodes. In order to decrease the space occupied by parts and pursue economy, we integrated the circuit shown in the broken line of Fig. 6 into a single part, and developed a Fuji Electric original diode chip rectifier. There are two types of chips, one is the upper arm side (cathode common) and another is the lower arm side (anode common). Because of this development, smaller total equipment size and improved reliability with non-bonded connections are expected.

4. Conclusion

An overview of the compact type inverter FVR-C11S/S11S series has been presented.

We expect that this series will satisfy many users with its low noise operation by the utilization of a quasi-resonance type switching IC, etc. and wide variety of functions made possible.

We will continue to make efforts to develop products gentle for the environment such as by adopting lead free solder, and to realize further improvements which correspond to the needs of the market.