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Fuji Electric

Innovating Energy Technology

Medium-voltage Drives

FRENIC4600FM5d

24D1-E-0003a

Environment-friendly drives.

Medium-voltage drive FRENIC4600FM5d is used for direct variable-speed control of medium-voltage motors, and greatly raises the efficiency and power factor, stabilizes motor operation and conserves energy.

Compact design for space saving

- The industry's smallest-class inverter achieved by significant panel size reduction

Ideal inverter for power sources and motors

- The multi-phase diode rectifier system reduces harmonics on the power source side.
- Due to the use of Fuji Electric's unique multi-level PWM control system, the switching surge is reduced and existing motors (standard ones) can be operated.

High-efficiency and high-power factor

- The use of a multi-phase diode, full-wave rectifier provides a high-power factor (95% or more) on the power source.
- The elimination of output transformers for operation has improved total efficiency (approx. 97%).
- Fuji Electric's original multi-level PWM control has reduced the IGBT switching loss.

FRENIC4600FM5d, capacity: 6.6 kV, 960 kVA panel
*The door is optional.
(In the standard configuration, a cover is provided.)

FRENIC4600FM5d

High-reliability

- Higher equipment reliability is achieved by reducing the number of inverter cells by using a single-phase, 3-level inverter, etc..
- Stable operation is maintained despite load fluctuations, by the simple sensor-less vector control function.
- The control device has a 32-bit MPU for quick response and high-accuracy.

Contributes to energy saving

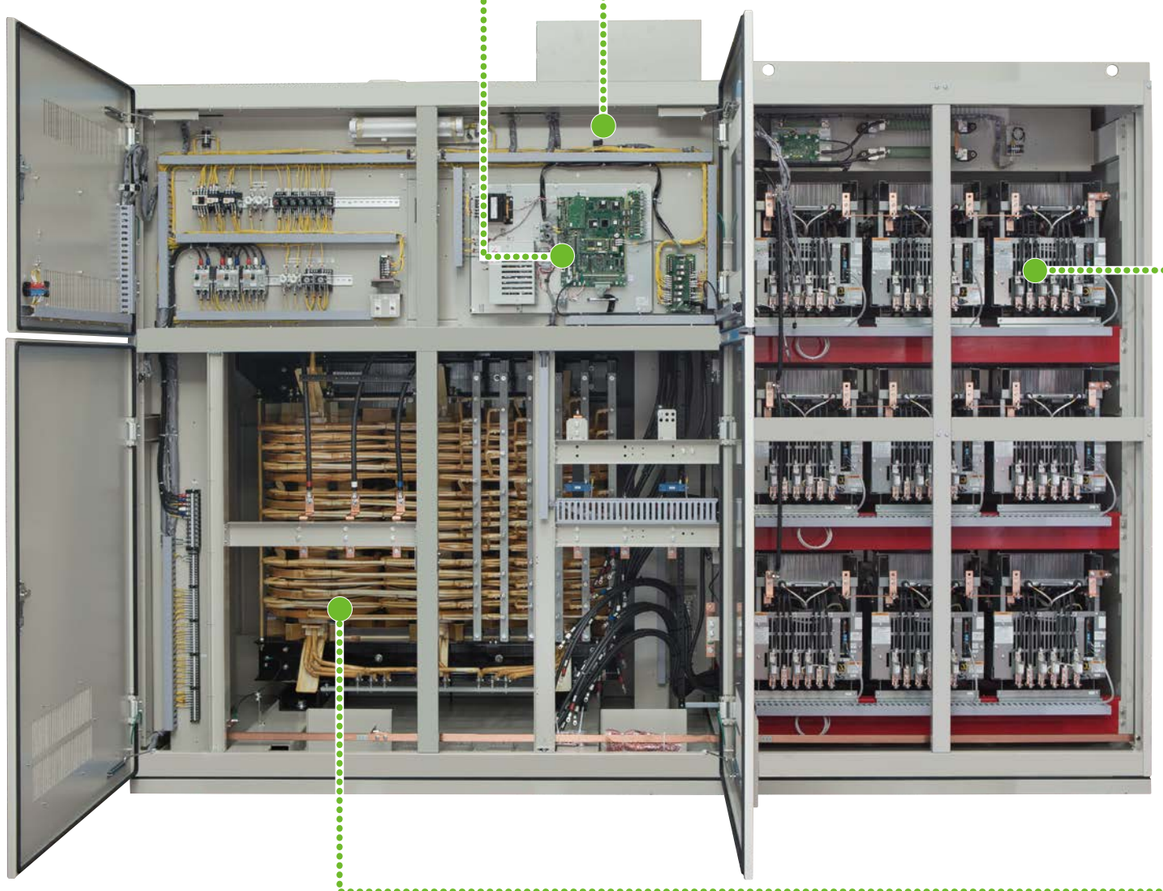
- A substantial energy saving is achieved by variable-speed control of a square-law reduced torque load such as a fan or pump.

Easy maintenance

- The inverter is air-cooled, requiring no cooling water.
- Start/stop operation, parameter setting, fault display and data monitoring are performed from the touch panel with simple loader functions.
- Simple, built-in auto-tuning functions facilitate testing and adjustment.
- Fault diagnoses are easily performed.
- A dry-type input transformer is adopted.

Simple circuit configuration

High-reliability and simple-maintenance inverters utilizing the latest power electronics such as 3-level inverter, mounting of special MPU and no need for harmonic filter/power-factor regulating capacitor.



FRENIC4600FM5d, capacity: 6.6 kV, 960 kVA panel
*The door is optional.
(In the standard configuration, a cover is provided.)

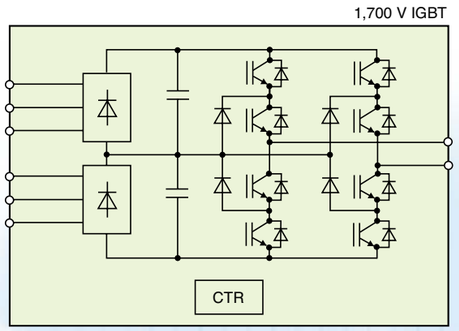
When requested, protection covers can be provided inside the inverter panel (as an option). Protection covers will protect from unexpected contact with live metal parts of the main circuit.

Cooling fan

- Air-cooled inverters make maintenance easy.

Inverter cell

- The number of inverter cells has been substantially reduced by adopting a single-phase, 3-level inverter design.
- Each inverter cell alone can be replaced easily, because the controller, diodes, IGBT elements and DC intermediate capacitor are combined into an integral body.



Master control PC board

- Mounting of a 32-bit MPU, and a special MPU in the voltage and current detection system offers a quick response and high accuracy.
- Incorporation of a simple sensor-less vector control function enables inverters to maintain stable operation irrespective of load fluctuation even without a speed sensor.
- Vector control with a speed sensor is available (as an option) for equipment having high speed and torque accuracy requirements.

Input multiplex-winding transformer

- Harmonic current on the power source side is low due to a multiplex configuration of the secondary winding.
- 36-phase equivalent rectification is achieved to allow the harmonic current to conform to the guidelines.
- Harmonic filters and power factor improving capacitors are not needed.
- Because a dry-type input transformer is used in the panel, external cabling work between the input transformer and inverter panel is no longer necessary.

Examples of applications

FRENIC4600FM5d contributes greatly to energy saving in the driving operation of various types of industrial facilities. Energy saving trends are continuing to expand throughout the world and will accelerate in the future, and this will further expand the application areas for this series.

Petrochemicals

- Hydrogen compressor
- Oil transport pneumatic conveyor
- Fan, pump, granulator

Mining

- Belt conveyor
- Grinder
- Mine ventilation fan

Electric power

- Induced draft fan (IDF), forced draft fan (FDF)
- Primary, secondary blower
- Condensate pump
- Circulating water pump
- Conveying pump

Water treatment

- Purification plant
- Seawater desalination facilities
- Wastewater treatment plant

Iron and steel

- Blast furnace blower
- Primary, secondary dust blower
- Sintered fan
- Circulating water pump
- High-pressure phosphorus removal pump
- Fan, cooling water pump
- Crusher

Other industries

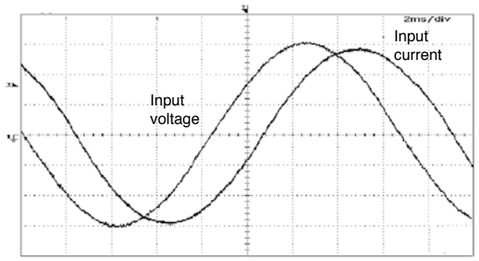
- Paper making, pulp
- Sugar refining (squeezer)
- Automotive test equipment
- Rubber, cement, etc.

Clean power input

Substantial reduction of harmonic current on power source side

Due to progress in power electronics, semiconductors have recently been used for industrial electrical equipment and household electrical appliances in order to enhance convenience and ease of operation. However, due to harmonic currents generated from such equipment and appliances, the voltage of the power system is often distorted and many troubles occur in equipment connected to the power system. However, because the use of equipment containing power electronics will increase, measures for suppressing harmonics need to be improved.
FRENIC4600FM5d suppresses the harmonics by using a multi-phase diode rectification system (equivalent to 36-phase) and therefore is an inverter that is friendly to a power source that conforms to the harmonic restraint guidelines.

■Current waveform on power source side



■Harmonic current content (6.6 kV)

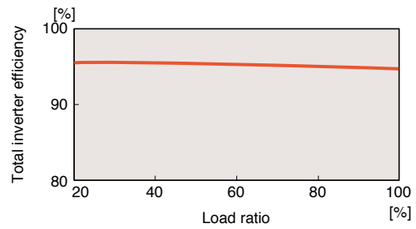
Order	5th	7th	11th	13th	17th	19th	23rd	25th	35th	37th
IEEE value [%]	4.00	2.86	1.83	1.49	1.14	1.02	0.87	0.80	0.80	0.80
Measured value (*) [%]	0.58	1.0	0.20	0.32	0.75	0.54	0.06	0.24	0.58	0.27

(*): Example value from our full load test

Total inverter efficiency as high as approximate 97% (at full load)

- Because an output transformer is unnecessary, inherent losses are eliminated.
- Multi-level PWM control minimizes switching loss.
- Because the harmonic current on the power source side is reduced, the primary winding of the input transformer has a reduced loss due to the harmonics.

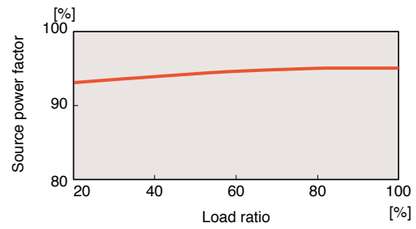
■Total inverter efficiency curve (including input transformer)



Source power factor as high as 95% or more (at full load)

- Due to full-wave rectification with multi-phase diodes, operation is allowed with the source power factor (power factor on power source side) set at a high level.
- A phase advancing capacitor and a DC reactor for improving the source power factor are unnecessary.
- A smaller power capacity suffices for inverter operation.

■Source power factor curve



Friendly to machines

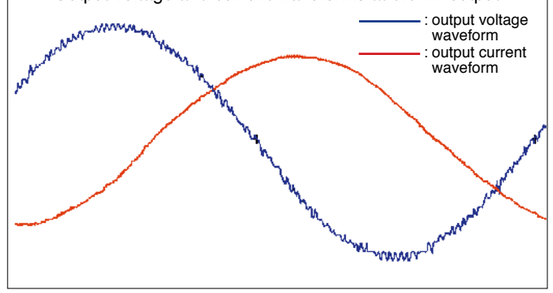
If a harmonic current component is contained in the inverter output current, a torque ripple occurs on the output shaft of a motor. A torque ripple means a change in rotational speed or a large vibration if the frequency of the torque ripple matches the natural frequency of the mechanical system and torque ripple is large.

In FRENIC4600FM5d, the harmonic component on the output side is extremely small due to the multi-level (max. 13 levels) PWM control and the main component of torque ripple is at around the carrier frequency (several kHz). Therefore, torque ripple hardly affects the machine side.

Friendly to motors

- The multi-level PWM control provides an almost sinusoidal output current waveform, thus reducing motor torque ripple.
- Because the output current is almost sinusoidal, a motor suffers less loss due to harmonics.
- The multi-level (max. 13 levels) PWM control minimizes switching surge and thereby reduces stress on the motor.
- There is no need to reduce motor capacity due to inverter drive.
- There is no need for special cables, etc. due to inverter drive.
- This inverter is applicable not only to a square-law reduced torque load, but also to a constant torque load such as an extruder.
- For driving a large-capacity motor in a system that has a small power capacity, voltage fluctuation, etc. due to the starting current of a motor will cause problems. However, because the starting current can be suppressed by the soft start of this inverter, operation can be performed.

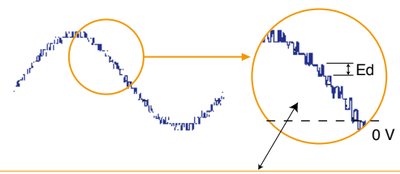
Output voltage and current waveforms at 6.6 kV output



Note

Surge voltage and multi-level output
The output voltage waveform of a PWM inverter is a DC chopping voltage (called "pulse voltage = surge voltage") whose amplitude is determined by voltage Ed of the DC intermediate circuit. When this surge voltage of inverter output is applied to a motor through a cable, the voltage is reflected repeatedly between the motor terminal and inverter terminal.
A sharp overvoltage higher than the inverter output voltage is thus generated at the motor terminal, which may cause dielectric breakdown of the winding.
Fuji Electric's medium-voltage inverter suppresses this DC intermediate voltage level using multi-level PWM control to achieve an output voltage waveform at 13 levels, and this enables overvoltage generated at the motor terminal to be suppressed.

Output voltage waveform (13 levels) in 6 kV class



In the 6 kV class Fuji Electric's medium-voltage inverter, the output voltage changes in 13 steps (corresponding to 13 levels) within 1/4 cycle. The voltage value of one step equals the DC intermediate circuit voltage Ed. Therefore, for the same voltage output, a larger number of steps means a smaller voltage value at one step. Thus, Fuji Electric's inverter can also reduce the surge voltage appearing at the motor terminal and thereby moderate the stress applied to the motor.

Main circuit configuration

Fig. 1 Main circuit configuration of 6.6 kV type

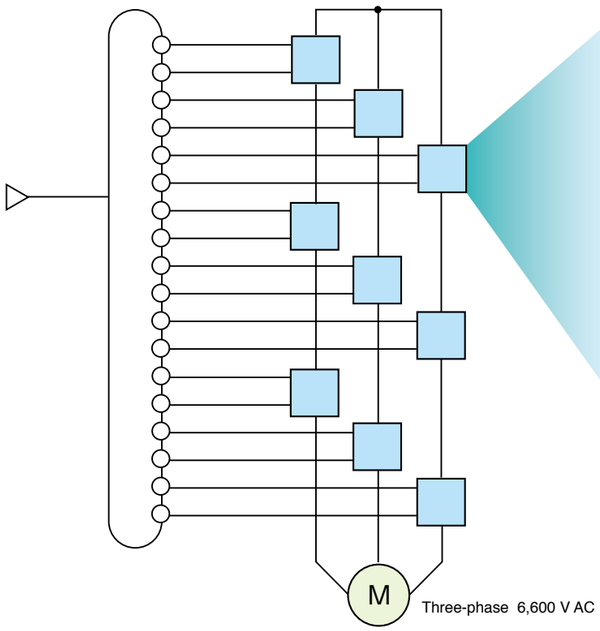
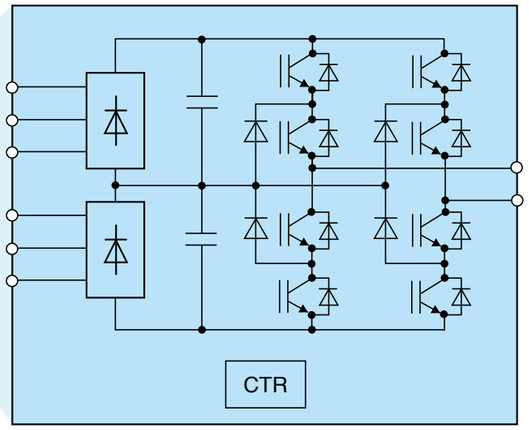


Fig. 2 Internal configuration of inverter cell



●Principle of operation

FRENIC4600FM5d consists of an input transformer and 9 inverter cells as shown in Fig. 1.
One inverter cell consists of a single-phase, 3-level inverter and can receive an output voltage of 1,270 V.
As shown in Fig. 1, this inverter unit obtains a phase voltage of approximately 3,810 V by connecting three inverter cells vertically. A star connection of these vertical cells can generate a line voltage of approximately 6,600 V.

Compared with a single-phase, 2-level inverter, use of a single-phase, 3-level inverter doubles the output voltage obtainable from one cell. Therefore, the required output voltage can be obtained by using fewer inverter cells. (See Figs. 3 and 4.)

Fig. 3 3-level voltage output

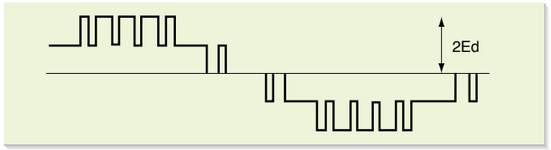
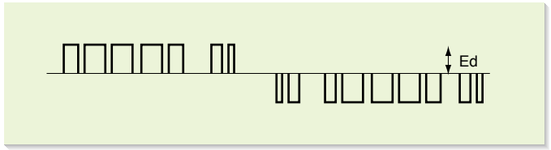


Fig. 4 2-level voltage output

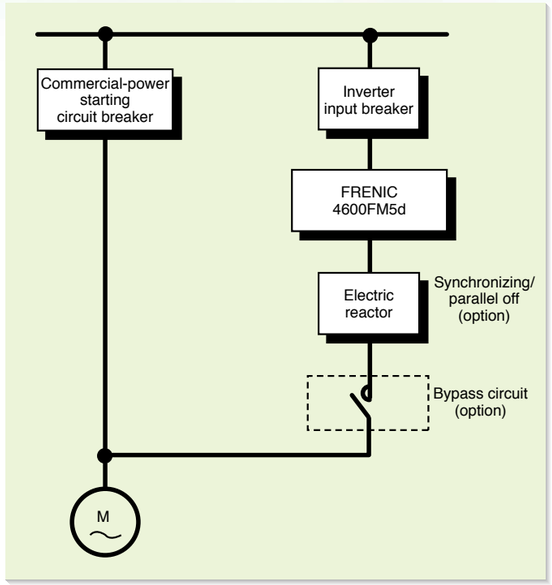


Ed: DC intermediate circuit voltage

Commercial power supply bypass circuit

●Changeover to the starting circuit by commercial power supply can be made by installing a bypass circuit (option) on the inverter output side.
In this configuration, motor drive power supply is duplicated, and changeover between commercial power supply and inverter operation is allowed for running a motor at the rated speed. (See Fig. 5.)

Fig. 5 Power system diagram



Synchronizing and parallel off function

●Shockless switching between inverter operation and commercial power operation allowed by phase control according to system voltage. (See Fig. 6.)
(Synchronizing/parallel off function: option)
An optional electric reactor must be installed on the output side of the inverter to enable this function.

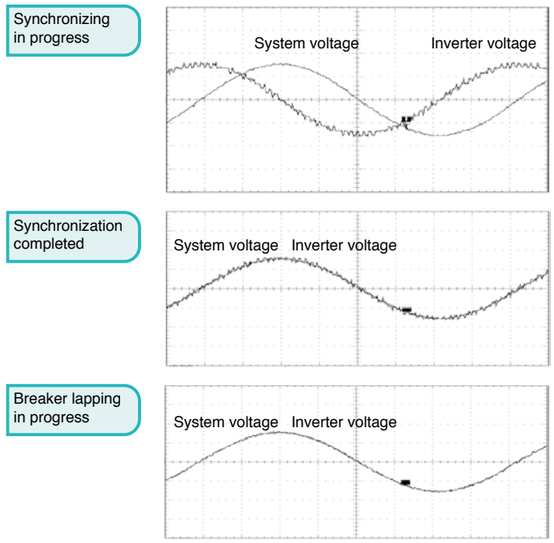
Restart after momentary power interrupt function

●In the event of a voltage drop due to a momentary power interruption, the operation processing pattern can be selected according to the application.

1. **Selection of major fault at voltage drop due to momentary power interruption**
   The inverter is stopped in the major fault status and the motor is set in the free run status.
2. **Selection of restart under free run (option)**
   Inverter operation is stopped and the motor is set in the free run status. Upon power recovery, the motor under deceleration in free run or under stop is automatically accelerated again through a speed search function.
3. **Selection of continuing operation at voltage drop due to momentary power interruption (option)**
   Inverter operation is continued without setting the motor in the free run status even when a voltage drop due to a momentary power interruption occurs. As soon as line voltage is recovered, the motor is accelerated again back to the operating speed.

Notes:
(1) A voltage drop due to a momentary power interruption will be detected at 85% or less of the rated voltage.
(2) Operation can be continued within 300 ms at a voltage drop due to a momentary power interruption (option).

Fig. 6 Synchronization/parallel off waveform



Data setting and monitoring

Operation and monitoring simplified by the touch panel equipped with LCD

LED monitor

Under load running:
Displays the number of revolutions.

At tripping:
Flashing "Err" is displayed.

LCD monitor

Displays various information including operation data, set data and fault data.

UP and down key

Used for changing data No. and values of data setting.

Program key

Used for moving to the monitor screen.

Shift key (digit shift)

Used for shift the position of the cursor from one digit to another in order to change data.

Reset key

At tripping: Releases the stop status due to tripping.
Under programming: Returns to the previous layer.

Run key

Stop key

Function/data selection key

Used for selecting display data, moving to data changing mode, and saving data.

Display description of the touch panel

No.	Description	Number of items
1	Current, voltage and frequency at present (*)	7
2	Parameter setting items	About 320
3	Di/Do status display	7
4	Controller RAM data	About 80
5	Ai/Ao status display	11
6	Sent/received data	About 20
7	Cause of fault	20
8	Present time, operation time	3

(*): Displays 7 items on the 2-image screen.

Other functions

- **Fault history**
  Displays a chronological record of 100 faults with the cause and the date and time of occurrence.
- **Trip data display**
  Displays the sampling values of internal data and bit data ON/OFF status in the event of a fault.
- **Save of set data, load, and comparison**
  The set data can be saved in the EPROM of the touch panel.
  The saved data can also be loaded and compared with other saved data.

Options

FRENIC4600FM5d

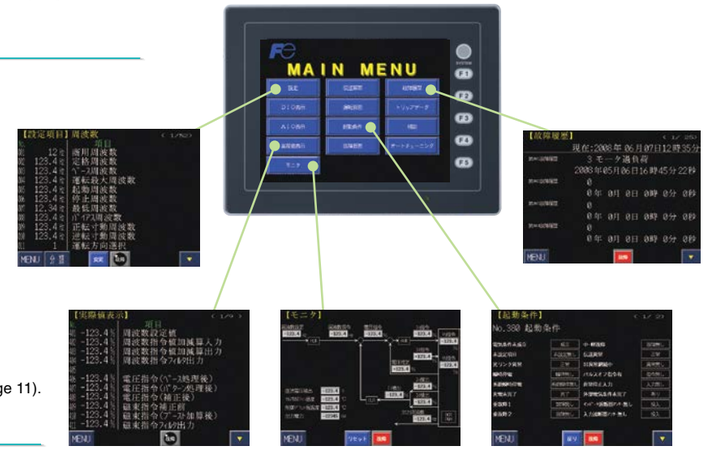
Large LCD touch panel

This is a 5.7-inch LCD setting and monitoring display that enables easy operation and monitoring.

Main functions of LCD touch panel

- Inverter start/stop
- Setting, change and indication of control parameters
- Bar graph display of actual value data
- Fault cause display
  (First fault and detailed display)
- Trend display
- Test operation, etc

Notes:
(1) The LCD unit can be mounted on the panel face
(at the position where the touch panel is mounted in page 11).
(2) The display language is Japanese, English or Chinese.



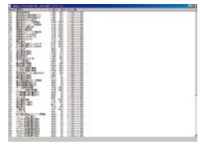
Maintenance tool DDC loader

Although the touch display on the unit's panel can be used for maintenance and adjustment, an optional DDC loader is provided as a maintenance and adjustment tool. The DDC loader uses a notebook computer and provides an easy-to-operate interactive system.

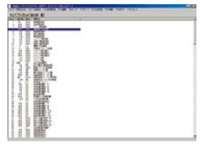
Main functions of maintenance tool

- Setting, change, display, and saving of control parameters
- Running status display
  Block diagram display, actual value display, internal data listing
- Indication of fault cause
  First fault, detailed display, trace-back data
- Test operation, etc

Notes:
(1) The display language is Japanese or English.
(2) The supported OS is Windows 7.

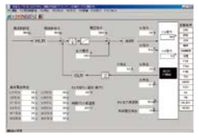


Internal data display screen



Data setting screen

Operation monitoring screen



Operation monitoring screen

Trace data screen

Standard specifications

Standard specifications (VT* specifications: For square reduction torque)

*VT: Variable Torque

●Description of code symbol (VT)

Basic code symbol

Code	Product category
FRN46–5	FRENIC4600FM5d

Control system

Code	Control system
F	VT specifications (V/F simple sensorless vector)
C	CT specifications (V/F simple sensorless vector)
S	CT specifications (sensorless vector)
V	CT specifications (vector with sensor)

Output voltage

Code	Output voltage
60	6.0kV
66	6.6kV

FRN46—5 F A — 665 60 — 1000 A

Input voltage and frequency

Code	Input voltage and frequency
605	6.0kV 50Hz
606	6.0kV 60Hz
665	6.6kV 50Hz
666	6.6kV 60Hz

Output capacity

Code	Output capacity
0420 to 0970	420 to 970kVA
1000 to 2300	1000 to 2300kVA

Auxiliary power source

Code	Auxiliary power source
A	Control power source: Single-phase 200 V or 220 V Fan power source: Three-phase 200 V or 220 V
Z	Other

●**Three-phase 6 kV series;** Overload capacity: 105% 1 min, 120% 1 min (At cold start, at cooling fin temperature of 40°C or lower)

Code symbol	Input voltage [kV]	Rated capacity [kVA]*1	Rated current [A]	Maximum current (when overloaded) [A]*2	Applicable motor maximum output [KW]*3	Main circuit insulation class	Main circuit standard rated short-circuit current [kA 1sec]		Control power source capacity [kVA]	Fan capacity [kVA]	Outline drawing	Outline dimensions A (Full width) [mm]	B (Transformer panel) [mm]	C (Converter panel) [mm]	E (Fan section) [mm]	F (Depth) [mm]	G (Maintenance space) [mm]	Approx. mass [kg]*4
FRN46–5FA–6□□60–0420□	6.0	420	41	49	340	6B	8.0		0.5	4.5	Fig. 1	3000	1900	1100	60	1300	1600	3200
FRN46–5FA–6□□66–0470□	6.6	470			370													
FRN46–5FA–6□□60–0500□	6.0	500	50	60	410	6B	8.0		0.5	4.5		3000	1900	1100	60	1300	1600	3300
FRN46–5FA–6□□66–0570□	6.6	570			450													
FRN46–5FA–6□□60–0600□	6.0	600	59	70	490	6B	8.0		0.5	4.5		3000	1900	1100	60	1300	1600	3600
FRN46–5FA–6□□66–0670□	6.6	670			530													
FRN46–5FA–6□□60–0700□	6.0	700	68	72	570	6B	8.0		0.5	4.5		3000	1900	1100	60	1300	1600	3800
FRN46–5FA–6□□66–0780□	6.6	780			630													
FRN46–5FA–6□□60–0860□	6.0	860	84	101	700	6B	8.0		0.5	4.5		3400	2000	1400	60	1400	1600	4000
FRN46–5FA–6□□66–0960□	6.6	960			760													
FRN46–5FA–6□□60–1000□	6.0	1000	98	103	800	6B	8.0		0.5	4.5		3400	2000	1400	60	1400	1600	4300
FRN46–5FA–6□□66–1120□	6.6	1120			900													
FRN46–5FA–6□□60–1200□	6.0	1200	115	138	960	6B	8.0		0.5	4.5		3400	2000	1400	285	1400	1600	5500
FRN46–5FA–6□□66–1320□	6.6	1320			1050													
FRN46–5FA–6□□60–1400□	6.0	1400	134	141	1120	6B	8.0		0.5	4.5		3400	2000	1400	285	1400	1600	6100
FRN46–5FA–6□□66–1540□	6.6	1540			1200													
FRN46–5FA–6□□60–1600□	6.0	1600	153	183	1280	6B	8.0		0.5	9.5	Fig. 2	4100	2400	1700	285	1500	1700	6400
FRN46–5FA–6□□66–1750□	6.6	1750			1400													
FRN46–5FA–6□□60–1800□	6.0	1800	173	208	1450	6B	8.0		0.5	9.5		4100	2400	1700	285	1500	1700	7100
FRN46–5FA–6□□66–2000□	6.6	2000			1600													
FRN46–5FA–6□□60–2100□	6.0	2100	202	212	1680	6B	8.0		0.5	9.5		4100	2400	1700	285	1500	1700	7400
FRN46–5FA–6□□66–2300□	6.6	2300			1850													

*1 For 2,600 kVA or more, see the FRENIC4600FM5e catalog (24D1-E-0039).
*2 At an output frequency of 25 Hz or less, the output current is limited. (At a frequency of 0.2 Hz, the current is 70% of rated current.)
*3 The applicable motor maximum output is the reference value of Fuji Electric's standard 4-pole motors.
*4 The approx. mass is the standard mass and depends on options.

●Dimensions

Front maintenance structure

Fig. 1

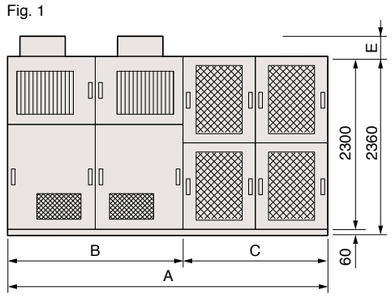
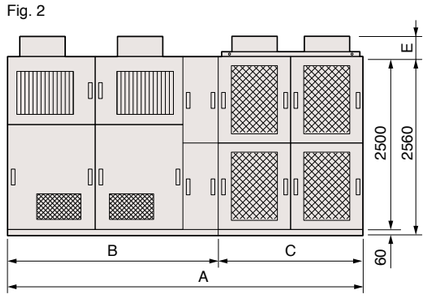
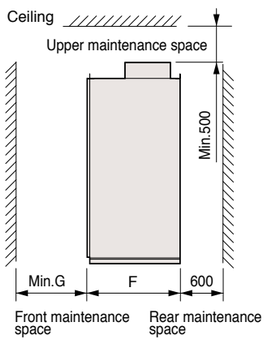


Fig. 2





●Standard interface

Input side		
Main circuit power source	Three-phase 6000 or 6600 V; 50 or 60 Hz	
Control power source	Single-phase 200 or 220 V, 50 or 60 Hz	
Fan power source	Three-phase 200 or 220 V, 50 or 60 Hz	
Frequency setting	0 to 10 V or 0 to 100%	Input impedance 1 MΩ
	or 4 to 20 mA, 0 to 100%	Input impedance 250 MΩ
Run command	Closed for run ("a" contact)	Dry contact
Stop command	Open for stop ("b" contact)	
External operation conditions	Closed when ready ("a" contact)	
Input circuit breaker closing completed	Closed when turned on ("a" contact)	

Output side		
Electrical condition ready	Closed when electrical condition ready ("a" contact)	Dry contact (contact capacity: AC 250 V, 2 A; DC 30 V, 3 A)
Running	Closed during operation ("a" contact)	
Major fault	Closed at major fault ("a" contact)	
Minor fault	Closed at minor fault ("a" contact)	
Input circuit breaker close condition	Closed when electrical condition ready ("a" contact)	
Input circuit breaker trip command	Closed at major fault ("a" contact)	
Analog signal (optional)*	0 to 10 V	Load resistance 10 kΩ or more
	4 to 20 mA	Load resistance 750 Ω or les

*The analog output signal is selectable (output current, output voltage, output frequency, etc).

Standard specifications

Standard specifications (CT* specifications: Constant torque application)

*CT: Constant Torque

●Description of code symbol (VT)

Basic code symbol

Code	Product category
FRN46–5	FRENIC4600FM5d

Control system

Code	Control system
F	VT specifications (V/F simple sensorless vector)
C	CT specifications (V/F simple sensorless vector)
S	CT specifications (sensorless vector)
V	CT specifications (vector with sensor)

Output voltage

Code	Output voltage
60	6.0kV
66	6.6kV

FRN46—5 F A — 665 60 — 1000 A

Input voltage and frequency

Code	Input voltage and frequency
605	6.0kV 50Hz
606	6.0kV 60Hz
665	6.6kV 50Hz
666	6.6kV 60Hz

Output capacity

Code	Output capacity
0420 to 0970	420 to 970kVA
1000 to 2300	1000 to 2300kVA

Auxiliary power source

Code	Auxiliary power source
A	Control power source: Single-phase 200 V or 220 V Fan power source: Three-phase 200 V or 220 V
Z	Other

●Three-phase 6 kV series; Converter overload capacity: 105% of rated current 1 min; 150% of CT applicable continuous current (motor protection) 1 min

Code symbol	Input voltage [kV]	Rated capacity [kVA] *1	Rated current [A]	CT applicable capacity [kVA]	CT applicable continuous current [A]	Maximum current (when overloaded) [A]	CT applicable motor maximum output [kW] *2	Main circuit insulation class		Main circuit standard rated short-circuit current [kA 1sec]	Control power source capacity [kVA]	Fan capacity [kVA]	Outline drawing	Outline dimensions A (Full width) [mm]	B (Transformer panel) [mm]	C (Converter panel) [mm]	D (Control/output panel) [mm]	E (Fan section) [mm]	G (Maintenance space) [mm]	Approx. mass [kg]*3
FRN46–5□A–6□□60–0340□	6.0	420	41	340	28	49	200	6B		8.0	0.5	4.5	Fig. 1	3000	1900	1100	60	1300	1600	3200
FRN46–5□A–6□□66–0370□	6.6	470		370			220													
FRN46–5□A–6□□60–0410□	6.0	500	50	410	35	60	280	6B		8.0	0.5	4.5		3000	1900	1100	60	1300	1600	3300
FRN46–5□A–6□□66–0450□	6.6	570		450			315													
FRN46–5□A–6□□60–0490□	6.0	600	59	490	41	70	315	6B		8.0	0.5	4.5		3000	1900	1100	60	1300	1600	3600
FRN46–5□A–6□□66–0530□	6.6	670		530			355													
FRN46–5□A–6□□60–0570□	6.0	700	68	570	48	72	355	6B		8.0	0.5	4.5		3000	1900	1100	60	1300	1600	3800
FRN46–5□A–6□□66–0630□	6.6	780		630			400													
FRN46–5□A–6□□60–0700□	6.0	860	84	700	58	101	450	6B		8.0	0.5	4.5		3400	2000	1400	60	1400	1600	4000
FRN46–5□A–6□□66–0760□	6.6	960		760			500													
FRN46–5□A–6□□60–0800□	6.0	1000	98	800	68	103	560	6B		8.0	0.5	4.5		3400	2000	1400	60	1400	1600	4300
FRN46–5□A–6□□66–0900□	6.6	1120		900			630													
FRN46–5□A–6□□60-0960□	6.0	1200	115	960	80	138	630	6B		8.0	0.5	4.5		3400	2000	1400	285	1400	1600	5500
FRN46–5□A–6□□66–1050□	6.6	1320		1050			710													
FRN46–5□A–6□□60–1120□	6.0	1400	134	1120	94	141	800	6B		8.0	0.5	4.5		3400	2000	1400	285	1400	1600	6100
FRN46–5□A–6□□66–1200□	6.6	1540		1200			850													
FRN46–5□A–6□□60–1280□	6.0	1600	153	1280	107	183	850	6B		8.0	0.5	9.5	Fig. 2	4100	2400	1700	285	1500	1700	6400
FRN46–5□A–6□□66–1400□	6.6	1750		1400			950													
FRN46–5□A–6□□60–1450□	6.0	1800	173	1450	121	208	950	6B		8.0	0.5	9.5		4100	2400	1700	285	1500	1700	7100
FRN46–5□A–6□□66–1600□	6.6	2000		1600			1060													
FRN46–5□A–6□□60–1680□	6.0	2100	202	1680	141	212	1180	6B		8.0	0.5	9.5		4100	2400	1700	285	1500	1700	7400
FRN46–5□A–6□□66–1850□	6.6	2300		1850			1320													

For water treatment applications, a special capacity series is available. We can also provide models with overload capacity of 120% for 1 min. Contact us separately to discuss your requirements.

*1 For 2,600 kVA or more, see the FRENIC4600FM5e catalog (24D1-E-0039).
*2 The applicable motor maximum output is the reference value of Fuji Electric's standard 4-pole motors.
*3 The approx. mass is the standard mass and depends on options.

●Dimensions

Front maintenance structure

Fig. 1

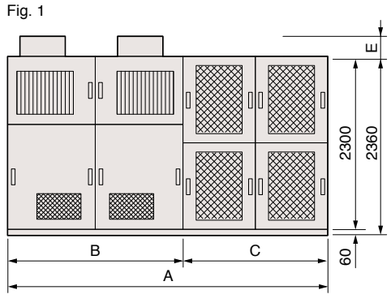
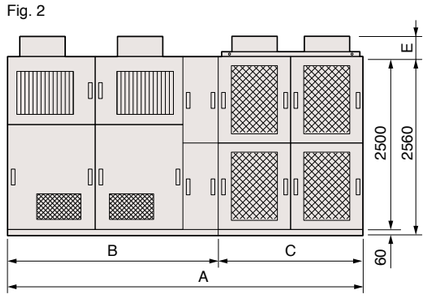
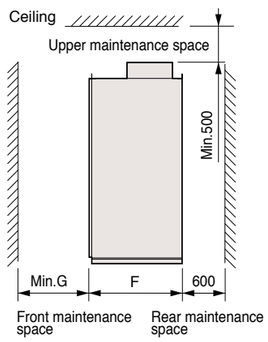


Fig. 2





●Standard interface

Input side		
Main circuit power source	Three-phase 6000 or 6600 V; 50 or 60 Hz	
Control power source	Single-phase 200 or 220 V, 50 or 60 Hz	
Fan power source	Three-phase 200 or 220 V, 50 or 60 Hz	
Frequency setting	0 to 10 V or 0 to 100%	Input impedance 1 MΩ
	or 4 to 20 mA, 0 to 100%	Input impedance 250 MΩ
Run command	Closed for run ("a" contact)	Dry contact
Stop command	Open for stop ("b" contact)	
External operation conditions	Closed when ready ("a" contact)	
Input circuit breaker closing completed	Closed when turned on ("a" contact)	

Output side		
Electrical condition ready	Closed when electrical condition ready ("a" contact)	Dry contact (contact capacity: AC 250 V, 2 A; DC 30 V, 3 A)
Running	Closed during operation ("a" contact)	
Major fault	Closed at major fault ("a" contact)	
Minor fault	Closed at minor fault ("a" contact)	
Input circuit breaker close condition	Closed when electrical condition ready ("a" contact)	
Input circuit breaker trip command	Closed at major fault ("a" contact)	
Analog signal (optional)*	0 to 10 V	Load resistance 10 kΩ or more
	4 to 20 mA	Load resistance 750 Ω or les

*The analog output signal is selectable (output current, output voltage, output frequency, etc).

Common specifications

Input	Main circuit	Three-phase 6000 or 6600 V; 50 or 60 Hz
	Auxiliary power source	Control power source: Single-phase 200 or 220 V, 50 or 60 Hz; Fan power source: Three-phase 200 or 220 V, 50 or 60 Hz
	Cell control power source	Supplied from AC main circuit (supplied from secondary side of input transformer)
	Allowable power source variation	Voltage: ±10%; Frequency: ±5%
Control system	Control system	V/f constant control with simple sensorless vector control, vector control, and sensorless vector control are available. (Must be selected when ordering.)
	Output frequency	Control range: 0.2 Hz to 50 or 60 Hz (option: up to 120 Hz); Accuracy: ±0.5% relative to maximum frequency (for analog frequency standard input); Resolution: 0.005%
	Acceleration, deceleration time	0.1 to 5500 s
	Main control functions	Current limit, stall prevention, jump frequency setting, deceleration to prevent overvoltage, restart after momentary power interruption (optional)
	Protection functions	Overcurrent, main circuit fuse blown, overvoltage, undervoltage, CPU fault, cooling fan stop
	Transmission functions (optional)	T-link, PROFIBUS-DP, Modbus
Structure	Panel	Steel panel, self-standing, enclosed; Protection rating: IP20 (Other rating optional); Cooling method: Forced ventilation with ceiling fan
	Paint finish color	Munsell 5Y7/1 (interior and exterior)
Ambient *1 conditions	Temperature	Ambient temp.: 0 to +40°C; Storage temp.: –10 to +60°C; Transport temp.: –10 to +70°C (+60 to +70°C: Within 24 h)
	Humidity	85% RH max. (non-condensing)
	Installation location	Indoor; Site altitude: Up to 1000 m above sea level; Acceleration vibration: up to 4.9 m/s^2 (10 to 50 Hz) Atmosphere: General environment free from corrosive gas, dust, flammable or explosive gas
Applicable standard		JIS, JEM, JEC

*1: To use this inverter unit at an ambient temperature of +40°C or more, at an altitude of 1,000 m or more, derating is required. Contact us.
Note 1) Regenerative braking is not provided.
Note 2) For this inverter unit, a separate dedicated input circuit breaker is required.

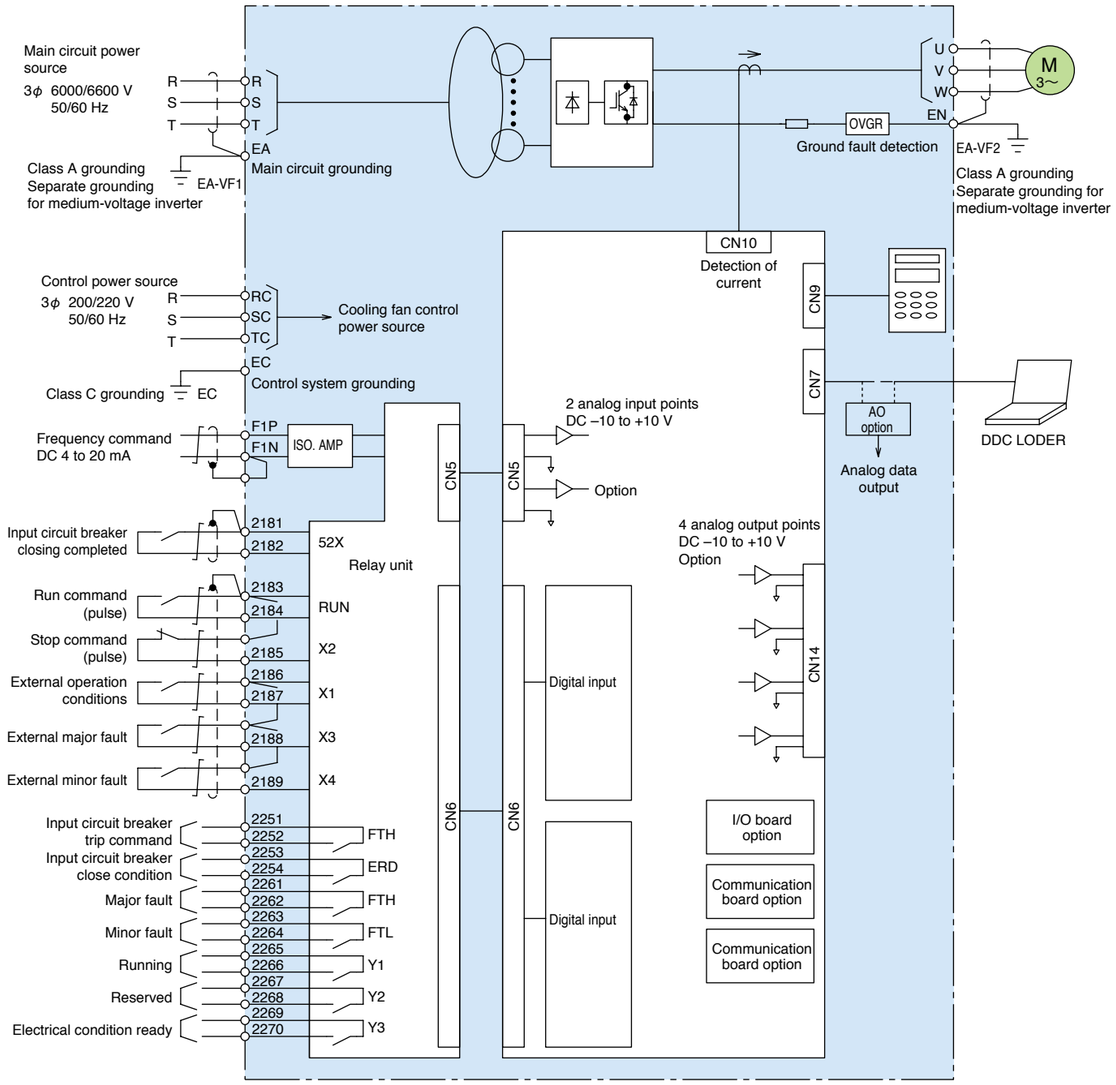
Protection functions

Item	Description	Touch panel display	Related function code
Overcurrent	This status is detected if the peak value of output current exceeds the overcurrent operation level. Although this function varies depending on the ripple rate (differs depending on motor constant) because of momentary operation, it means that current larger than approximately 200% of inverter rated current (in terms of effective value) is flowing.	OC	
Inverter overload	This status is detected if output current overload is detected (current that exceeds the inverter rated current is flowing continuously).	OLINV	
Motor overload	This status is detected if output current that exceeds the overload setting is flowing continuously for more than the set time.	OLM	No.169[No.358], No.170[No.359], No.171[No.360], No.173
Overfrequency, overspeed	This status is detected if the inverter output frequency or the revolving speed exceeds 120% of the rating.	OS	No.173
ACR CPU error	This error is output if any CPU interrupt for ACR does not occur for certain period.	A CPU	
Pulse distribution error	This error is output if the CPU for pulse distribution that controls the output pulse or its peripheral circuit is abnormal and the watchdog timer (WDT) is activated.	PDU	
Analog frequency setting error	This error is output if the analog frequency setting drops drastically. During momentary power interruption and within 100 ms after momentary power interruption, this fault is not detected.	AI	No.89, No.90
Motor starting jam	The starting jam is detected if the inverter output frequency is less than the setting and the output current detected value (calculated for the motor) is continuously over the set value for more than the set time.	MLK	No.176[No.367], No.177[No.368] No.178[No.369]
Momentary power interruption	This status is output if momentary power interruption of the DDC control power source (the voltage is less than 85% of power source voltage for more than 20 ms) occurs during motor operation.	PWRL	No.284
System momentary power interruption	This status is output if momentary power interruption of the system power source (the value is less than the set value of setting No. 295 for more than 4 ms) occurs during motor operation.	MPWRL	No.284
System power interruption fault	This fault is detected if the system power source drops less than the set value of momentary power interruption during motor operation and the momentary power interruption continues for more than the set time.	MLPWR	No.290, No.295, No.284, No.293

Item	Description	Touch panel display	Related function code
Power interruption fault	This fault is displayed if momentary power interruption of the DDC control power source (the voltage is less than 85% of power source voltage) occurs during motor operation and the momentary power interruption continues for more than the set time.	LPWRL	No.293, No.290, No.297, No.284
Circuit breaker switching fault	This fault is detected if both the inverter and the commercial circuit breaker are on for more than 1 second during synchronizing and parallel off operation.	MCLAP	No.173
Synchronizing jam	This fault is detected if phase focusing with the commercial power source does not complete synchronizing within 20 s after output of the synchronizing command during synchronizing and parallel off operation.	SYNC	
Flying start fault	This fault is detected if the number of retries during a speed search fault at the start-up of the inverter exceeds the retry limit setting.	RTRY	No.195, No.196
External minor fault	This fault is output if some minor fault is input from an external sequence.	FTB	
External major fault	This fault is output if some major fault is input from an external sequence.	FTA	
External intermediate fault	This fault is output if some intermediate fault is input from an external sequence.	FTC	
Ground fault	This fault is detected if the ground fault detecting relay is activated.	OVG	No.173
Fan and temperature major fault	This fault is detected if an inverter panel fan fault and transformer overheating (major fault) occur.	FANH	
Fan and temperature minor fault	This fault is detected if an inverter panel fan fault and transformer overheating (minor fault) occur.	FANL	
Printed circuit board temperature error	This error is detected if the temperature of the control printed circuit board exceeds 60°C.	OTDDC	
Transformer overheating major fault	This fault is detected if transformer overheating (major fault) occurs.	TRTMP	
Optical link error	This error is detected if an optical link carrying multiplex transmission causes an error.	LINK	
Modbus error	This fault is activated if a Modbus logic error (address error, parity error, etc.) occurs or transmission stops for more than the set time. (Detected only during Modbus interlock operation and when the MC-RN on conditions are satisfied.)	MOD	No.377, No.174
PSB card error	This error is activated after an emergency stop if "PSB error" is set at the status flag of the PROFIBUS transmission board (PSB). (Detected only during PLC interlock operation and when the MC-RN on conditions are satisfied.)	PSB	No.174
PROFIBUS error	This error is activated if transmission stops for more than 100 ms in the PROFIBUS. (Detected only during PLC interlock operation and when the MC-RN on conditions are satisfied.)	PROFI	No.174
MICREX error	This error is activated if the "TER: Transmission error" bit in data received from PLC is 1. (Detected only during PLC interlock operation and when the MC-RN on conditions are satisfied.)	MICRX	No.174
Upper transmission system error	This error is activated if the P(E) link healthy bit delivered from the MPU of IFC (transmission repeater) to the DLA of IFC is "0". (Detected only during PLC interlock operation and when the MC-RN on conditions are satisfied.)	IFC	No.174
DLA error	This error is activated if "DLA error" is set at the status flag of the D-LINE transmission board (DLA). (Detected only during PLC interlock operation and when the MC-RN on conditions are satisfied.)	DLA	No.174
D-LINE (T-LINK) error	This error is activated if transmission stops for more than 100 ms on the D-LINE/T-LINK. (Detected only during PLC interlock operation and when the MC-RN on conditions are satisfied.)	DLINE	No.174
Cell DC fuse blown	This status is output if the inverter DC main circuit fuse in a cell is blown. For individual confirmation, check the operation display in the unit.	DCF	
Cell main circuit overvoltage	This status is output if the DC main circuit voltage in each inverter cell is too high.	OV	
Main circuit overvoltage in cell deceleration	This status is output if the DC main circuit voltage is too high during inverter deceleration operation.	OVDEC	
Cell main circuit undervoltage P-M	This status is output if the DC main circuit voltage is too low (receiving voltage ratio is approximately 80%) during inverter operation or if the DC main circuit voltage does not exceed the detection level even after the initial charge.	UV PM	
Cell main circuit undervoltage M-N	This status is output if the DC main circuit voltage is too low (receiving voltage ratio is approximately 80%) during inverter operation or if the DC main circuit voltage does not exceed the detection level even after the initial charge.	UV MN	
Cell main circuit voltage unbalance	This status is output if the difference between the positive (P) and negative (N) sides of DC voltage in a cell exceeds 14% of rated voltage for more than 5 seconds.	UNB	
Cell PWM optical signal error	This error is detected if the optical link for PWM signals becomes abnormal.	PWM	
Cell control power source drop	This status is detected if the control power source voltage in a cell drops or if the control power source in a cell becomes abnormal.	PWRL	
Cell coolant overheating	This status is detected if the cooling fin temperature in a cell becomes 95°C or higher.	OTF	
Cell local optical link error	This error is detected if an error occurs in the optical link that composes multiplex transmission.	LLINK	

Standard connection diagram

Standard connection diagram



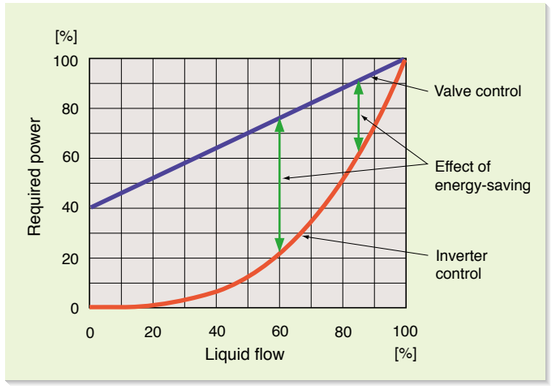
Contributes to energy saving

FRENIC4600FM5d

FRENIC4600FM5d inverter operation promises substantial energy-saving and carbon dioxide reduction.

In air-conditioning or pumping facilities, fans or pumps typically run at a constant speed even when the load is light. Adjustable speed control according to the load (air or liquid flow) through inverter operation greatly reduces energy consumption and maintains the maximum possible motor efficiency even at low-speed operation.

Liquid flow and power characteristics



Example of application and energy-saving effect

The following example compares constant speed motor operation with valve (or damper) control, against inverter adjustable speed control operation, and shows the electric power saved.

●Example conditions for calculation

Motor output:
1,000 kW, for annual operation time 4,000 hours
Operation pattern:
85% flow for 1/2 of overall time (2,000 hours)
60% flow for the remaining half (2,000 hours)

●Constant speed operation of motor (with valve control)

At 85% load of liquid flow (Q)
Required Power (P) = 91%×1,000 kW = 910 kW
At 60% load of liquid flow (Q)
Required Power (P) = 76%×1,000 kW = 760 kW
Annual power consumption
910 kW×2,000 h+760 kW×2,000 h = 3,340,000 kWh

●Inverter operation (adjustable speed control operation with inverter)

At 85% load of liquid flow (Q)
Required Power (P) = 61%×1,000 kW = 610 kW
At 60% load of liquid flow (Q)
Required Power (P) = 22%×1,000 kW = 220 kW
Annual power consumption
610 kW×2,000 h+220 kW×2,000 h=1,660,000 kWh

●Annual energy-saving

3,340,000−1,660,000 = 1,680,000 kWh
(energy-saving = about 50%)
Carbon dioxide reduction = 635,040 kg

List of Options and Spare Parts

FRENIC4600FM5α

List of options

Description			Standard specifications		Specified by customer
Rating	Rated short-time withstand current		See the list of code symbols in standard specifications.		☐(　　)kA　1s
	Auxiliary power source	Control power source	Single-phase　200/220 V		☐(　　)φ AC(　　)V　(　　)Hz
		Fan power source	Three-phase　200/220 V		☐(　　)φ AC(　　)V　(　　)Hz
		Power source for momentary power interrupt detection	The fan power source is used for momentary power interrupt detection. (The same system as the main circuit must be used.)		☐(　　)φ AC(　　)V　(　　)Hz
Structure, paint finish	Protective structure		IP20		☐IP(　　)　IP21, 22, 30, 31, 32 are supported.
	Front side specifications		Hooking cover (door only in control section)		☐(　　)
	Rear side specifications		Hooking cover		☐(　　)
	Door grip type		Flat type (key No. 200)		☐(　　)
	Door stopper		Not provided		☐Provided
	Card folder in panel		Not provided		☐Provided
	Protective cover in charge section	Main circuit	Not provided		☐Provided
		Control circuit	Not provided		☐Provided
		Part	Not provided		☐Provided
	Ceiling fan redundancy		No redundancy		☐Provided
	Paint finish color		Munsell 5Y7/1 (semigloss)		☐Front(　　), Inside(　　)
	Environment	Processing for tropical and humid zones	Not provided		☐Provided
		Measures against corrosive gas	Not provided		☐Provided
		Processing for salt resistance	Not provided		☐Provided
	Channel base		No prior delivery (shipping with panel mounted)		☐Prior delivery (double base)
	Cable storage		Lower part for both main circuit and control section		☐Main circuit: Input(　　), Output(　　), Control(　　)
	Cable cover plate		Steel plate (In two parts)		☐(　　)
	Dimensions of loading entry		No restrictions		☐Restricted(W=　　mm, H=　　mm, D=　　mm)
	Cable support		Provided only on control circuit		☐Main circuit：(　　), Control(　　)
Wiring	Wiring colors		Main circuit: Black; Control section: Yellow; Ground wire: Green		☐(　　)
	Phase identification	Three-phase circuit	Phase 1: Red; Phase 2: White; Phase 3: Blue; Neutral phase: Black		☐Phase 1：(　　), Phase 2：(　　), Phase 3：(　　), Neutral phase：(　　)
		Single-phase circuit	Phase 1: Red; Neutral phase: Black; Phase 2: Blue		☐Phase 1：(　　), Neutral phase：(　　), Phase 2：(　　)
		DC circuit	Positive electrode (P): Red; Negative electrode (N): Blue		☐Positive electrode(P)：(　　), Negative electrode(N)：(　　)
Transformer	Dial thermometer		Not provided		☐Provided (2 warning points (major and minor) are included in INV.)
	Wheel		Not provided (provided as a standard component for 3.3 kV, 770 kVA (VT specifications) or lower)		☐Provided
	Tap		±5%		☐(　　)
Control	Control frequency range		0.2 to 50/60 Hz		☐0.2 to (　　)Hz
	Inverter start-up		0 Hz start-up (start-up from stopped state)		☐Lead-in start-up, ☐Speed search start-up
	Momentary power interruption		Major fault		☐Restart
					☐Duration　300 ms (Control power source: Commercial power)
					☐Duration 300 ms (Control power source: UPS)
	Synchronizing and parallel off		Not provided		☐Synchronizing, ☐Parallel off
	Commercial switching		Not provided		☐Direct, ☐Reactor, ☐(　　)
	Transmission		Not provided		☐PROFIBUS-DP, ☐Modbus, ☐T-LINK
	Frequency (speed) command		Analog DC 4 to 20 mA		☐Analog(　to　), ☐Panel surface adjusting knob, ☐Outside adjusting knob
					☐Transmission, ☐Others(　　)
	Rotating direction		Normal rotation only		☐Normal and reverse rotation provided (☐Normal and reverse rotation DI command or ☐Analog signal −100 to +100%)
	Operation location switching		Not provided		☐Local and remote switching
	Number of spare terminals for control		10% (with terminal cover)		☐(　　)
Accessories	Panel interior lighting		Not provided		☐Provided, AC (　　) V, (☐Fuse or ☐MCB)
	Outlet		Not provided		☐Provided, AC (　　) V, (☐Fuse or ☐MCB)
	Panel interior space heater		Not provided		☐Provided, AC (　　) V, (☐Fuse or ☐MCB)
	Motor cooling circuit		Not provided		☐Provided, AC(　　)V　(　　)kW
	Motor winding temperature detection		Not provided		☐Pt100 ΩX(　　)pcs, ☐NTCX(　　)pcs, ☐Fault contact X (　　) pcs
	Motor bearing temperature detection		Not provided		☐Pt100 ΩX(　　)pcs, ☐Fault contact X (　　) pcs
	Motor space heater circuit		Not provided		☐Provided, AC(　　)V　(　　)kW
	Thermolabel		Not provided		☐Provided,(　　)
	Display and operation unit		Small LCD (touch panel) with Japanese language display		☐Touch panel (English)
					☐Large LCD (10.4 in.) (☐Japanese or ☐Chinese)
	DIO extension card		Not provided		☐Provided　Di: DC 24 V　3 mA　4 points, Do: DC 24 V　Max50 mA　8 points
	Panel meter		Not provided		☐80 mm square class 2.5, ☐110 mm square class 1.5　*
					☐(　　)in total, (　　)in total, (　　)in total, (　　)in total *
	AO external output		Not provided		☐(　　)points　(☐4-20 mA　OR　☐0-10 V)*
	Panel surface push button		Not provided		☐PB(run), ☐PBL(run)
					☐PB(stop), ☐PBL(stop)
					☐PB(fault reset), ☐PBL(fault reset)
					☐PB(emergency stop)
					☐PB(　　), ☐PBL(　　)
	Collective indicator		Not provided		☐(　　)window
	Foundation bolt		Not provided		☐Provided(　　)
	Field web adapter		Not provided		☐Provided
Auxiliary component	Lifter		Not provided		☐Provided
	DDC loader		Not provided		☐PC, software, cable, ☐Software, cable
	AO for testing		Not provided		☐Provided
Overseas standard	IEC supported		Not provided		☐Provided
	EC Directive (CE marking)		Not provided		☐Provided

*Provided with AO output as a set

Spare parts

Description	Recommended number of spare parts	Specified
Inverter cell	2 units	
Control stack	1 unit	
Cooling fan	100%	
Air filter	100%	
Touch panel	1 unit	
Relay unit	1 unit	
Relay power source unit	1 unit	

Wealth of functions to accommodate every need

FRENIC4600FM5d

Application	Series	Features	Output voltage [V]	Capacity range [kVA] (10 / 100 / 1000 / 10000)
For plant	FRENIC 4000VM5	Vector controlled inverter for plants • High-performance vector control system for quick response, high-accuracy and wide range speed control. • The DC-link system allows highly efficient plant operation.	400	5400
	FRENIC 4000FM5	V/f controlled inverter for plants • Frequency of fan, pump and group-driven motors can be controlled accurately. • The DC-link system allows highly efficient plant operation.	400	900
	FRENIC 4400VM5	Large-capacity vector controlled inverter • The capacity of FRENIC4000 series units has been increased due to 3-level control.	800	6000
	FRENIC 4400FM5	Large-capacity V/f controlled inverter • The capacity of FRENIC4000 series units has been increased due to 3-level control.	800	2000
	FRENIC 4700VM5	Medium-voltage large-capacity vector controlled inverter • The capacity of FRENIC4000 series units has been increased thanks to the series-connected device and 3-level control.	3440	7800
	FRENIC 4800VM5	Medium-voltage, water-cooling, large-capacity and vector controlled inverter • The capacity of FRENIC4000 series units has been increased due to 3-level control. • Downsizing achieved by adopting a water-cooling system	3100	24000
For general industry (medium-voltage)	FRENIC 4600FM5	Medium-voltage direct-output inverter • 3.3/6.6 kV IGBT inverter • Variable speed operation of medium-voltage motors saves energy. • Circuit configuration and control are well designed for power supplies and motors.	3300 6600	3750 7500
	FRENIC 4600FM5e	Medium-voltage direct-output inverter (for fans and pumps) • Compact • Variable speed operation of medium-voltage motors saves energy. • Circuit configuration and control are well designed for power supplies and motors.	3300 6600	5200 10500
	FRENIC 4600FM5d		6600	2300
For general industry (low-voltage)	FRENIC-VG	High-performance vector controlled inverter	200 400	90 kW 800 kW
	FRENIC-MEGA	High-performance V/f controlled inverter	200 400	90 kW 630 kW
	FRENIC-ECO	V/f controlled inverter for fans and pumps	200 400	110 kW 560 kW

Selection of inverter capacity

When selecting inverter capacity, select an inverter whose rated current value is larger than the operating current of the motor to be driven.

●Selection example 1

For driving a 6.6 kV, 60 Hz, 600 kW, 4-pole motor:

Rated current value of motor: 65 A

Operating current value of motor: 65 A

→Select an inverter capacity of 780 kVA (68 A).

(65 < 68 A)

●Selection example 2

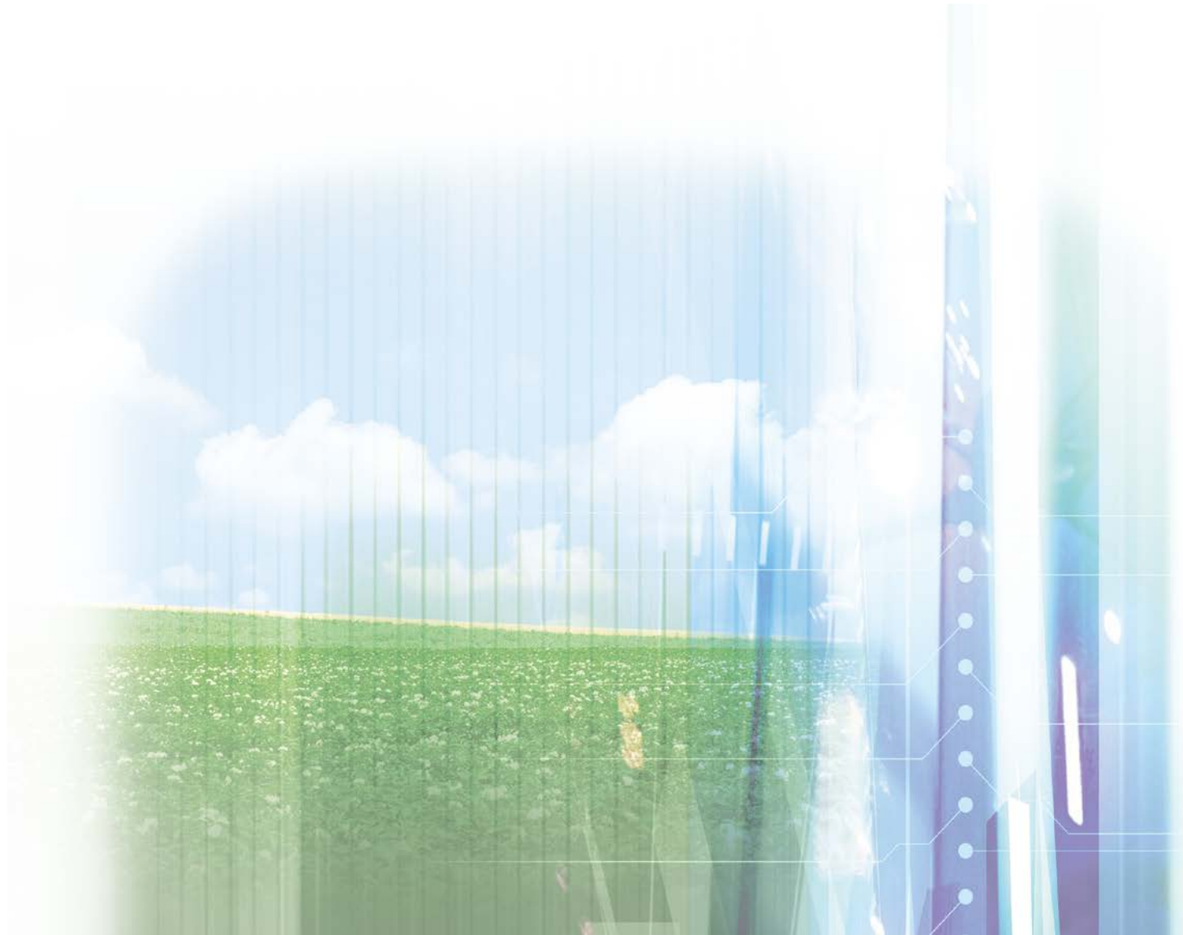
For driving a 6.6 kV, 60 Hz, 1,600 kW, 4-pole motor:

Rated current value of motor: 173 A

Operating current value of motor: 130 A

→Select an inverter capacity of 1,540 kVA (134 A).

(130 < 134 A)



Ordering Information

Ordering Information

When placing an order or making an inquiry, please state the following.

Application of inverter					**Remarks:**
Load machine specifications					
Name: ☐Pump, ☐Fan, ☐Blower, ☐Air compressor, ☐Other ( )					
Load torque characteristics: ☐Square-law speed, ☐Constant torque, ☐Constant output					
Moment of load inertia after conversion into motor shaft (J): kg・m²					
Overload: %					
Input specifications					
Rated voltage: V± %		Rated frequency: Hz± %			
Control power source: Three-phase, 2-wires, 200/220 V, 50/60 Hz					
Drive motor					
Motor specifications: ☐Squirrel-cage rotor, ☐ ( ), ☐Existing, ☐New installation					
Rating	Output: kW	No. of poles:	Voltage: kV		
	Frequency: Hz	Speed: r/min	Current: A		
Speed control					
Controllable range: r/min to r/min					
Rotational frequency setting method					
☐Analog signal: 4 to 20 mA, 0 to 10 V, ☐Up/down signal, ☐ ( )					
Commercial power source bypass circuit					
☐with, ☐without					
Ambient conditions					
Install location: Indoor	Humidity: %RH	Temperature: ℃	Altitude: m		
Provision of air conditioning:		Limit on carrying-in:			

JAB CM021

EC97J1061 051

Kobe Factory, where this instrument is manufactured, is certified by ISO14001 Environmental management systems.

MEMO