Fuji Electric

Innovating Energy Technology

Medium-voltage Drives

FRENIC4600FM6e

Medium Voltage Drive

24D1-E-0128c

Our Medium-voltage Drives aim to protect the environment and create clean energy for everyone.

Founded in 1923, Fuji Electric is an internationally renowned major general industrial electronics equipment manufacturer, and our products are widely used in various fields such as power generation, iron and steel, oil & gas, mining, chemicals, cement, water plant.

Fuji Electric has continued its tireless efforts in the development and application of advanced power electronic technology that is a fusion of such fields as power semiconductors, microelectronic circuits, and automatic control systems. Since the 1980s we have been manufacturing and delivering to the world medium-voltage drives speed control devices for various types of load equipment drives. Among these, our FRENIC4600FM6e medium-voltage drive is a high-performance, high reliability medium-voltage drive speed control device.

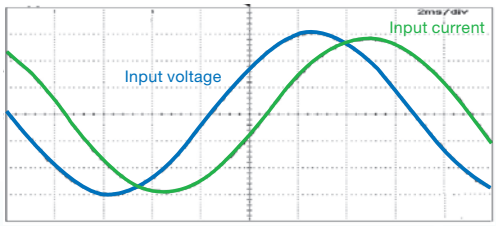
Contents

Features

1 Substantial reduction of harmonic current on power source side

- A multi-phase diode rectifier system (18 to 54 phases) is used to suppress harmonics. Significantly less harmonics are generated than conventional models, and because the amount of harmonics generated is much lower than that specified in IEEE-519 (1992), this is a drive that does not degrade the power supply.

Current waveform on power source side



Harmonic current content

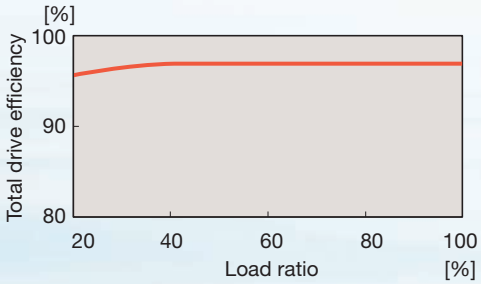
Order	5th	7th	11th	13th	17th	19th	23th	25th	35th	37th
IEEE value [%]	4.00	2.86	1.83	1.49	1.14	1.02	0.87	0.80	0.80	0.80
Measured value [%](*)	0.58	1.0	0.20	0.32	0.75	0.54	0.06	0.24	0.58	0.27

(*) Example value from our full load test

2 High efficiency: Total efficiency of approx. 97%

- Because an output transformer is unnecessary, inherent losses are eliminated.
- Use of our proprietary multi-level PWM control system reduces switching losses.
- 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.

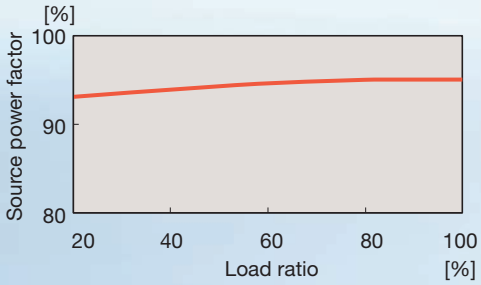
Total drive efficiency curve (including input transformer)



3 High power factor: Source power factor greater than 95%

- The use of a multi-phase diode full-wave rectifier increases the power factor on the power source side, enabling operation at a high power factor.
- A phase advancing capacitor and a DC reactor for improving the source power factor are unnecessary.
- A smaller power capacity suffices for drive operation.

Source power factor curve



4 High reliability

- High-accuracy, rotation speed sensor-less vector control functions enable stable operation during load variations from low speed to high speed.
- World-class Fuji own brand IGBT cells, redundant bypass control technology, and multi-level fault alarm functions are employed to ensure very high reliability.
- A high-end 32-bit motor control MCU is employed in the control device for quick response and high accuracy.

5 Vector control

- Advanced and practical vector control technology is adopted for asynchronous and synchronous motors and achieves high-accuracy non-velocity vector control with a large starting torque, fast response dynamics and high load capacity.

6 Easy maintenance

- The drive is air-cooled, requiring no cooling water.
- Start/stop operations, parameter setting, fault display, and data monitoring are easily performed on a touch panel with simplified input functions.
- A simple auto-tuning function for test adjustments facilitate adjustment.
- Fault diagnosis are easily performed.
- A dry-type input transformer is adopted.

Industrial applications

Cement

- Fans
- Kilns
- Separators
- Bucket elevators

Chemicals

- Granulators
- Compressors
- Fans and pumps

Water treatment

- Water plant

Iron and Steel

- Fans
- Induction blowers
- Dust collectors
- Cooling water pumpsr

Power generation

- Turbo refrigerators
- Banbury mixers
- Ball mills

Other industries

- Turbo refrigerators
- Banbury mixers
- Ball mills

Simple circuit configuration

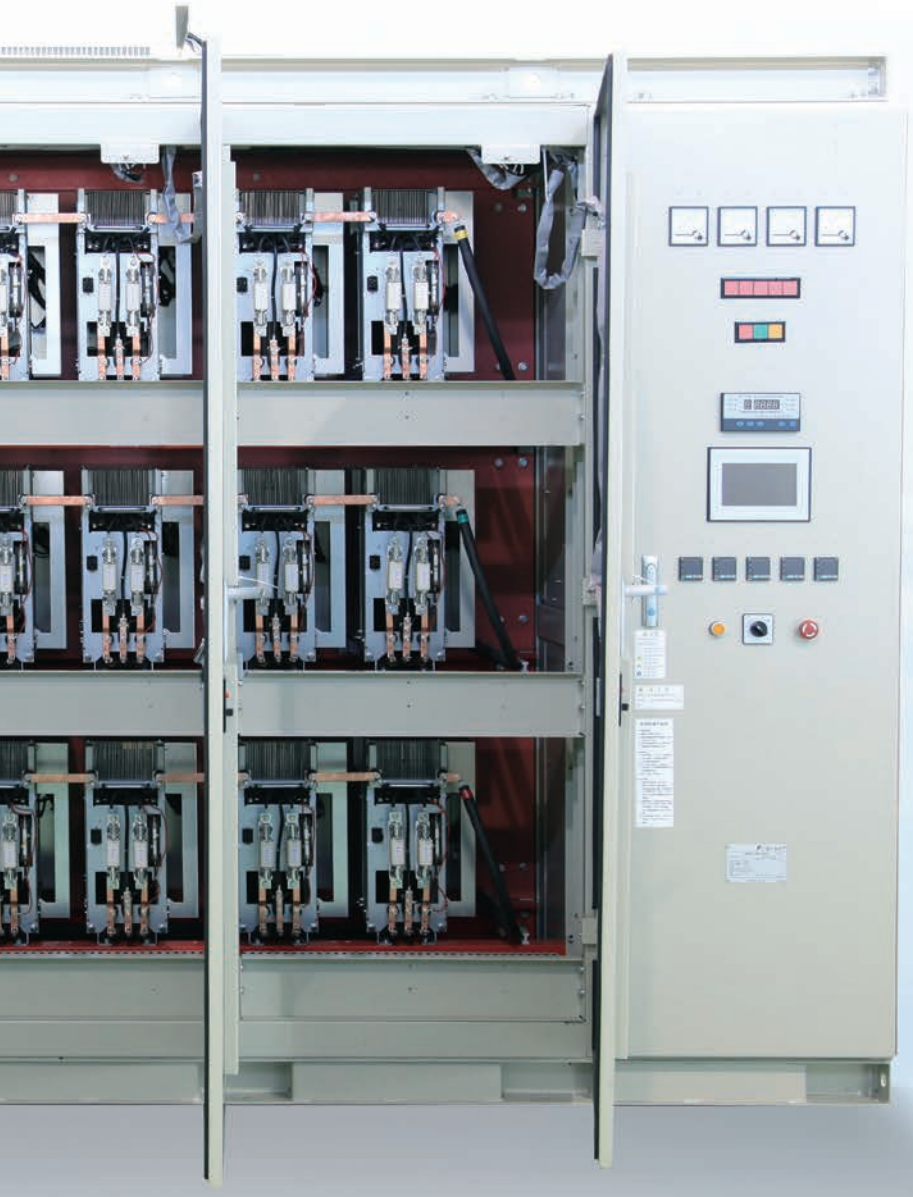
The medium-voltage drives utilize internationally advanced electronics technology, and are equipped with a highly integrated motor control MCU and a multi-level cell tandem structure with an optimized design. There is no need for harmonic filters outside the rating or power factor correction capacitors. The reliability is very high, and these inverters are easy to operate and maintain.

Master control panel

- Equipped with an optimal 32-bit MCU for industrial motor control, and a voltage detection system utilizes a special ARM sampling platform. Boasting high-speed response and high control accuracy, also features short acceleration time to fluctuations in torque load, and acceleration with high control performance that will not allow overcurrent.
- Flexible interface enables easy operation by the customer. Made-to-order options tailored to the customer's needs are also possible.

Input multiplex winding transformer

- Harmonic current on the power source side is low due to a multiplex configuration of the secondary winding.
- With the use of a multi-phase rectifier (18 to 54 phases), harmonic current emissions completely satisfy the provisions of the IEEE. The installation of harmonic filters and power factor correction capacitors is not required.
- A dry-type transformer is adopted on the input side, and because the transformer is on the panel, there is no external connection work required for the cable between the transformer and the drive panel.
- Since the dry-type isolated transformer is an integrated design, the electric motor is protected, making it easy to install and reducing the installation costs.

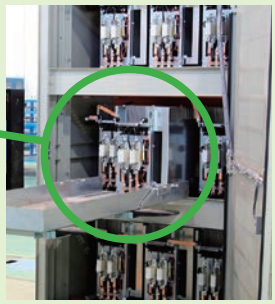


Cooling fan

- Air-cooled inverters make maintenance easy.

Inverter cell

- The stability of the system is further improved with the use of a cell tandem phase structure equipped with a cell intelligent bypass function.
- Each inverter cell alone can be taken out and replaced easily, because the controller, diodes, IGBT elements and DC intermediate capacitor are combined into an integral body.
- Utilizes the latest Fuji 1700 VAC IGBT with the world's top-class delivery track record, and boasts high reliability.



Main circuit configuration

Main circuit configuration diagram

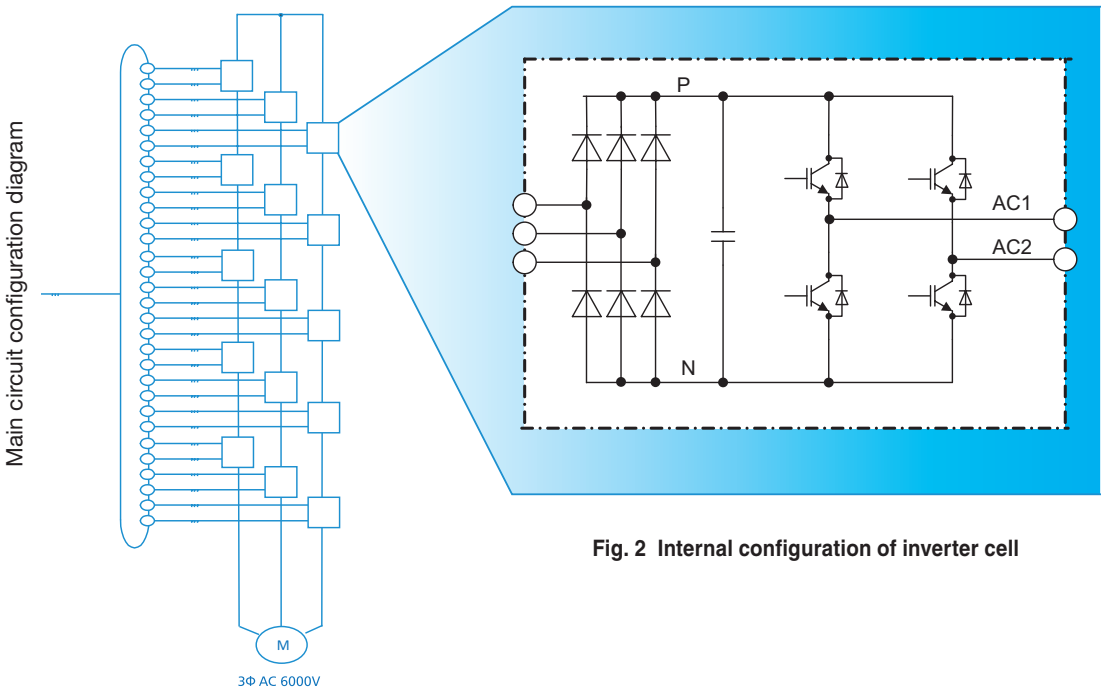


Fig. 1 Main circuit configuration diagram of 6 kV type

Fig. 2 Internal configuration of inverter cell

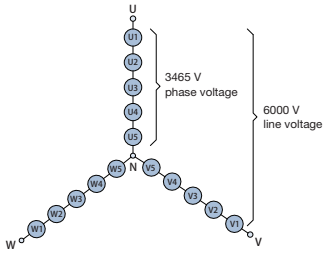


Fig. 3 6 kV configuration

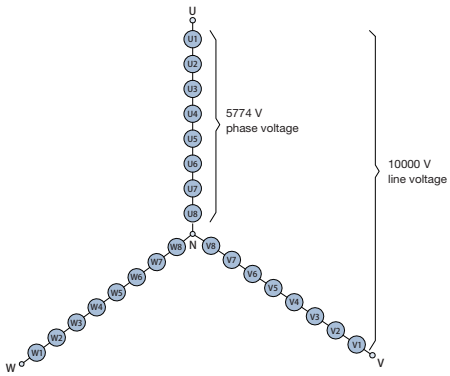


Fig. 4 10 kV configuration

- The drive configuration is as shown in Figure 1. A 6 kV class drive comprises the input transformer and 15 inverter cells. (A 10 kV class drive is composed of 24 inverter cells.)

- Each inverter cell consists of one single-phase two-level inverter which yields an output voltage of 693 V. As shown in Fig. 3, when a 6 kV class five inverter cells are cascade-connected to each phase, the phase voltage is approximately 3465 V. With a three-phase star connection it is possible to obtain a line voltage of approximately 6000 V.

- As shown in Fig. 4, when a 10 kV class eight inverter cells are cascade-connected to each phase, the phase voltage is approximately 5774 V. With a three-phase star connection it is possible to obtain a line voltage of approximately 10000 V.

Friendly to machines

If a harmonic current component is contained in the drive 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.

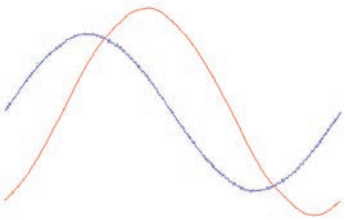
In FRENIC4600FM6e, the harmonic component on the output side is extremely small due to the multi-level PWM control and the main component of torque ripple is at around the carrier frequency (several kHz). Therefore, torque ripple hardly affects the machine side.

Friendly to motors

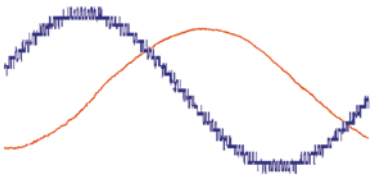
- The multi-level PWM control provides an almost sinusoidal output current waveform, thus reducing motor torque ripple.
- The output current waveform is nearly sinusoidal, reducing the harmonic losses of the motor.
- The multi-level PWM control minimizes switching surge voltage and thereby reduces stress on the motor.
- There is no need to reduce motor capacity due to drive.
- There is no need for special cables, etc. due to drive.
- This drive 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 drive, operation can be performed.

: output voltage waveform : output current waveform

Output voltage and current waveforms at 10 kV output



Output voltage and current waveforms at 6 kV output



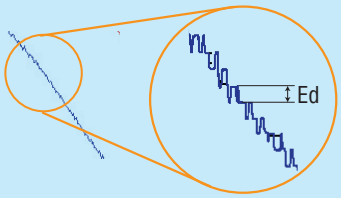
Note

Surge voltage and multi-level output

The output voltage waveform of a PWM drive 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 drive output is applied to a motor through a cable, the voltage is reflected repeatedly between the motor terminal and drive terminal. A sharp overvoltage higher than the drive output voltage is thus generated at the motor terminal, which may cause dielectric breakdown of the winding.

The multi-level PWM control of Fuji medium-voltage drives makes it possible to suppress the DC intermediate voltage, and effectively controls the overvoltage generated at the motor terminals.



Output voltage waveform (17 levels) in 10 kV class

In the 10 kV class Fuji Electric's medium-voltage drives, the output voltage changes in 17 steps (corresponding to 17 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 drive can also reduce the surge voltage appearing at the motor terminal and thereby moderate the stress applied to the motor.

Functional description

Synchronous motor vector control device (option)

At the core of the FRENIC4600FM6e drive is a high-speed MCU, which is equipped with a vector control program that is internationally advanced and comprises a high-performance controller platform. The device will adapt to the advanced requirements of frequent start-ups and rate adjustments.

Main capabilities:

- Slow startup torque is large, with fast torque reaction during high speeds.
- Equipped with an electric motor rotor positioning function for the smooth start-up of synchronous motors.
- The drive can automatically adjust the excitation current, enabling high system efficiency.

Cell automatic bypass function (option)

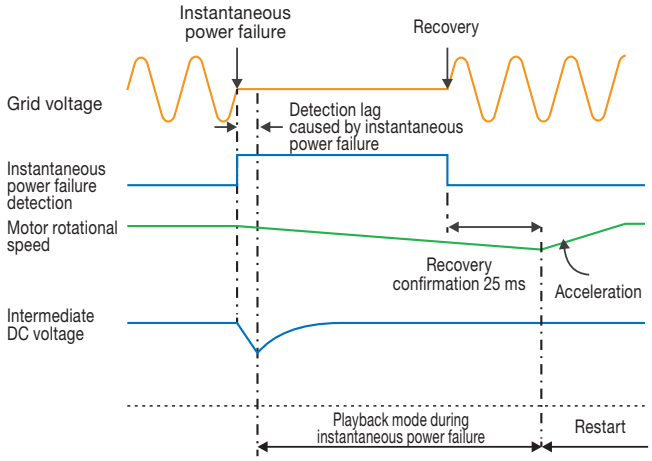
- When the cell automatic bypass function is selected, failures due to shutdowns are significantly reduced, greatly improving the reliability of the equipment.
- The FRENIC4600FM6e can accurately grasp the location of the failure point, and bypass the failed cell.
- The bypass control is completely separated from each of the power cells, and the FRENIC4600FM6e can automatically bypass a failed power cell within 0.5 seconds.

Description of instantaneous power failures

- It is possible to select the combined operation mode to use in the event of an instantaneous voltage drop.

1. Select instantaneous voltage drop as a major fault
   The drive performs a major fault stop, and the motor will be in a free-run state.
2. Selection of free-run restart (option)
   The drive stops operating, and the motor will be in a free-run state. When the power supply power recovers, the speed search function will automatically re-accelerate the motor that is decelerating in the free-run state or if the motor has already stopped.
3. Selection of continued operation when an instantaneous voltage drop occurs (option)
   If the motor does not enter the free-run state when an instantaneous voltage drop occurs, the drive can operate continuously.
   After the recovery of the power supply voltage, the motor will be promptly re-accelerated and return to the operating speed.

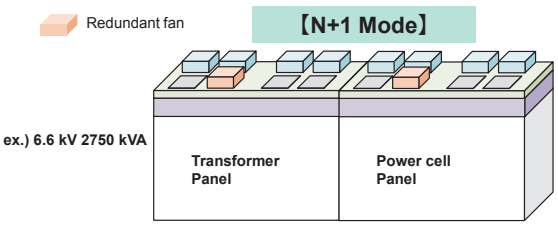
Fig. 1 Continuous operation process



Note 1) When the instantaneous voltage drop is below 65% of the rated voltage. Note 2) The instantaneous voltage drop duration is less than 300 ms. (option)

Fan redundant function (option)

Fuji FRENIC4600FM6e drive adopts N+1 fan Redundant Control Mode



Whenever a single fan fails, drive can continue to operate without stopping operation due to a failure of a single fan.

Synchronization undisturbed switch (option)

Shockless switching between drive operation and commercial power operation allowed by phase control according to system voltage. An electric reactor must be installed on the output side of theinverter to enable this function.

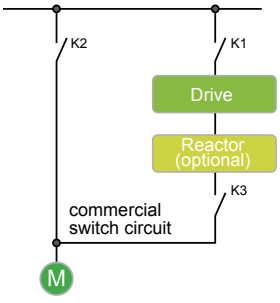


Fig.2 Power system diagram

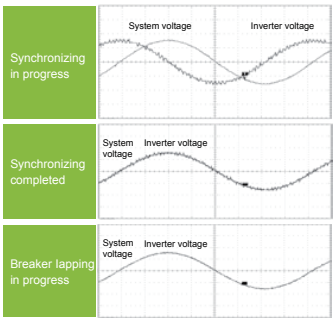


Fig.3 Synchronization/parallel off waveform

Control functions

The FRENIC4600FM6e medium-voltage drives is equipped with 32-bit RISC processors for each of the CPUs used for the basic controls such as frequency control, operation programs, and various interfaces; for the high-speed computing used for the current control; as well as for the voltage processing and output voltage pulse waveform processing.

To enable combined optimal control for various applications, FRENIC4600FM6e have integrated the following functions in the internal system.

1 Logic functions

- In accordance with external logic and control signals, the system is operated and stopped by software.

2 Adjustment functions

- Based on the sampling control principles, FRENIC4600FM6e have achieved an optimal adjustment control.

3 Control parameter setting functions

- Each of the control parameters of the system can be set and optimally adjusted from the keypad, HMI or centralized monitoring system.

4 Fault detection functions

- When faults occur, they can be displayed and verified using the HMI, keypad or centralized monitoring system.
- In addition, tracking backup data can be collected before and after the fault using the keypad or centralized monitoring system.

5 Independent operation functions

- Can control operation of the FRENIC4600FM6e with no need to connect to the DCS.
- The operation methods include communications, external input access operations, analog command operations, and operations panel operations.

6 Power failure protection functions

- Power failure processing is performed when a power outage failure occurs. Data in RAM (built-in memory) is backed up by the capacitor, and one week of data can be preserved even in a non-energized state.
- In addition, setting data in non-volatile memory (flash memory), is backed up even in a non-energized state, and setting data is not lost.

7 Online, analog quantity data output

- During operation, the related data can be output in analog mode.

Data setting and monitoring

Very easy operation and monitoring using the 7-inch color HMI

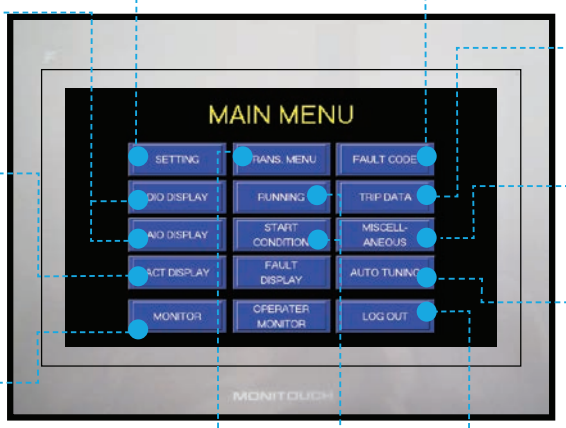
Setting
Setting, change and display of control parameters

DIO display, AIO display
Display input and output state and functional distribution information

Actual value display
Display each actual value of the drive (frequency command, voltage command, current value command, current detection, etc.)

Monitoring device
Control each actual value of the drive as displayed on a block diagram

Transmission screen
Display state of transmission and input-output numerical values



Fault screen, fault history
Display fault (major, medium, minor fault) generation time and cause of fault Check up to 100 previous faults in the history

Trip data
Display the data for each component at time of fault

Accessory functions
Set the internal time, check the status of the drive

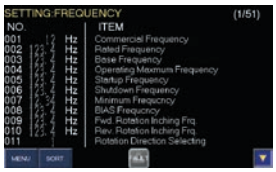
Automatic adjustment
Automatically adjust the motor

Log out
Monitor the screen, but parameters can not be changed

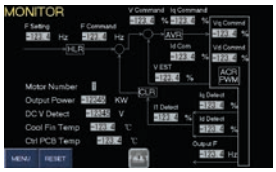
Operation screen and start-up conditions
Confirm frequency settings and operating conditions (satisfied, not satisfied)

Example of display screen

Operation screen

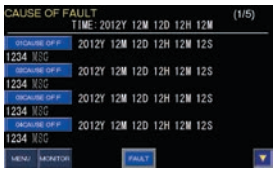


Setting screen



Monitoring screen

Start-up condition screen



Fault history screen

HMI display contents

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.

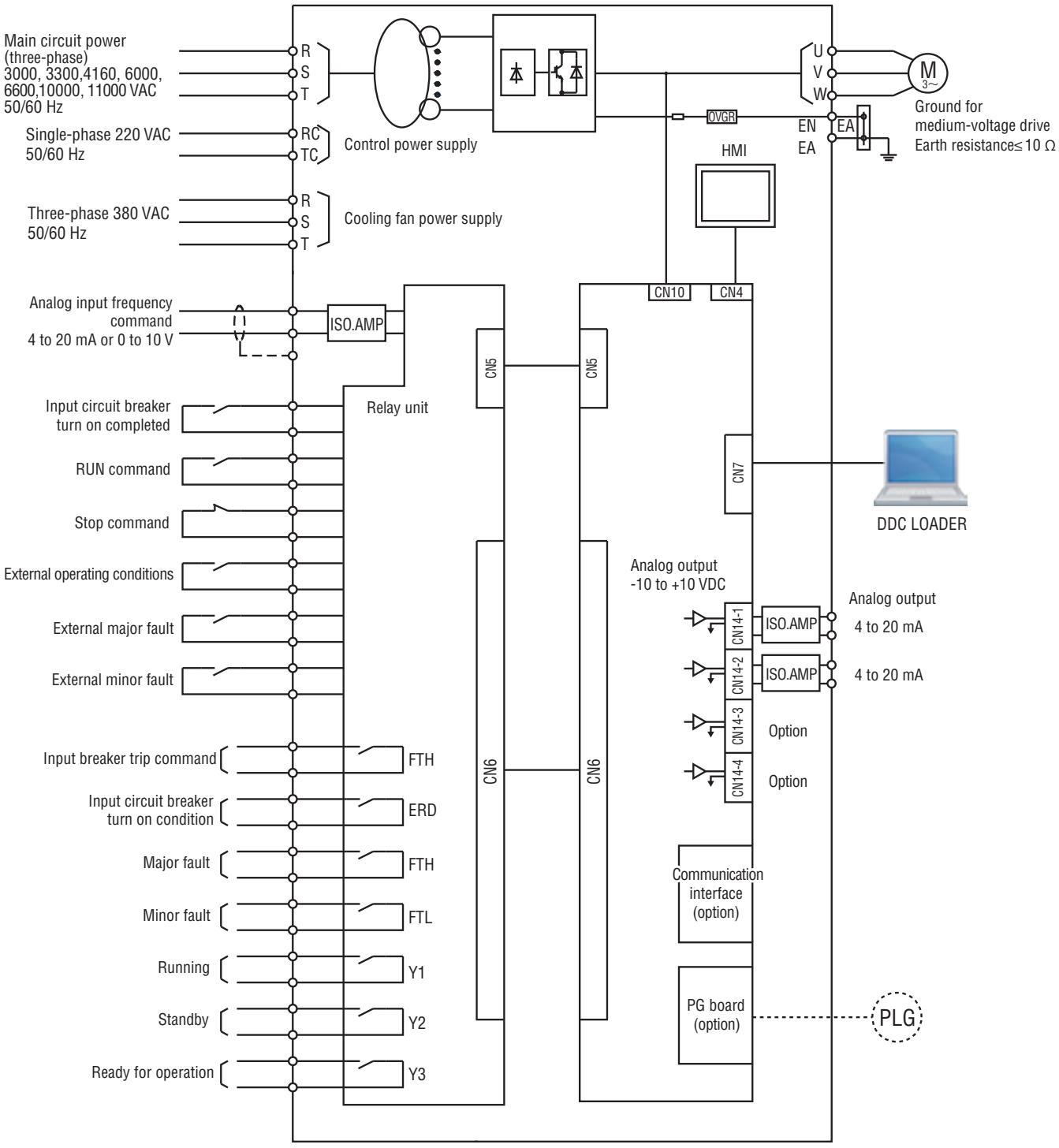
Trip data display
Displays the sampling values of internal data and bit data ON/OFF status in the event of a fault.

Save of set data, load, and comparison
The set data can be saved in the EPROM of the HMI. The saved data can also be loaded and compared with other saved data.

Standard specifications

Model number		FRENIC4600FM6e
Input	Main circuit	Three-phase, 3000, 3300, 4160, 6000, 6600, 10000, 11000 VAC, 50/60 Hz
	Control circuit	Single-phase, 220 VAC 50/60 Hz
	Fan power supply	Three-phase, 380 VAC 50/60 Hz
	Allowable power variation	Voltage: -35% to +10%, Frequency: ±5%
Control	Control method	V/f constant control with simple vector control without speed sensor Vector control with speed sensor (induction motor) vector control without speed sensor (induction motor) vector control with speed sensor *speed detection options (synchronous motor) vector control without speed sensor (synchronous motor)
	Output frequency control range	0 Hz to 72 Hz (option: up to 200 Hz) (Please consult for over 72 Hz)
	Output frequency accuracy	Relative highest frequency ±0.5% (at analog frequency reference input)
	Output frequency resolution	0.005%
	Acceleration and deceleration time	0.1 to 5500 s
	Overload capacity	110% 60 s (made-to-order possible tailored to customer's needs)
	Main control functions	Current limit, resonance point automatic frequency hopping, deceleration overvoltage avoidance, frequency stall control, instantaneous power failure restart, Cell automatic bypass function (option)
	Protective functions	Overcurrent, main circuit fuse blown, overvoltage, undervoltage, CPU abnormal, cooling fan stopped, etc.
	Communication functions (option)	Modbus, Profinet, T-LINK, Profibus-DP
Structure	Panel structure	Steel self-closing panel
	Protection grade	IP31 (Option: up to IP42, Option)
	Cooling system	Forced air cooling by fan at panel top (Option: Fan Redundant Function N+1)
	Paint color	RAL7032 (orange peel finish)
	Type of Capacitor	Electrolytic capacitor (Option: Film capacitor)
Ambient conditions	Ambient temperature	0 to +40°C (storage temperature: -10 to +60°C)
	Humidity	Less than 90% RH (non-condensing), RH up to 95% option available
	Altitude	Max. 1000 m above sea level (high altitude specification option also available)
	Vibration	4.9 m/s^2 or less (10 to 50 Hz)
	Installation location	Indoor general environment, with no corrosive gas, dust, flammable, explosive gas
	Cable Length	1000 m (Option: please consult for over 1000 m)
Applicable standards		IEC, GB, DL (Option: CE)

Standard connection diagram



Standard interface

Input side		
Main circuit power supply	Three-phase 3000/3300/4160/6000/6600/10000/11000 VAC, 50/60 Hz	
Control power supply	Single-phase 220 V, 50/60 Hz	
Fan power supply	Three-phase 380 V, 50/60 Hz	
Frequency setting (*)	0 to 10 V / 0 to 100%	Input impedance 1 MΩ
	or 4 to 20 mA / 0 to 100%	Input impedance 250 Ω
Run command	Opening for run ("a" contact)	Dry contact
Stop command	Opening for stop ("b" contact)	
External operating conditions	Closure when ready ("a" contact)	
Input circuit breaker turn on completed	Closure when closed ("a" contact)	

(*):1 point as standard, maximun 2 points as option.

Output side		
Ready for operation	Closure when ready ("a" contact)	Dry contact (contact capacity: 250 VAC, 2 A or 30 VDC, 3 A)
Running	Closure under operation ("a" contact)	
Major fault	Closure at major fault ("a" contact)	
Minor fault	Closure at minor fault ("a" contact)	
Input circuit breaker turn on condition	Closure when electrical condition ready ("a" contact)	
Input breaker trip command	Closure in major fault ("a" contact)	
Analog signal (option) (*)	0 to 10 V	Load resistance 10 kΩ or more
	4 to 20 mA	Load resistance 750 Ω or less

(*): The analog output signal is selectable (output current, outp-ut voltage, output frequency, and others). 2 points as standard, maximum 4 points as option.

Format Description

FRN46 – 6 F A – 60 5 60 – 1000 A

Basic format

Code	Product category
FRN46-6	FRENIC4600FM6e

Control method

Code	Control method
F	Variable torque (VT), simple speed sensor-less vector control
S	Constant torque (CT), speed sensor-less vector control
V	Constant torque (CT), with speed sensor vector control

Input voltage

Code	Input voltage
30	3.0 kV
33	3.3 kV
42	4.16 kV
60	6.0 kV
66	6.6 kV
X0	10 kV
X1	11 kV

Input frequency

Code	Input frequency
5	50 Hz
6	60 Hz

Auxiliary power

Code	Auxiliary power
A	Control power supply: single-phase 220 VAC Fan power supply: three-phase 380 VAC
Z	Other

Output capacity

Code	Output capacity
0450 to 0920	450 to 920 kVA
1000 to 9500	1000 to 9500 kVA
10000 to 18300	10000 to 18300 kVA

* For details, see the reference capacity standard.

Output voltage

Code	Output voltage
30	3.0 kV
33	3.3 kV
42	4.16 kV
60	6.0 kV
66	6.6 kV
X0	10 kV
X1	11 kV

* There are restrictions on the combination of input and output voltages.

Selection of capacity

Selection of standard capacity

Three-phase 3 kV series; Overload capacity: 110% 1 min.								
Input voltage [kV]	Rated capacity [kVA]	Rated current [A]	Maximum current*1 (overload) [A]	Full width (transformer panel + converter panel) [mm]	Depth*2 [mm]	Overall height [mm]	Overall height (excluding fan) [mm]	Approximate mass*3 [kg]
3.0	500	93	102	2,900 (1,750+1,150)	1,100	2,556	2,209	4,000
3.3	550							
3.0	700	130	143					4,300
3.3	740							
3.0	900	178	196					4,500
3.3	1,000							
3.0	1,200	227	250	3,500 (1,950+1,550)	1,300	2,566	2,052	6,250
3.3	1,300							
3.0	1,350	266	293					6,450
3.3	1,500							
3.0	1,600	312	343					6,800
3.3	1,750							
3.0	2,000	385	423	4,100 (2,150+1,950)		2,594	2,152	8,000
3.3	2,200							
3.0	2,250	443	484					8,400
3.3	2,500							
3.0	2,600	500	550	4,700 (2,350+2,350)	1,400			9,600
3.3	2,850							
3.0	3,150	635	699	6,600 (2,100+2,700+1,800)	1,700	3,011	2,652	12,500
3.3	3,600							
3.0	3,500	675	743					12,800
3.3	3,850							
3.0	4,700	914	1,006	7,100 (2,100+2,800+2,200)	1,700	3,011	2,654	14,700
3.3	5,200							
3.0	4,950	962	1,059					14,900
3.3	5,500							

*1: Output current is limited at an output frequency of 25 Hz or less. (70% of the rated current at a frequency of 0.2 Hz)
*2: The required maintenance space is as follows. (The following values are for reference. Please contact us for details.)
3 kV 500 to 2,600 kVA/ 3.3 kV 550 to 2,850 kVA: Front 1,500/Rear 500,
3 kV 3,150 to 4,950 kVA/ 3.3 kV 3,600 to 5,500 kVA: Front 2,000/Rear 600
As an option, the maintenance space can be changed to only the front.
*3: Approximate mass is for the standard specification, and may vary depending the use of optional features.

Note: The external dimensions are subject to change.

Three-phase 4 kV series; Overload capacity: 110% 1 min.								
Input voltage [kV]	Rated capacity [kVA]	Rated current [A]	Maximum current*1 (overload) [A]	Full width (transformer panel + converter panel) [mm]	Depth*2 [mm]	Overall height [mm]	Overall height (excluding fan) [mm]	Approximate mass*3 [kg]
4.16	700	97	107	2,600	1,900	2,460	2,100	3,800
4.16	970	135	148					4,400
4.16	1,250	178	196					4,600
4.16	1,650	229	252	4,500 (2,300+2,200)	1,400	3,064	2,453	7,600
4.16	1,900	266	293					7,700
4.16	2,250	312	343					7,900
4.16	2,750	382	420	5,400 (2,800+2,600)	1,500			10,000
4.16	3,200	443	484					10,200

*1: Output current is limited at an output frequency of 25 Hz or less. (70% of the rated current at a frequency of 0.2 Hz)
*2: The required maintenance space is as follows. (The following values are for reference. Please contact us for details.)
700 to 3,200 kVA: Front 1,500/Rear 600
For the following capacities, the maintenance space can be changed to front only as an option.
1,650 to 3,200 kVA
*3: Approximate mass is for the standard specification, and may vary depending the use of optional features.

Note: The external dimensions are subject to change.

Three-phase 6 kV series; Overload capacity: 110% 1 min.								
Input voltage [kV]	Rated capacity [kVA]	Rated current [A]	Maximum current*1 (overload) [A]	Full width (transformer panel + converter panel) [mm]	Depth*2 [mm]	Overall height [mm]	Overall height (excluding fan) [mm]	Approximate mass*3 [kg]
6.0	450	44	48	2,500	1,670	2,460	2,100	2,950
6.6	500							
6.0	510	49	54					3,050
6.6	550							
6.0	550	53	58					3,100
6.6	600							
6.0	610	59	65					3,200
6.6	670							
6.0	700	67	74					3,250
6.6	770							
6.0	770	74	82					3,300
6.6	840							
6.0	880	87	96					3,600
6.6	1,000							
6.0	1,000	93	102					3,700
6.6	1,100							
6.0	1,100	106	116	2,600	1,900			4,600
6.6	1,200							
6.0	1,200	115	127					5,000
6.6	1,300							
6.0	1,350	130	143					5,100
6.6	1,500							

Selection of capacity

Selection of standard capacity

Input voltage [kV]	Rated capacity [kVA]	Rated current [A]	Maximum current*1 (overload) [A]	Full width (transformer panel + converter panel) [mm]	Depth*2 [mm]	Overall height [mm]	Overall height (excluding fan) [mm]	Approximate mass*3 [kg]
6.0	1,500	144	159	2,600	1,900			5,400
6.6	1,650							
6.0	1,700	162	178					5,500
6.6	1,850							
6.0	1,850	178	196					5,600
6.6	2,000							
6.0	2,000	192	211	4,800 (2,300+2,500)	1,470	3,064	2,453	7,100
6.6	2,200							
6.0	2,250	218	240					7,150
6.6	2,500							
6.0	2,500	241	265					7,650
6.6	2,750							
6.0	2,750	266	293					7,750
6.6	3,000							
6.0	3,000	289	318					7,900
6.6	3,300							
6.0	3,300	312	343					8,000
6.6	3,600							
6.0	3,700	356	392	6,200 (2,800+3,400)	1,570			10,100
6.6	4,000							
6.0	4,000	385	424					10,200
6.6	4,400							
6.0	4,600	443	487					10,300
6.6	5,100							
6.0	4,800	462	508	6,800 (2,900+3,900)				11,700
6.6	5,300							
6.0	5,200	500	550					11,800
6.6	5,700							
6.0	5,900	563	619	7,400 (3,000+3,000+1,400)	1,670	3,162	2,552	14,950
6.6	6,500							
6.0	6,600	635	699					15,950
6.6	7,250							
6.0	7,000	675	743					16,950
6.6	7,700							
6.0	7,500	722	794	11,100 (2,900+3,000+3,800+1,400)	1,600			22,500
6.6	8,300							
6.0	8,360	803	883					23,500
6.6	9,200							
6.0	9,400	900	990					24,500
6.6	10,000							
6.0	10,000	962	1,058					25,500
6.6	11,000							

*1: Output current is limited at an output frequency of 25 Hz or less. (70% of the rated current at a frequency of 0.2 Hz)
*2: The required maintenance space is as follows. (The following values are for reference. Please contact us for details.)
6 kV 450 to 1,850 kVA/ 6.6 kV 500 to 2,000 kVA: Front 1,200/Rear 600, 6 kV 2,000 to 11,000 kVA/ 6.6 kV 3,300 to 11,000 kVA: Front 1,500/Rear 600
For the following capacities, the maintenance space can be changed to front only as an option.
6 kV:2,000 to 10,000 kVA /6.6 kV 2,200 to 11,000 kVA
*3: Approximate mass is for the standard specification, and may vary depending the use of optional features.
Note: The external dimensions are subject to change.

Three-phase 10 kV series; Overload capacity: 110% 1 min.								
Input voltage [kV]	Rated capacity [kVA]	Rated current [A]	Maximum current*1 (overload) [A]	Full width (transformer panel + converter panel) [mm]	Depth*2 [mm]	Overall height [mm]	Overall height (excluding fan) [mm]	Approximate mass*3 [kg]
10	500	29	32	3,400	1,770	2,460	2,100	3,700
10	625	36	40					3,900
10	700	40	44					4,000
10	800	46	51					4,100
10	920	53	58					4,200
10	1,000	58	64					4,300
10	1,160	67	74					4,600
10	1,280	74	81					4,700
10	1,350	78	86					4,800
10	1,500	87	96					4,900
10	1,600	93	102					5,000
10	1,700	98	108	5,400 (2,400+3,000)	1,370	2,783	2,253	6,000
10	1,850	107	118					6,100
10	2,000	115	127					6,700
10	2,250	130	143					6,800
10	2,500	144	158					6,950
10	2,750	159	175					7,050
10	3,080	178	196					7,150
10	3,350	193	212	7,100 (2,900+4,200)	1,570	3,064	2,453	9,900
10	3,750	217	239					11,500
10	4,200	242	266					11,600
10	4,600	266	293					11,800
10	5,000	289	318	7,300 (3,100+4,200)				11,900
10	5,400	312	343					13,000
10	5,850	338	372	8,300 (3,100+5,200)				13,050
10	6,600	381	419					14,200
10	7,000	404	444	11,400 (2,900+2,700+5,800)	1,500			19,650
10	7,700	443	487					19,850
10	8,000	462	508					20,300
10	8,700	500	550					20,400
10	10,500	606	667	12,500 (2,900+2,900+5,700+1,000)	1,700	3,119	2,652	22,000
10	11,700	675	743					23,200
10	13,500	779	857	14,100 (3,200+3,200+6,700+1,000)	1,700	3,239	2,671	25,800
10	16,500	962	1,058					28,800

*1: Output current is limited at an output frequency of 25 Hz or less. (70% of the rated current at a frequency of 0.2 Hz)
*2: The required maintenance space is as follows. (The following values are for reference. Please contact us for details.)
500 to 3,080 kVA: Front 1,200/Rear 600, 3,350 to 16,500 kVA: Front 1,500/Rear 600
For the following capacities, the maintenance space can be changed to front only as an option.
1,700 to 16,500 kVA
*3: Approximate mass is for the standard specification, and may vary depending the use of optional features.

Note: The external dimensions are subject to change.

Selection of standard capacity

Three-phase 11 kV series; Overload capacity: 110% 1 min.								
Input voltage [kV]	Rated capacity [kVA]	Rated current [A]	Maximum current*1 (overload) [A]	Full width (transformer panel + converter panel) [mm]	Depth*2 [mm]	Overall height [mm]	Overall height (excluding fan) [mm]]	Approximate mass*3 [kg]
11	625	33	36	3,700	1,700	2,460	2,100	4,100
11	700	37	41					4,300
11	800	42	46					4,400
11	920	48	57					4,500
11	1,000	52	58					4,600
11	1,150	60	66					4,700
11	1,250	67	74					5,000
11	1,350	71	78					5,100
11	1,500	79	87					5,200
11	1,600	84	92					5,300
11	1,750	93	102					5,400
11	1,850	97	107	6,600 (2,800+3,800)	1,500	2,783	2,253	8,100
11	2,000	105	116					8,200
11	2,250	118	130					9,000
11	2,500	130	143					9,200
11	2,750	144	158					9,300
11	3,100	163	179					9,400
11	3,400	178	196					9,500
11	3,750	197	217	8,200 (3,100+5,100)		3,064	2,453	11,400
11	4,200	220	242					13,100
11	4,600	241	265					13,300
11	5,000	266	293					13,500
11	5,400	283	311					13,800
11	6,000	312	343					14,000
11	6,600	346	381	11,900 (2,900+2,600+3,500+2,900)				21,200
11	7,000	367	404					21,400
11	7,700	404	444					21,600
11	8,400	443	487					21,800
11	8,700	457	503	13,000 (3,100+3,100+6,800)		3,063	2,452	22,300
11	9,500	500	550					22,400
11	11,500	604	664	15,200 (2,200+3,700+2,300+3,800+3,200)	1,700	3,094	2,652	28,500
11	12,800	675	743					29,500
11	15,000	787	866	16,200 (2,200+3,700+2,800+4,300+3,200)		3,239		34,400
11	18,300	962	1,058					36,400

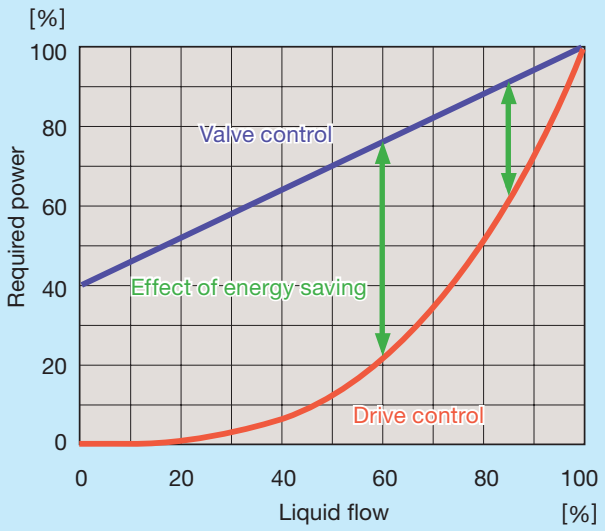
*1: Output current is limited at an output frequency of 25 Hz or less. (70% of the rated current at a frequency of 0.2 Hz)
*2: The required maintenance space is as follows. (The following values are for reference. Please contact us for details.)
625 to 3,400 kVA: Front 1,200/Rear 600, 3,750 to 18,300 kVA: Front 1,500/Rear 600
For the following capacities, the maintenance space can be changed to front only as an option.
1,850 to 18,300 kVA
*3: Approximate mass is for the standard specification, and may vary depending the use of optional features.

Note: The external dimensions are subject to change.

FRENIC4600FM6e inverter operation promises substantial energy saving and CO_2 reduction.

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

Liquid flow and power characteristics



Principle of energy conservation

This can be seen with the principle of fluid dynamics.

$$\frac{Q_1}{Q_2}=\frac{N_1}{N_2},\ \frac{H_1}{H_2}=\left(\frac{N_1}{N_2}\right)^2,\ \frac{P_A}{P_C}=\left(\frac{N_1}{N_2}\right)^3$$

In the equation:
N—rotational speed of the motor
Q—flow
H—pressure
P—shaft output

In the above equation, the flow rate of the load and rotational speed of the motor; the pressure of the load and the square of the rotational speed of the motor; and the output of the load and the cube of the rotational speed of the motor, all have a directly proportional relationship.

Example of usage and effects

When a constant speed electric motor that controls a valve (damper) is operated at a variable speed by the drive, the energy-saving effects (cost savings) on electric power charges will be as follows.

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)

During constant speed operation of motor

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

During drive operation (variable speed operation by the drive)

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

Annual energy saving effect

3,340,000 - 1,660,000 = 1,680,000 kWh
If 1 kWh = 0.8 yuan, the electricity bill for the year will be 1.344 million yuan (RMB).
CO_2 reduction = 635,040 kg

Abundant variations in the series

The abundant variation of products in this series can meet a variety of needs.

Application	Series	Features	Output voltage [V]	Capacity range [kVA] 10 100 1000 10000
For plant	FRENIC-GS	Vector or V/f controlled drive for plants • Drives with high-performance control (quick response, high-accuracy and wide range of speed control) and superior supervising. • The DC-link system allows highly efficient plant operation.	400 690	3900 3900
	FRENIC 4000VM6	Vector controlled drive for plants • High-performance vector control system for quick response, high-accuracy and wide range of speed control. • The DC-link system allows highly efficient plant operation.	400	5400
	FRENIC 4000FM6	V/f controlled drive 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 4400VM6	Large-capacity vector controlled drive • The capacity of FRENIC4000 series units has been increased due to 3-level control.	850	8400
	FRENIC 4800VM6	Medium-voltage, water-cooling, large-capacity and vector controlled drive • The capacity of FRENIC4000 series units has been increased due to 3-level control. • Downsizing achieved by adopting a water-cooling system	3300	26400
	LEONIC-M700	• Thyristor control equipment for DC motors of over 450 kW (panel type).	DC220 DC440 DC750	.....
	LEONIC-M Compact	• Unit-type DC motor controller, which facilitates maintenance of existing equipment.	DC220 DC440	75 kW 150 kW
For general industry (medium-voltage)	FRENIC 4600FM6e	• Medium-voltage direct output drive (for fan/pump) • Achieve the compactness • Achieve energy savings by operating the motor at variable speed • Power supply and motor friendly circuit configuration and control design	3000/3300 4160 6000/6600 10000 11000	5500 3200 11000 16500 18300
For general industry (low-voltage)	FRENIC-VG	High-performance vector controlled drive	200 400 690	90 kW 800 kW 450 kW
	FRENIC-MEGA	High-performance V/f controlled drive	200 400	90 kW 630 kW

Ordering information

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

1. Application of drive

2. 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•m^2
- Overload: ☐ %

3. Input specifications

- Rated voltage: ☐ V ± ☐ %
- Rated frequency: ☐ Hz ± ☐ %
- Control power supply: Single-phase, two-wires, 220 V, 50 Hz
- Fan power supply: Three-phase, three-wires, 380 V, 50 Hz

4. Drive motor

- Motor specifications (Existing or New installation)
- Rating

  Output: ☐ kW, No. of poles: ☐,

  Voltage: ☐ kV, Frequency: ☐ Hz,

  Speed: ☐ r/min, Rated current: ☐ A

5. Rotational speed control range: ☐ r/min to ☐ r/min

6. Rotational frequency setting method

- (Analog signal: 4 to 20 mA, 0 to 10 V, Up/down signal, etc.)

7. Commercial power source bypass circuit (with or without)

8. Ambient conditions

- Install location: Indoor
- Altitude
- Provision of air conditioning
- Limitation on Transportation
- Humidity
- Temperature

Fuji Electric Co., Ltd.
Gate City Ohsaki, East Tower, 11-2, Osaki 1-chome, Shinagawa-ku, Tokyo 141-0032, Japan
Phone : +81-3-5435-7111

Internet address : www.fujielectric.co.jp

2024-4(D2024c/D2016)0.3FOLS Printed in Japan