Fuji Electric

Innovating Energy Technology

FRENIC4600FM5e

Fuji Medium-voltage IGBT Inverters

AC Adjustable Speed Drive

24D1-E-0035d

Fuji Electric strives to use its medium voltage inverter to protect the environment and create clean energy for you.

Fuji Electric, founded in 1923, is a well-known large-sized comprehensive industrial electrical equipment manufacturer which widely used in the fields of electric power, iron and steel, petroleum, mining, chemical, cement, automobiles, and utilities.

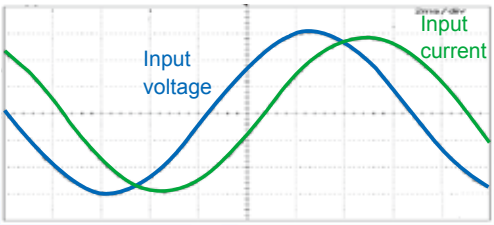
Fuji Electric works constantly to explore developments and applications that combine advanced electrical and electronic technologies such as power semiconductors, microelectronic circuits, and automatic control systems. Since the 1980s, Fuji has produced adjustable speed drives used in all kinds of load equipment, of which the FRENIC4600FM5e medium voltage IGBT inverter is known as Fuji Electric's main high-performance, high-reliability medium voltage adjustable speed drive.

Contents

1 Substantial reduction of harmonic current on power source side

- FRENIC4600FM5e suppresses the harmonics by using a multi-pulse diode rectification system (24 to 60 pulses), thereby substantially reducing the generation of harmonics in comparison with previous models. The harmonic generation level stipulated in IEEE-519 (1992) is satisfied. This inverter is ideal for power sources.

Current waveform on power source side



Harmonic current content

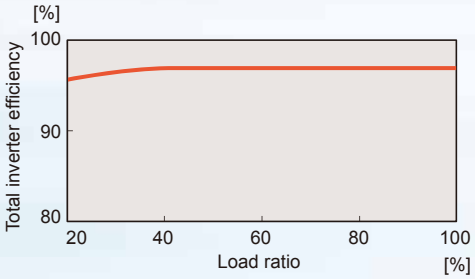
Order	5th	7th	11th	13th	17th	19th	23th	25th	35th	37th
IEEE value [%]	4.00	2.86	1.83	1.49	1.14	1.02	0.87	0.80	0.80	0.80
Measured value (*) [%]	0.58	1.0	0.20	0.32	0.75	0.54	0.06	0.24	0.58	0.27

(*): Measure example from actual load test.

2 Total inverter efficiency as high as approximate 97%

- 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 harmonic losses.

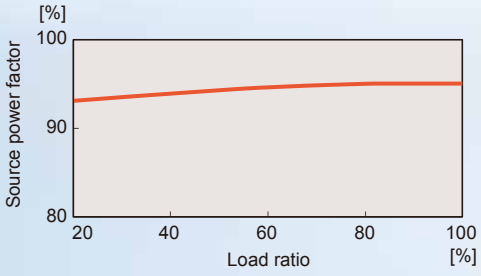
Total inverter efficiency curve (including input transformer)



3 Source power factor as high as 95% or more

- 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



Note: The efficiency and power factor data on this page are calculated by assuming that a 315kW motor is operated at the rated speed with a 3.3kV-input, 390kVA-output inverter. The data on efficiency is obtained using Fuji Electric's standard 4-pole motor.

4 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.

5 Vector control

- Vector control with a speed sensor is available (as an option) for equipment having high speed and torque accuracy requirements. (option)

6 Easy maintenance

- The inverter is air-cooled, requiring no cooling water.
- Start/stop operation, parameter setting, fault display and data monitoring are performed on 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.

Industry Applications

Construction Materials

- Kiln head cooling fans
- Kiln tail heating fans
- Grinders
- Cement rotary kilns

Petrochemical

- Catalytic cracking unit
- Hydrogenation compressor
- Oil and gas transmission device
- Blowers/pumps/pelletizer

Mining

- Belt conveyers
- Grinders
- Mine air circulation blowers

Iron and steel

- Blast fumace blowers
- Primary/secondary dust blowers
- Dry quenched coke circulation blower
- High-pressure phosphorus ejector pump
- Blowers/water pumps
- Crusher

Electric power

- Induced draft fan/forced draught fan
- Primary/secondary blowers
- Condensation pumps
- Recirculation pumps
- Feed pumps

Others

- Water conservancy, utilities (pumps)
- Sugaring (mill)
- Test crew
- Internal mixer

Reasonable circuit structure

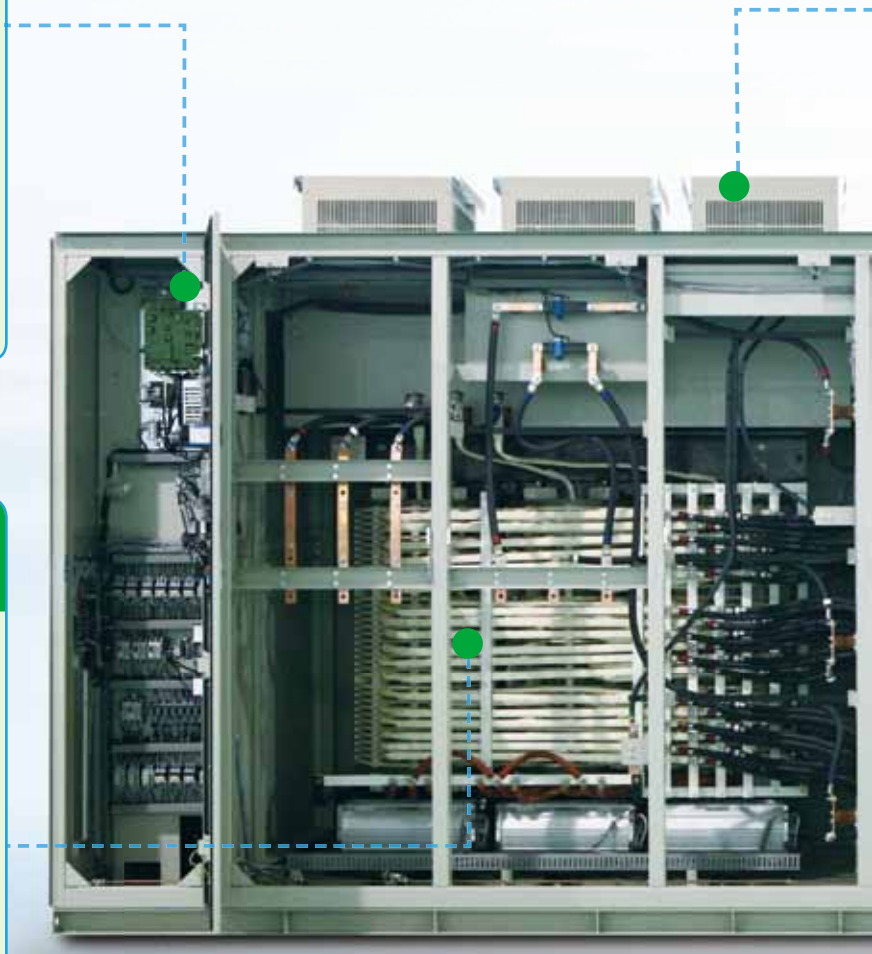
High-reliability and simple-maintenance inverters utilizing the latest power electronics such as 3-level inverter, mounting of special MPU and no need for harmonic filter/power-factor regulating capacitor.

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.

Input multiplex-winding transformer

- Harmonic current on the power source side is low due to a multiplex configuration of the secondary winding.
- Multi-pulse rectification (24 to 60 pulses) and the generation of harmonics meet the IEEE standard.
- Harmonic filters and power factor regulating capacitors are not needed.
- Because a dry-type input transformer is integrated in the panel, external cabling work between the input transformer and inverter panel is no longer necessary.



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.

Main circuit configuration

Fig. 1 Main circuit configuration of 6kV type

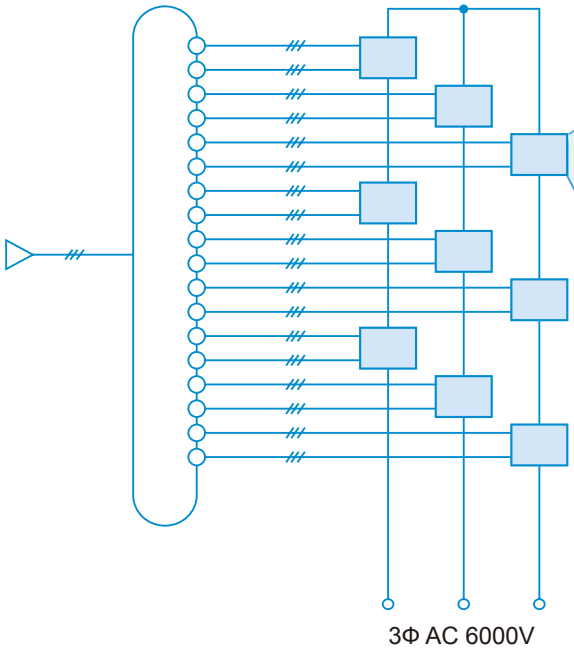
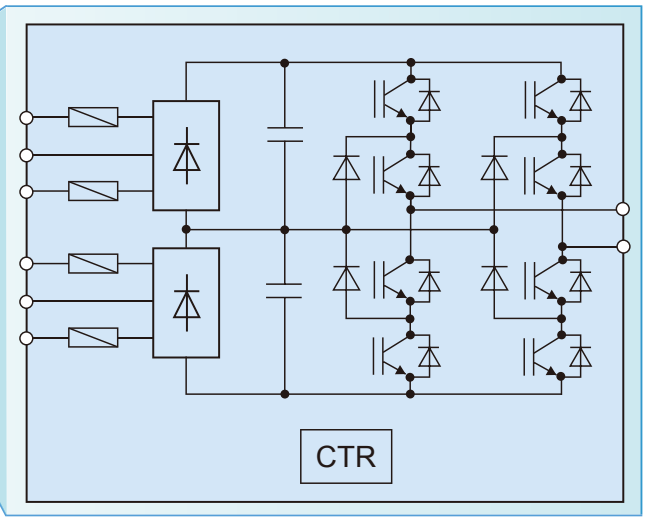


Fig. 2 Internal configuration of inverter cell



Principle of operation

FRENIC4600FM5e consists of an input transformer and 9 inverter cells in case of the 6kV type as shown in Fig. 1 (the 10kV type has 12-15 inverter cells and the 4.16 and 3kV types have 6 inverter cells.).

One inverter cell consists of a single-phase, 3-level inverter and can output 1,155V. As shown in Fig. 1, the 6kV type obtains a phase voltage of about 3,465V by connecting 3 inverter cells in series and a star connection of the vertical cell pairs can generate a line voltage of about 6,000V.

Use of the single-phase, 3-level inverter doubles the output voltage obtainable from one cell when compared with a single-phase, 2-level inverter. Therefore, an output voltage can be obtained by using a smaller number of inverter cells. (See Figs. 3 and 4.)

Fig. 3 3-level voltage output

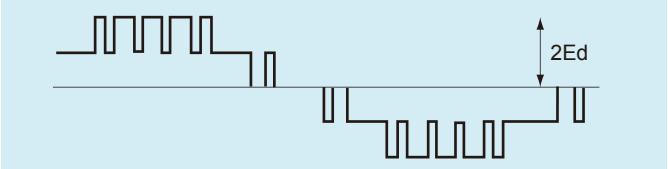
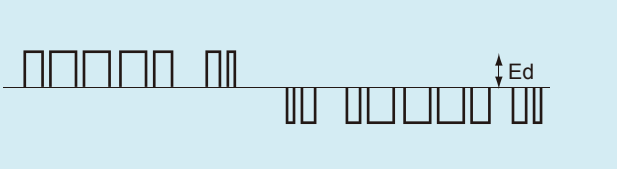


Fig. 4 2-level voltage output



Ed: Intermediate DC voltage

Friendly to machines

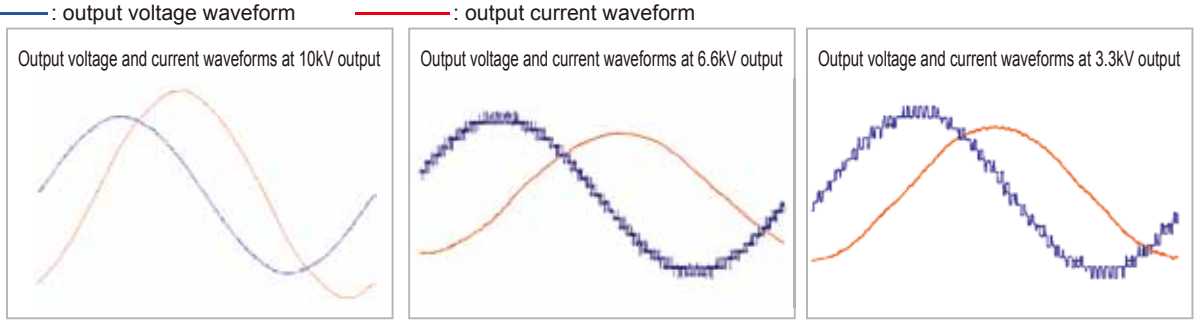
If a harmonic current component is contained in the inverter output current, a torque pulsation occurs on the output shaft of a motor. A torque pulsation means a change in rotational speed or a large vibration if the frequency of the torque pulsation matches the natural frequency of the mechanical system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

In FRENIC4600FM5e, the harmonic component on the output side is extremely small due to the multi-level (max. 21 levels) PWM control and the main component of torque pulsation is at around the carrier frequency (several kHz). Therefore, torque pulsation hardly affects the machine side.

Friendly to motors

- The multi-level PWM control provides an almost sinusoidal output current waveform, thus reducing motor torque pulsation.
- Because the output current is almost sinusoidal, a motor suffers less loss due to harmonics.
- The multi-level (max. 21 levels) PWM control minimizes switching surge and thereby reduces stress on the motor.
- There is no need to reduce motor capacity after applying inverter drive.
- There is no need for special cables, etc. after applying 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 waveform : output current waveform



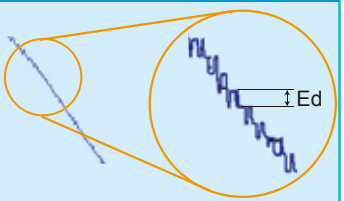
Note

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 the DC intermediate voltage level so as to realize an output voltage waveform at 21 levels in the 10kV class, at 13 levels in the 6kV class and 9 levels in the 3kV class. As a result, the overvoltage generated at the motor terminal can be suppressed.



Output voltage waveform (13 levels) in 6kV class

In the 6kV 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.

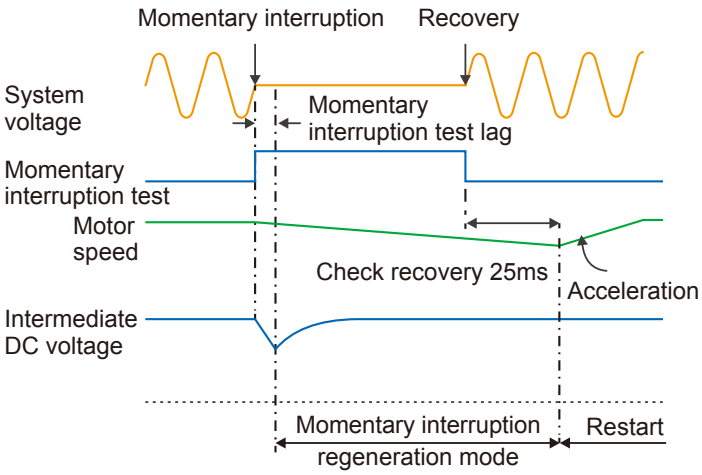
Thus, Fuji Electric's inverter can also reduce the surge voltage appearing at the motor terminal and thereby moderate the stress applied to the motor.

Momentary interruption introduction

- 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.

Fig. 1 Sequence During Continuous Operation



Notes1) A voltage drop due to a momentary power interruption will be detected at 80% or less of the rated voltage.
Notes2) Operation can be continued within 300ms at a voltage drop due to a momentary power interruption (option).

Synchronization undisturbed switch

- Shockless switching between inverter operation and commercial power operation allowed by phase control according to system voltage. (See Fig. 3.) (Synchronizing/parallel off function: option)

  An electric reactor must be installed on the output side of the inverter to enable this function.

Fig. 2 Power system diagram

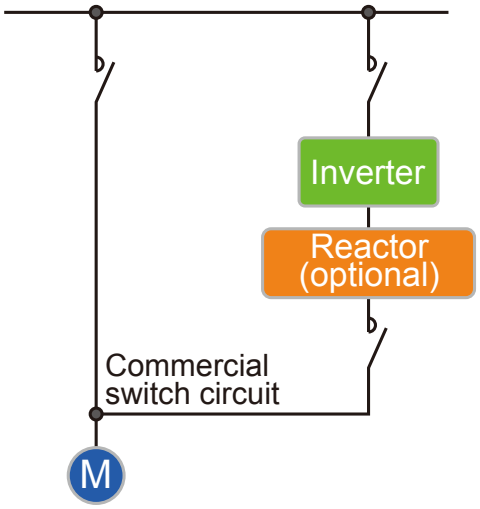
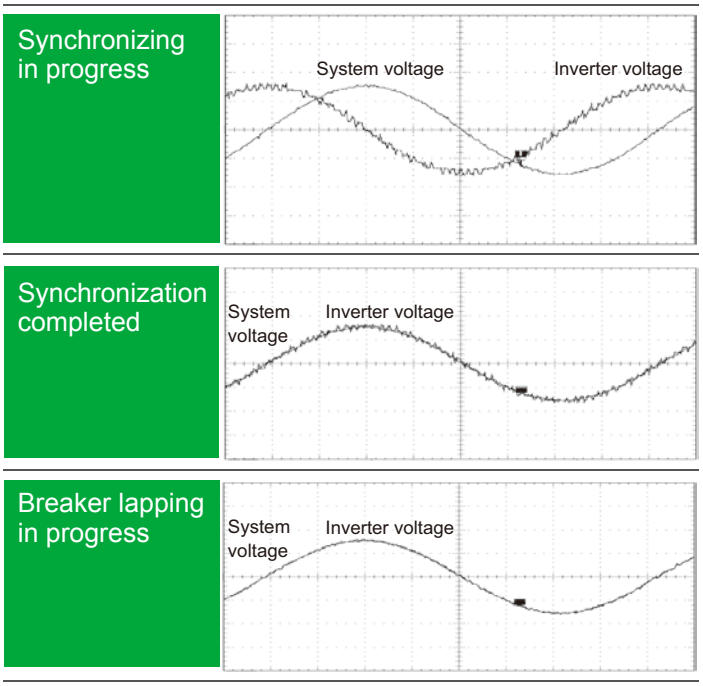


Fig. 3 Synchronization/parallel off waveform



Control Functions

The CPU for the FRENIC4600FM5e series of medium voltage inverter's basic control system (control, operation program, and all types of interfaces), high speed computing electric current control system, and medium voltage command processing and output voltage pulse waveform processing system has a 32-bit RISC processor.

The system provides the best control for all types of functions and internally integrates the following functions:

1 Logic Function

- Provides system operation and stoppage through software based on external logic and control signals.

2 Regulation Function

- Provides the best regulation control based on the sampling control principle.

3 Control Parameter Setting Function

- Can set all system control parameters through the operations panel, programmer, POD, or central monitoring system and provide the best adjustment capability.

4 Malfunction Detection Function

- When failure occur, it confirms information through the operations panel's monitor, POD, programmer, or central monitoring system.
- Also, the followed back up data before and after the failure occuring can be collected through the programmer, or central monitoring system.

5 Independent Operation Function

- Can control operation of the FRENIC4600FM5e 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 Outage Protection System

- When power outages occur, processing can proceed without power, with the RAM data having backup capacity, allowing data to be maintained for one week without power.
- It also backs up the settings data in flash memory, meaning that the settings will not be lost when there is a power outage.

7 On-line · Analog Data Output

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

Data setting and monitoring

Simple operation and monitoring on the 5.7" LCD touch panel

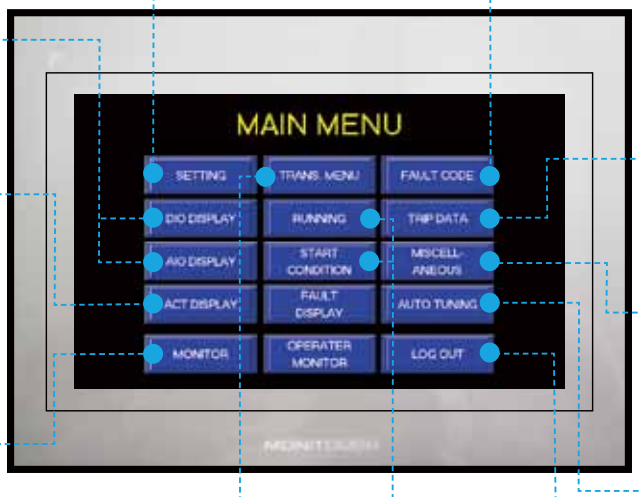
Setting
The control parameters can be set, changed, and displayed.

DIO display, AIO display
Displays the I/O status and function assignment data.

Act display
Displays the actual value of each part of the inverter (such as frequency reference, voltage reference, current reference, and current detection).

Monitor
Displays the actual value of each part of the inverter by the control block.

Trans. menu
Displays the transmission status and I/O data value.



Fault code
Displays the date and time of occurrence of faults (major, medium, and minor faults) along with their causes.

Fault history of up to 100 occurrences can be checked.

Trip data
Displays the data of each part at the time fault occurs.

Miscellaneous
The time setting of the internal clock and inverter data can be checked.

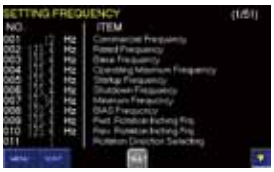
Auto tuning
The motor can be tuned.

Running, Start condition
The frequency setting and operation conditions (approved or unapproved) can be checked.

Log out
The screen can be monitored, in which the parameter can not be changed.

Screen examples


Running


Setting


Monitor


Start condition


Fault history

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.

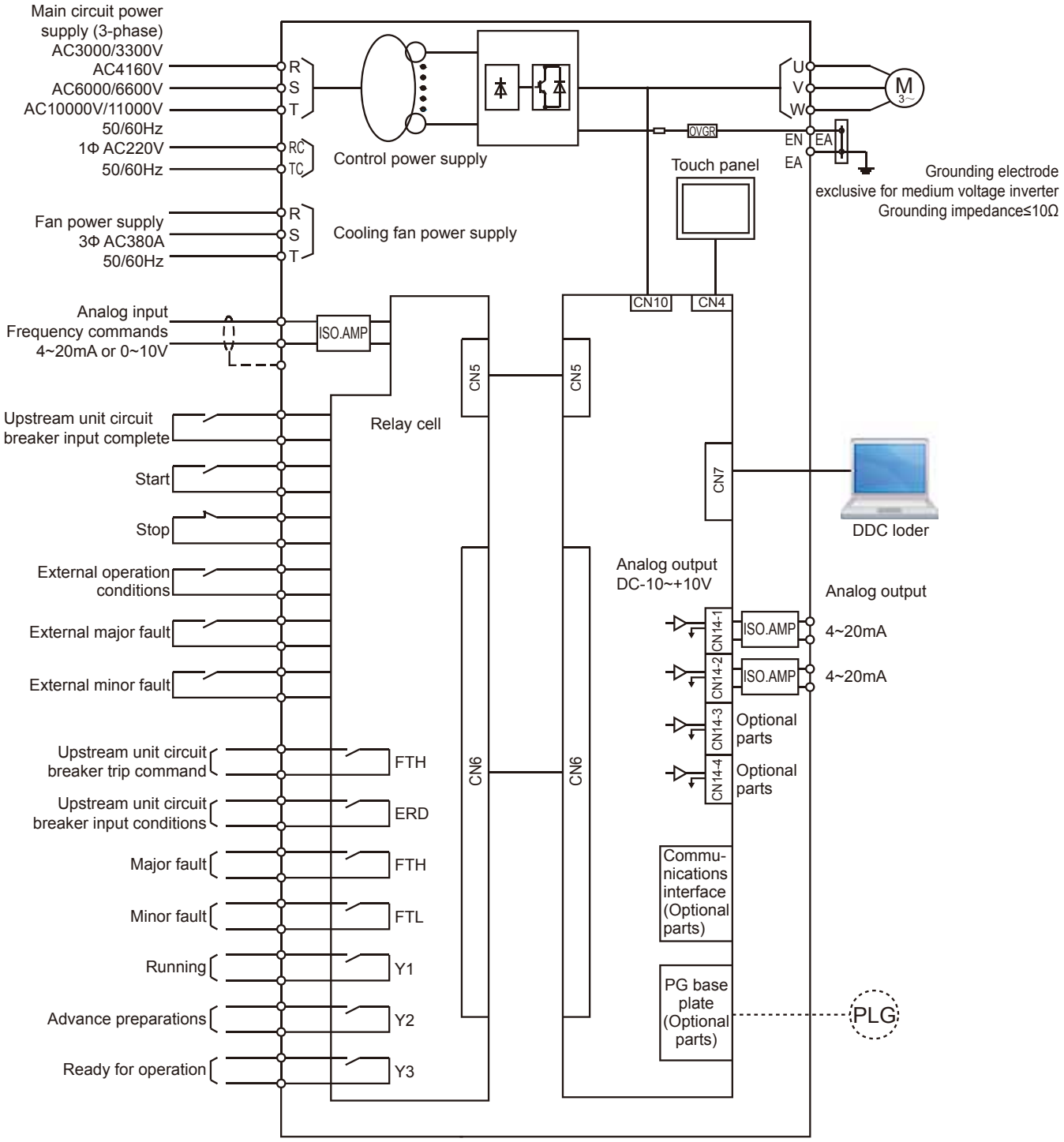
Trip data display
Displays the sampling values of internal data and bit data ON/OFF status in the event of a fault.

Save, recover and compare setting data
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.

Inverter standard specifications

Inverter type		FRENIC4600FM5e
Input	Main circuit	3-phase 3000/3300V, 4160V, 6000/6600V, 10000/11000V, 50/60Hz
	Control circuit	single-phase 220V 50/60Hz
	Fan power supply	3-phase 380V 50/60Hz
	Allowable power variation	Voltage: -10% ~ +10%, Frequency: ±5%
Control	Control system	V/f constant with simple sensor-less vector control, vector control without speed sensor, vector control with speed sensor.
	Output frequency control range	0.2Hz to 50/60Hz (option to 120Hz).
	Output frequency accuracy	Relative maximum frequency ±0.5% (when the analog frequency is the baseline input).
	Output frequency resolution	0.005%
	Accel./decel. time	0.1 to 5500s
	Overload capability	120% for 60s under condition of cold start if cooling fan temperature is less than 40°C.
	Main control function	Current limit, stall prevention, jump frequency setting, automatic deceleration, momentary drop protection and stop/restart (option)
	Protection function	Overcurrent, main circuit fuse blown, overvoltage, undervoltage, CPU fault, cooling fan stop
	Transmission function (option)	T-link, Profibus-DP, Modbus
Structure	Panel structure	Steel panel self-standing enclosed.
	Degree of protection	IP20 (up to IP31/IP42 options)
	Cooling	Forced ventilation with ceiling fan (Leather tone non gloss).
	Coating color	RAL7032 (Leather tone non gloss).
Ambient conditions	Ambient temperature	0 ~ +40°C (Storage temp.: -10 ~ +60°C)
	Humidity	90% RH below (no condensation), option: 95% RH max.
	Altitude	Altitude: 1,000 meters and below (high altitude is optional).
	Vibration	4.9m/s^2 and below (10 to 50Hz).
	Installation place	Indoor, general environment free from corrosive gas, dust and flammable/ explosive gas
Applicable standard		IEC, JIS, JEM, JEC, GB, CE (Option)

Standard connection diagram



Standard interface

Input side		
Main circuit power supply	3-phase 3000/3300/4160/6000/6600/10000V, 50/60Hz	
Control power supply	Single phase 220V, 50/60Hz	
Fan power supply	3-phase 380V, 50/60Hz	
Frequency setting	0 to 10V/0 to 100%	Input impedance 1MΩ
	or 4 to 20mA/0 to 100%	Input impedance 250Ω
Run command	Closure for run ("a" contact)	Dry contact
Stop command	Opening for stop ("b" contact)	
Ready for operation	Closure when ready ("a" contact)	
Input circuit breaker status signal	Closure when closed ("a" contact)	

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

(*): The analog output signal is selectable (output current, output voltage, output frequency, and others).

Selection explanation

FRN46 – 4 F A – 60 5 60 – 1000 A

Basic model number

Reference number	Product differentiation
FRN46-4	FRENIC4600FM5e

Control method

Reference number	Control method
F	Variable torque, V/F constant with simple speed sensor-less vector control
S	Constant torque, speed sensor-less vector control
V	Constant torque, vector control with speed sensor

Input voltage

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

Input frequency

Reference number	Input frequency
5	50Hz
6	60Hz

*There are limitations of the combination of input voltage and input frequency.

Output voltage

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

Output capacity

Reference number	Auxiliary power
0275~0980	275~980 kVA
1000~9500	1000~9500kVA
X500	10500kVA

*For detalls, see standard capacity specincations

Auxiliary power

Reference number	Auxiliary power
A	Control power: Single-phase 220V Fan power: Three-phase 380V
Z	Other

Capacity selections

Standard capacity selections

Voltage rating 3kV						
Model	Rated capacity [kVA]	Rated current [A]	Maximum current (overload) [A]	Applied electric motor power (reference) [kW]	External appearance (reference)	Approximate weight [kg]
FRN46-4□A-30□30-0350□	350	69	72	280	Fig. 1	2500
FRN46-4□A-30□30-0500□	500	98	103	400	Fig. 2	3000
FRN46-4□A-30□30-0700□	700	135	141	560	Fig. 3	4100
FRN46-4□A-30□30-1050□	1050	202	212	850	Fig. 4	4500
FRN46-4□A-30□30-1350□	1350	262	276	1120	Fig. 5	6200
FRN46-4□A-30□30-1600□	1600	306	321	1320	Fig. 5	7000
FRN46-4□A-30□30-2350□	2350	460	483	2000	Fig. 6	8300
FRN46-4□A-30□30-3200□	3200	612	643	2800	Fig. 7	12300
FRN46-4□A-30□30-4750□	4750	918	964	4000	Fig. 8	26000

Voltage rating 3.3kV						
Model	Rated capacity [kVA]	Rated current [A]	Maximum current (overload) [A]	Applied electric motor power (reference) [kW]	External appearance (reference)	Approximate weight [kg]
FRN46-4□A-33□33-0390□	390	69	72	315	Fig. 1	2500
FRN46-4□A-33□33-0560□	560	98	103	450	Fig. 2	3000
FRN46-4□A-33□33-0770□	770	135	141	630	Fig. 3	4100
FRN46-4□A-33□33-1150□	1150	202	212	950	Fig. 4	4500
FRN46-4□A-33□33-1500□	1500	262	276	1250	Fig. 5	6200
FRN46-4□A-33□33-1750□	1750	306	321	1500	Fig. 5	7000
FRN46-4□A-33□33-2600□	2600	460	483	2250	Fig. 6	8300
FRN46-4□A-33□33-3500□	3500	612	643	3000	Fig. 7	12300
FRN46-4□A-33□33-5200□	5200	918	964	4500	Fig. 8	26000

*1: The applicable motor output is the reference value of Fuji Electric's standard 4-pole motors.

*2: External appearance and weight are for reference only. Please take the final drawing as the standard.

External appearance

3kV series

Fig. 1
3kV :350kVA
3.3kV:390kVA

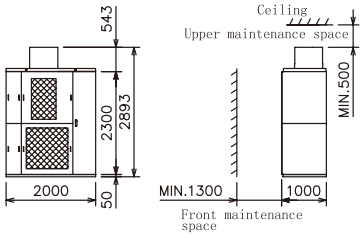


Fig. 2
3kV :500kVA
3.3kV:560kVA

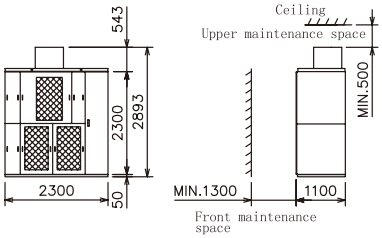


Fig. 3
3kV :700kVA
3.3kV:770kVA

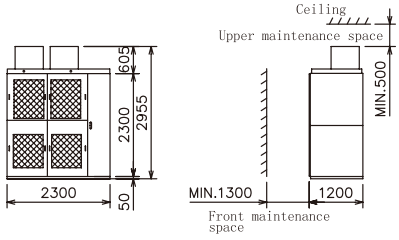


Fig. 4
3kV :1050kVA
3.3kV:1150kVA

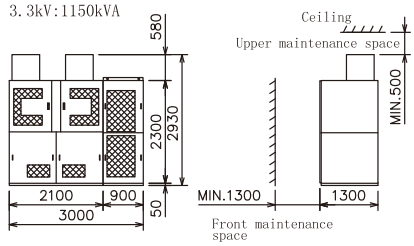


Fig. 5
3kV :1350, 1600kVA
3.3kV:1500, 1750kVA

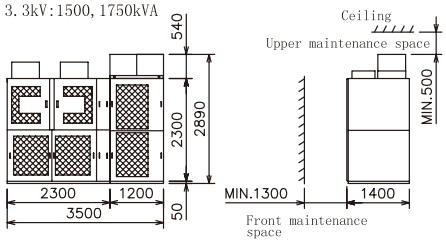


Fig. 6
3kV :2350kVA
3.3kV:2600kVA

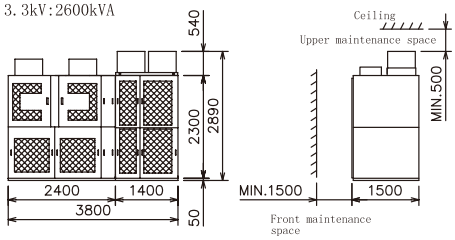
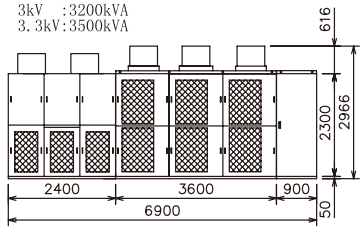


Fig. 7
3kV :3200kVA
3.3kV:3500kVA



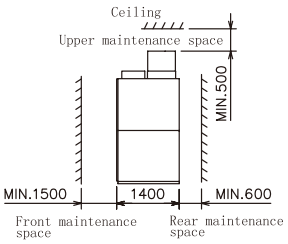
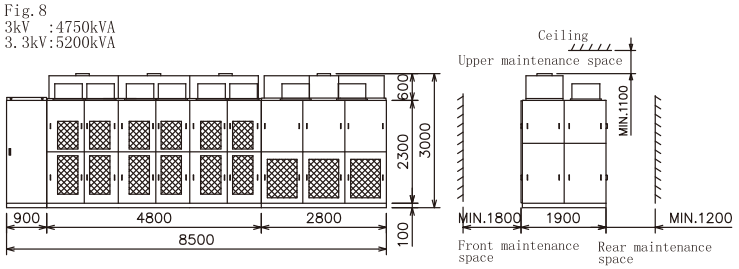


Fig. 8
3kV :4750kVA
3.3kV:5200kVA



Standard capacity selections

Voltage rating 4.16kV						
Model	Rated capacity [kVA]	Rated current [A]	Maximum current (overload) [A]	Applied electric motor power (reference) [kW]	External appearance (reference)	Approximate weight [kg]
FRN46-4□A-42□42-0310□	310	43	54	250	Fig. 9	2900
FRN46-4□A-42□42-0350□	350	49	54	280	Fig. 9	2950
FRN46-4□A-42□42-0420□	420	58	64	340	Fig. 9	3100
FRN46-4□A-42□42-0500□	500	70	77	400	Fig. 9	3250
FRN46-4□A-42□42-0660□	660	92	110	530	Fig. 10	3750
FRN46-4□A-42□42-0720□	720	100	110	580	Fig. 10	3850
FRN46-4□A-42□42-0790□	790	110	121	630	Fig. 11	4100
FRN46-4□A-42□42-0900□	900	125	150	710	Fig. 11	4250
FRN46-4□A-42□42-0980□	980	136	150	800	Fig. 11	4400
FRN46-4□A-42□42-1100□	1100	150	165	900	Fig. 12	5100
FRN46-4□A-42□42-1270□	1270	176	194	1000	Fig. 12	5350
FRN46-4□A-42□42-1450□	1450	202	212	1150	Fig. 12	5650
FRN46-4□A-42□42-1620□	1620	225	248	1300	Fig. 13	6250
FRN46-4□A-42□42-1920□	1920	266	279	1600	Fig. 13	6700
FRN46-4□A-42□42-2230□	2230	310	326	1800	Fig. 14	7600
FRN46-4□A-42□42-2900□	2900	402	482	2350	Fig. 15	10200
FRN46-4□A-42□42-3300□	3300	459	482	2700	Fig. 15	11600

*1: The applicable motor output is the reference value of Fuji Electric's standard 4-pole motors.
*2: External appearance and weight are for reference only. Please take the final drawing as the standard.

External appearance

4.16kV series

Fig. 9
4. 16kV:260, 300, 430, 500kVA

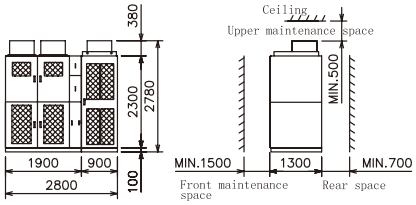


Fig. 10
4. 16kV:660, 720kVA

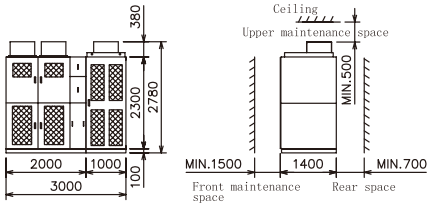


Fig. 11
4. 16kV:790, 900, 980kVA

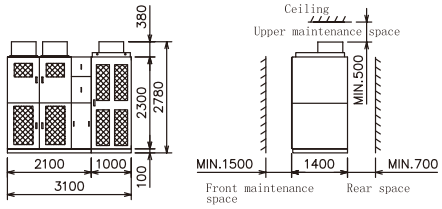


Fig. 12
4. 16kV:1100, 1270, 1450kVA

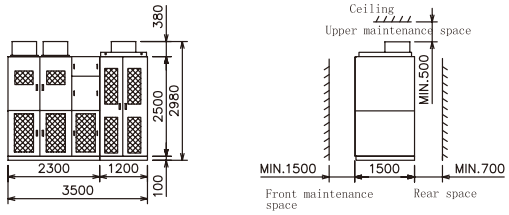


Fig. 13
4. 16kV:1620, 1920kVA

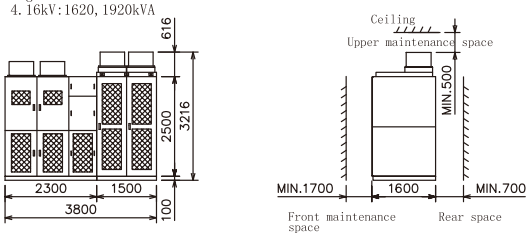


Fig. 14
4. 16kV:2230kVA

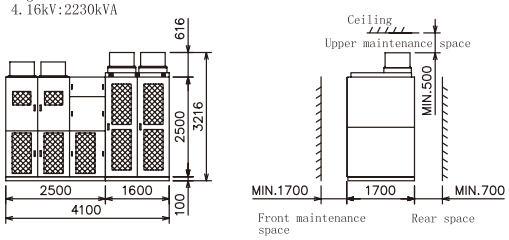
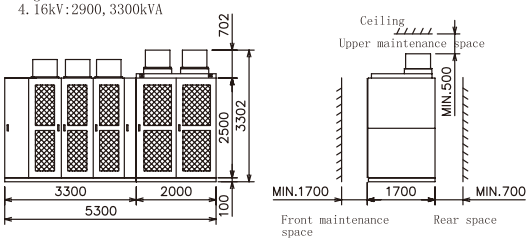


Fig. 15
4. 16kV:2900, 3300kVA



Capacity selections

Standard capacity selections

Voltage rating 6kV						
Model	Rated capacity [kVA]	Rated current [A]	Maximum current (overload) [A]	Applied electric motor power (reference) [kW]	External appearance (reference)	Approximate weight [kg]
FRN46-4□A-60□60-0275□	275	26	40	220	Fig. 16	3100
FRN46-4□A-60□60-0340□	340	33	40	280	Fig. 16	3200
FRN46-4□A-60□60-0380□	380	36	40	300	Fig. 16	3250
FRN46-4□A-60□60-0415□	415	40	54	315	Fig. 16	3300
FRN46-4□A-60□60-0460□	460	45	54	355	Fig. 16	3400
FRN46-4□A-60□60-0510□	510	49	54	400	Fig. 16	3450
FRN46-4□A-60□60-0550□	550	53	64	450	Fig. 16	3500
FRN46-4□A-60□60-0600□	600	58	64	490	Fig. 16	3700
FRN46-4□A-60□60-0670□	670	64	77	530	Fig. 16	3800
FRN46-4□A-60□60-0730□	730	70	77	560	Fig. 16	3900
FRN46-4□A-60□60-0840□	840	81	110	650	Fig. 17	4350
FRN46-4□A-60□60-0950□	950	92	110	750	Fig. 17	4600
FRN46-4□A-60□60-1040□	1040	100	110	800	Fig. 17	4700
FRN46-4□A-60□60-1140□	1140	110	121	900	Fig. 18	5050
FRN46-4□A-60□60-1300□	1300	125	150	1000	Fig. 18	5300
FRN46-4□A-60□60-1410□	1410	136	150	1120	Fig. 18	5450
FRN46-4□A-60□60-1470□	1470	142	165	1200	Fig. 19	6250
FRN46-4□A-60□60-1560□	1560	150	165	1300	Fig. 19	6400
FRN46-4□A-60□60-1680□	1680	161	194	1400	Fig. 19	6600
FRN46-4□A-60□60-1830□	1830	176	194	1500	Fig. 19	6800
FRN46-4□A-60□60-2000□	2000	192	212	1700	Fig. 19	7100
FRN46-4□A-60□60-2100□	2100	202	212	1800	Fig. 19	7250
FRN46-4□A-60□60-2340□	2340	225	248	2000	Fig. 20	8100
FRN46-4□A-60□60-2420□	2420	233	279	2100	Fig. 20	8250
FRN46-4□A-60□60-2640□	2640	254	279	2240	Fig. 20	8600
FRN46-4□A-60□60-2760□	2760	266	279	2400	Fig. 20	8800
FRN46-4□A-60□60-2900□	2900	279	326	2500	Fig. 21	9600
FRN46-4□A-60□60-3080□	3080	296	326	2700	Fig. 21	9850
FRN46-4□A-60□60-3220□	3220	310	326	2800	Fig. 21	10800
FRN46-4□A-60□60-3340□	3340	321	482	2900	Fig. 22	10800
FRN46-4□A-60□60-3850□	3850	371	482	3400	Fig. 22	11600
FRN46-4□A-60□60-4180□	4180	402	482	3700	Fig. 22	12100
FRN46-4□A-60□60-4550□	4550	440	482	4000	Fig. 22	12700
FRN46-4□A-60□60-4770□	4770	459	482	4200	Fig. 22	13650
FRN46-4□A-60□60-5500□	5500	529	635	4500	Fig. 23	23500
FRN46-4□A-60□60-6400□	6400	612	643	5600	Fig. 23	24500
FRN46-4□A-60□60-9500□	9500	918	964	8000	Fig. 24	51000

Voltage rating 6.6kV						
Model	Rated capacity [kVA]	Rated current [A]	Maximum current (overload) [A]	Applied electric motor power (reference) [kW]	External appearance (reference)	Approximate weight [kg]
FRN46-4□A-66□66-0300□	300	26	40	240	Fig. 16	3100
FRN46-4□A-66□66-0380□	380	33	40	300	Fig. 16	3200
FRN46-4□A-66□66-0410□	410	36	40	330	Fig. 16	3250
FRN46-4□A-66□66-0460□	460	40	54	360	Fig. 16	3300
FRN46-4□A-66□66-0510□	510	45	54	400	Fig. 16	3400
FRN46-4□A-66□66-0560□	560	49	54	450	Fig. 16	3450
FRN46-4□A-66□66-0610□	610	53	64	500	Fig. 16	3500
FRN46-4□A-66□66-0660□	660	58	64	540	Fig. 16	3700
FRN46-4□A-66□66-0730□	730	64	77	600	Fig. 16	3800
FRN46-4□A-66□66-0800□	800	70	77	650	Fig. 16	3900
FRN46-4□A-66□66-0930□	930	81	110	750	Fig. 17	4350
FRN46-4□A-66□66-1050□	1050	92	110	850	Fig. 17	4600
FRN46-4□A-66□66-1140□	1140	100	110	900	Fig. 17	4700
FRN46-4□A-66□66-1260□	1260	110	121	1000	Fig. 18	5050
FRN46-4□A-66□66-1430□	1430	125	150	1120	Fig. 18	5300
FRN46-4□A-66□66-1550□	1550	136	150	1250	Fig. 18	5450
FRN46-4□A-66□66-1660□	1660	142	165	1350	Fig. 19	6250
FRN46-4□A-66□66-1710□	1710	150	165	1450	Fig. 19	6400
FRN46-4□A-66□66-1840□	1840	161	194	1550	Fig. 19	6600
FRN46-4□A-66□66-2010□	2010	176	194	1700	Fig. 19	6800
FRN46-4□A-66□66-2190□	2190	192	212	1850	Fig. 19	7100
FRN46-4□A-66□66-2310□	2310	202	212	2000	Fig. 19	7250
FRN46-4□A-66□66-2570□	2570	225	248	2200	Fig. 20	8100
FRN46-4□A-66□66-2660□	2660	233	279	2300	Fig. 20	8250
FRN46-4□A-66□66-2900□	2900	254	279	2500	Fig. 20	8600
FRN46-4□A-66□66-3040□	3040	266	279	2650	Fig. 20	8800
FRN46-4□A-66□66-3190□	3190	279	326	2800	Fig. 21	9600
FRN46-4□A-66□66-3380□	3380	296	326	3000	Fig. 21	9850
FRN46-4□A-66□66-3540□	3540	310	326	3100	Fig. 21	10800
FRN46-4□A-66□66-3670□	3670	321	482	3200	Fig. 22	10800
FRN46-4□A-66□66-4240□	4240	371	482	3700	Fig. 22	11600
FRN46-4□A-66□66-4590□	4590	402	482	4000	Fig. 22	12100
FRN46-4□A-66□66-5030□	5030	440	482	4400	Fig. 22	12700
FRN46-4□A-66□66-5250□	5250	459	482	4600	Fig. 22	13650
FRN46-4□A-66□66-6000□	6000	529	635	5000	Fig. 23	23500
FRN46-4□A-66□66-7000□	7000	612	643	6000	Fig. 23	24500
FRN46-4□A-66□66-X500□	10500	918	964	9000	Fig. 24	51000

*1: The applicable motor output is the reference value of Fuji Electric's standard 4-pole motors.
*2: External appearance and weight are for reference only. Please take the final drawing as the standard.

External appearance

6kV series

Fig. 16
6kV :275, 340, 380, 415, 460, 510, 550, 600, 670, 730kVA
6. 6kV:300, 380, 410, 460, 510, 560, 610, 660, 730, 800kVA

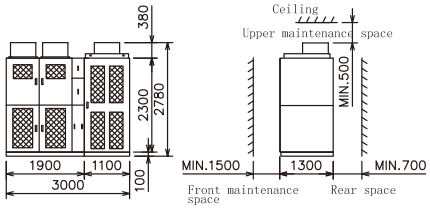


Fig. 17
6kV :840, 950, 1040kVA
6. 6kV:930, 1050, 1140kVA

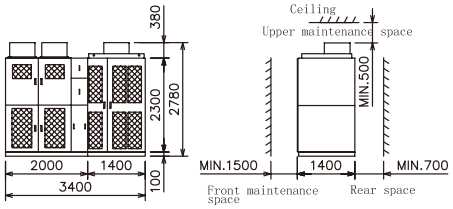


Fig. 18
6kV :1140, 1300, 1410kVA
6. 6kV:1260, 1430, 1550kVA

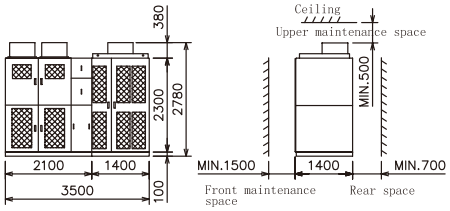


Fig. 19
6kV :1470, 1560, 1680, 1830, 2000, 2100kVA
6. 6kV:1660, 1710, 1840, 2010, 2190, 2310kVA

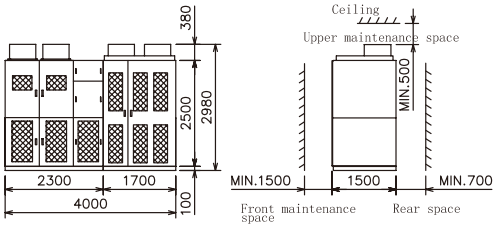


Fig. 20
6kV :2340, 2420, 2640, 2760kVA
6. 6kV:2570, 2660, 2900, 3040kVA

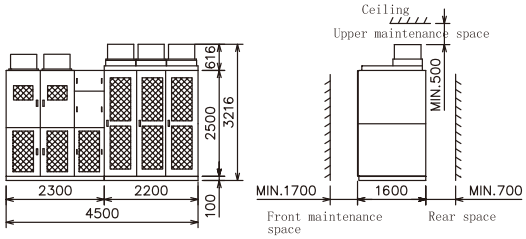


Fig. 21
6kV :2900, 3080, 3220kVA
6. 6kV:3190, 3380, 3540kVA

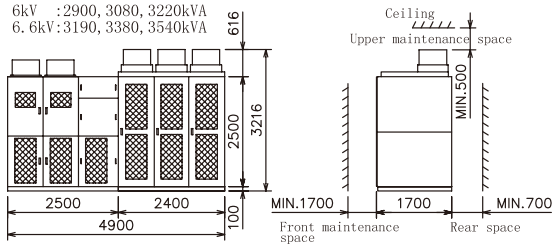


Fig. 22
6kV :3340, 3850, 4180, 4550, 4770kVA
6. 6kV:3670, 4240, 4590, 5030, 5250kVA

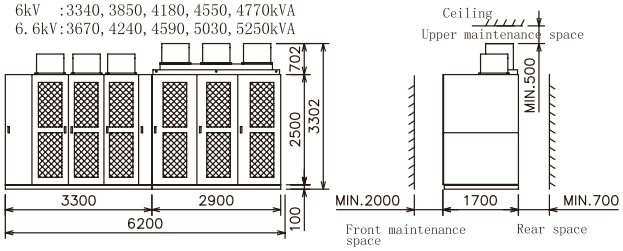
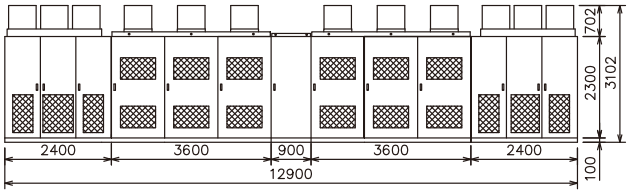


Fig. 23
6kV :5500, 6400kVA
6. 6kV: 6000, 7000kVA



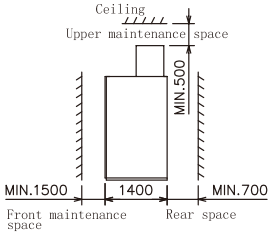
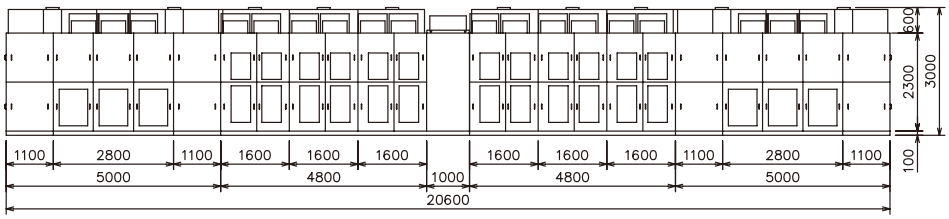
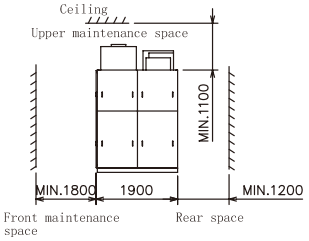


Fig. 24
6kV :9500kVA
6. 6kV:10500kVA





Capacity selections

Standard capacity selections

Voltage rating 10kV						
Model	Rated capacity [kVA]	Rated current [A]	Maximum current (overload) [A]	Applied electric motor power (reference) [kW]	External appearance (reference)	Approximate weight [kg]
FRN46-4□A-X0□X0-0500□	500	29	40	400	Fig. 25	4450
FRN46-4□A-X0□X0-0625□	625	36	40	500	Fig. 25	4650
FRN46-4□A-X0□X0-0740□	740	43	54	630	Fig. 25	4800
FRN46-4□A-X0□X0-0850□	850	49	54	710	Fig. 25	4950
FRN46-4□A-X0□X0-0920□	920	53	64	750	Fig. 25	5200
FRN46-4□A-X0□X0-1000□	1000	58	64	800	Fig. 25	5300
FRN46-4□A-X0□X0-1125□	1125	65	77	900	Fig. 25	5500
FRN46-4□A-X0□X0-1210□	1210	70	77	1000	Fig. 25	5600
FRN46-4□A-X0□X0-1400□	1400	81	110	1200	Fig. 26	6200
FRN46-4□A-X0□X0-1600□	1600	92	110	1400	Fig. 26	6500
FRN46-4□A-X0□X0-1730□	1730	100	110	1500	Fig. 26	6650
FRN46-4□A-X0□X0-1900□	1900	110	121	1700	Fig. 26	7150
FRN46-4□A-X0□X0-2160□	2160	125	150	1800	Fig. 26	7500
FRN46-4□A-X0□X0-2350□	2350	136	150	2000	Fig. 26	7750
FRN46-4□A-X0□X0-2450□	2450	142	165	2100	Fig. 27	9250
FRN46-4□A-X0□X0-2600□	2600	150	165	2240	Fig. 27	9450
FRN46-4□A-X0□X0-2860□	2860	165	194	2500	Fig. 27	9800
FRN46-4□A-X0□X0-3050□	3050	176	194	2700	Fig. 27	10100
FRN46-4□A-X0□X0-3300□	3300	192	212	2900	Fig. 27	10400
FRN46-4□A-X0□X0-3500□	3500	202	212	3050	Fig. 27	10700
FRN46-4□A-X0□X0-3670□	3670	212	248	3200	Fig. 28	12100
FRN46-4□A-X0□X0-3900□	3900	225	248	3400	Fig. 28	12400
FRN46-4□A-X0□X0-4400□	4400	254	279	3800	Fig. 28	13100
FRN46-4□A-X0□X0-4600□	4600	266	279	4000	Fig. 28	13350
FRN46-4□A-X0□X0-5110□	5110	295	326	4500	Fig. 29	15050
FRN46-4□A-X0□X0-5370□	5370	310	326	4700	Fig. 29	15400
FRN46-4□A-X0□X0-5570□	5570	321	482	4850	Fig. 30	16400
FRN46-4□A-X0□X0-6430□	6430	372	482	5600	Fig. 30	18900
FRN46-4□A-X0□X0-6950□	6950	402	482	6000	Fig. 30	19900
FRN46-4□A-X0□X0-7590□	7590	438	482	6600	Fig. 30	21150
FRN46-4□A-X0□X0-7950□	7950	459	482	7000	Fig. 30	21900

Voltage rating 11kV						
Model	Rated capacity [kVA]	Rated current [A]	Maximum current (overload) [A]	Applied electric motor power (reference) [kW]	External appearance (reference)	Approximate weight [kg]
FRN46-4□A-X1□X1-0550□	550	29	40	450	Fig. 25	4450
FRN46-4□A-X1□X1-0690□	690	36	40	560	Fig. 25	4650
FRN46-4□A-X1□X1-0810□	810	43	54	630	Fig. 25	4800
FRN46-4□A-X1□X1-0930□	930	49	54	800	Fig. 25	4950
FRN46-4□A-X1□X1-1010□	1010	53	64	850	Fig. 25	5200
FRN46-4□A-X1□X1-1110□	1110	58	64	900	Fig. 25	5300
FRN46-4□A-X1□X1-1240□	1240	65	77	1000	Fig. 25	5500
FRN46-4□A-X1□X1-1330□	1330	70	77	1120	Fig. 25	5600
FRN46-4□A-X1□X1-1540□	1540	81	110	1300	Fig. 26	6200
FRN46-4□A-X1□X1-1750□	1750	92	110	1500	Fig. 26	6500
FRN46-4□A-X1□X1-1910□	1910	100	110	1600	Fig. 26	6650
FRN46-4□A-X1□X1-2100□	2100	110	121	1800	Fig. 26	7150
FRN46-4□A-X1□X1-2380□	2380	125	150	2000	Fig. 26	7500
FRN46-4□A-X1□X1-2590□	2590	136	150	2240	Fig. 26	7750
FRN46-4□A-X1□X1-2700□	2700	142	165	2350	Fig. 27	9250
FRN46-4□A-X1□X1-2860□	2860	150	165	2500	Fig. 27	9450
FRN46-4□A-X1□X1-3140□	3140	165	194	2700	Fig. 27	9800
FRN46-4□A-X1□X1-3350□	3350	176	194	2900	Fig. 27	10100
FRN46-4□A-X1□X1-3660□	3660	192	212	3200	Fig. 27	10400
FRN46-4□A-X1□X1-3850□	3850	202	212	3350	Fig. 27	10700
FRN46-4□A-X1□X1-4040□	4040	212	248	3500	Fig. 28	12100
FRN46-4□A-X1□X1-4290□	4290	225	248	3750	Fig. 28	12400
FRN46-4□A-X1□X1-4840□	4840	254	279	4200	Fig. 28	13100
FRN46-4□A-X1□X1-5070□	5070	266	279	4400	Fig. 28	13350
FRN46-4□A-X1□X1-5620□	5620	295	326	4900	Fig. 29	15050
FRN46-4□A-X1□X1-5910□	5910	310	326	5200	Fig. 29	15400
FRN46-4□A-X1□X1-6120□	6120	321	482	5400	Fig. 30	16400
FRN46-4□A-X1□X1-7080□	7080	372	482	6200	Fig. 30	18900
FRN46-4□A-X1□X1-7650□	7650	402	482	6700	Fig. 30	19900
FRN46-4□A-X1□X1-8340□	8340	438	482	7300	Fig. 30	21150
FRN46-4□A-X1□X1-8750□	8750	459	482	7700	Fig. 30	21900

*1: The applicable motor output is the reference value of Fuji Electric's standard 4-pole motors.
*2: External appearance and weight are for reference only. Please take the final drawing as the standard.

External appearance

10kV series

Fig. 25
10kV:500, 625, 740, 850, 920, 1000, 1125, 1210kVA
11kV:550, 690, 810, 930, 1010, 1110, 1240, 1330kVA

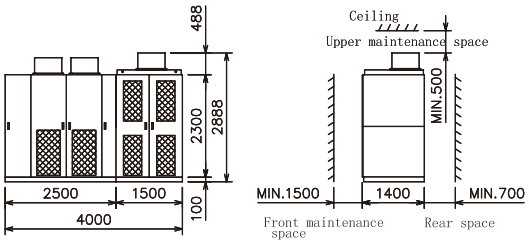


Fig. 26
10kV:1400, 1600, 1730, 1900, 2160, 2350kVA
11kV:1540, 1750, 1910, 2100, 2380, 2590kVA

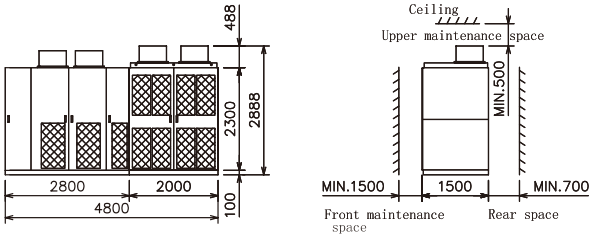


Fig. 27
10kV:2450, 2600, 2860, 3050, 3300, 3500kVA
11kV:2700, 2860, 3140, 3350, 3660, 3850kVA

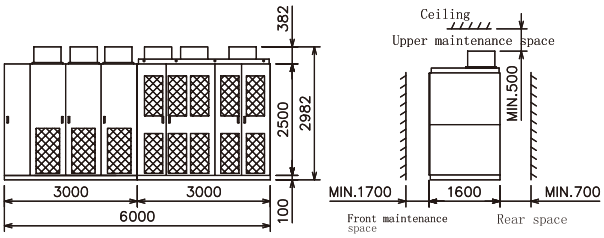


Fig. 28
10kV:3670, 3900, 4400, 4600kVA
11kV:4040, 4290, 4840, 5070kVA

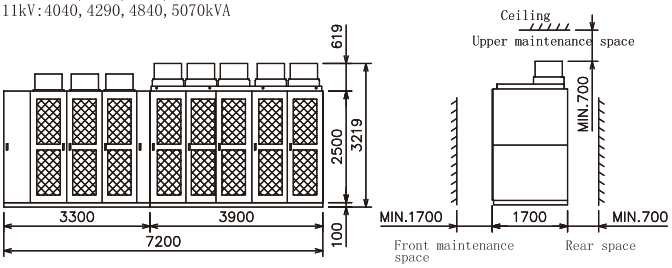


Fig. 29
10kV:5110, 5370kVA
11kV:5620, 5910kVA

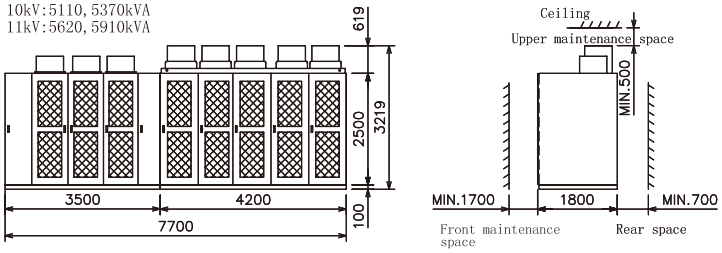
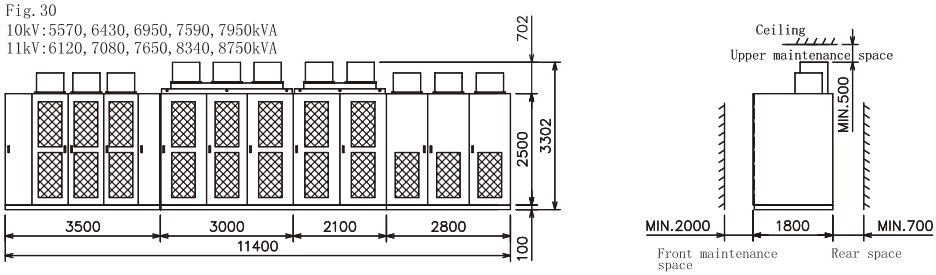


Fig. 30
10kV:5570, 6430, 6950, 7590, 7950kVA
11kV:6120, 7080, 7650, 8340, 8750kVA

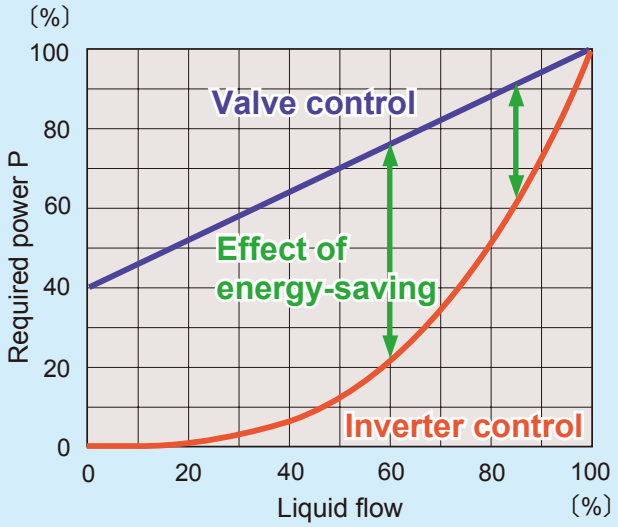


Significant energy-saving effect

FRENIC4600FM5e 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—Power characteristics P



Energy-saving principle

We can get the following formula from the principle of fluid mechanics:

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

In the above formula: N——motor speed;
Q——flow;
H——pressure;
P——shaft power.

The above formula shows that the load flow is proportional to the motor speed. The load pressure is proportional to the square of the motor speed. The load power is proportional to the cube of the motor speed.

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

Motor output:

1,000kW, 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%×1,000kW = 910kW

At 60% load of liquid flow (Q)

Required Power (P) = 76%×1,000kW = 760kW

Annual power consumption

910kW×2,000h+760kW×2,000h = 3,340,000kWh

Inverter operation (adjustable speed control operation with inverter)

At 85% load of liquid flow (Q)

Required Power (P) = 61%×1,000kW = 610kW

At 60% load of liquid flow (Q)

Required Power (P) = 22%×1,000kW = 220kW

Annual power consumption

610kW×2,000h+220kW×2,000h = 1,660,000kWh

Annual energy-saving

3,340,000-1,660,000 = 1,680,000kWh

(energy-saving = about 50%)

Carbon dioxide reduction = 635,040kg

Wealth of functions to accommodate every need

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 high 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 high 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 •3.3/6.6kV 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.	3000/3300 4160 6000/6600 10000	4750/5200 3300 9500/10500 7950
For general industry (low-voltage)	FRENIC-VG	High-performance vector controlled inverter	200 400	90kW 800kW
	FRENIC-MEGA	High-performance V/f controlled inverter	200 400	90kW 630kW
	FRENIC-ECO	V/f controlled inverter for fans and pumps	200 400	110kW 560kW

FRENIC4600FM5e (6.6kV 10,500kVA(*))

(*): Max. capacity of this model

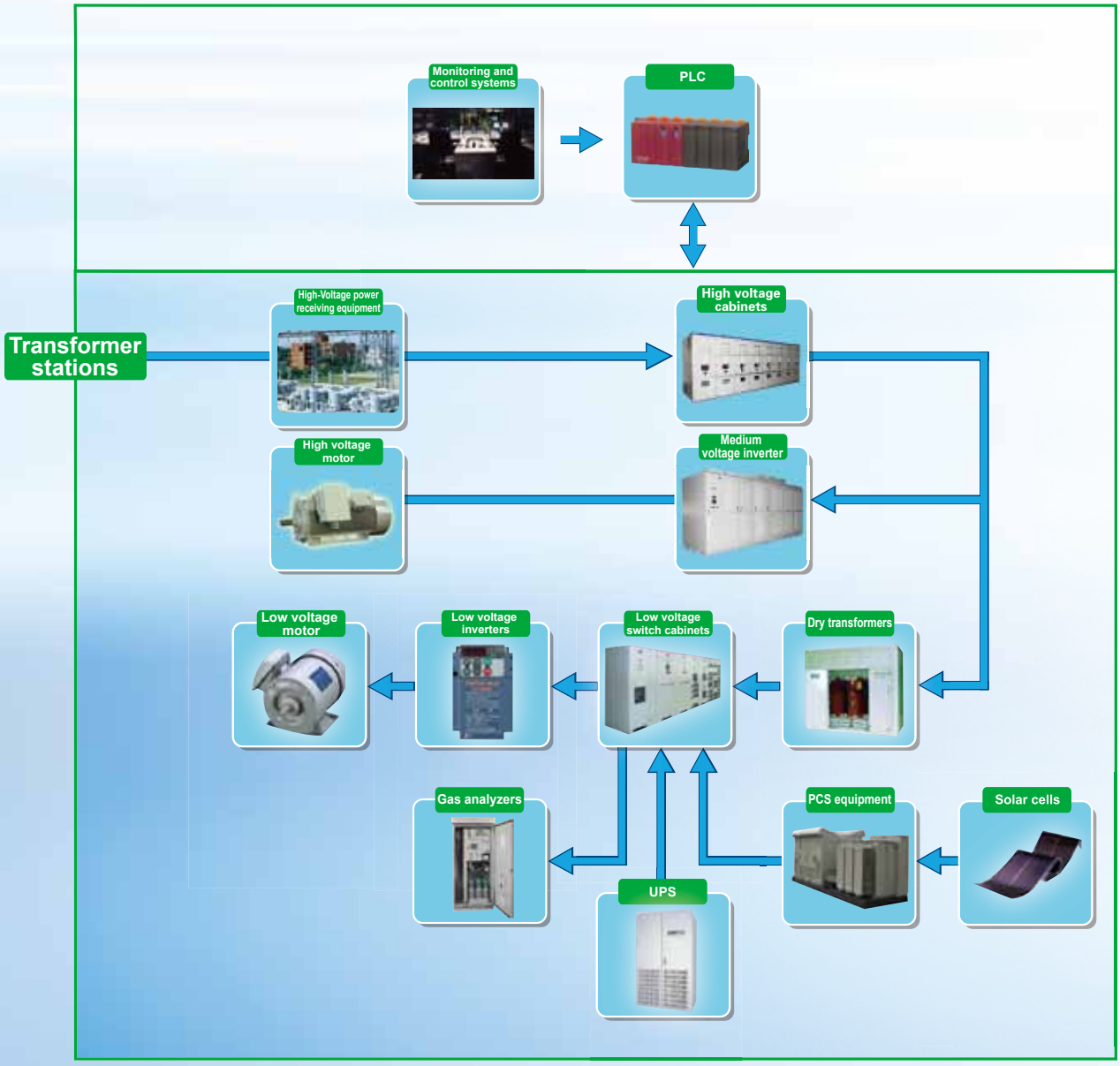
Fuji electrical system solutions

With convenient, reliable solutions to meet the different needs of various customers

With more than 10 years experience, Fuji Electric has provided complete, convenient, effective, reliable solutions in countries and regions all around the world. Fuji Electric has helped enterprise customers improve their production efficiency, fulfill environmental requirements, and reduce lower operations costs. With customized smart production management systems and automated technology control systems, Fuji Electric has solved all kinds of difficulties for customers so they could meet all types of requirements.

Fuji Electric has used its exclusive technical support and outstanding service ethic to become the industry's energy-saving and energy generation expert, providing a series of product solutions in the following areas:

•Energy systems •Industrial systems •Social systems



Ordering Information

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

1.Application

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 source: 1Φ, 2w, 220V, 50Hz
- Fan power 3Φ, 3w, 380V, 50Hz

4.Drive motor

- Motor specifications ☐ (Existing, New installation)
- Rating

  Output ☐ kW, No. of poles ☐ P,
  Voltage ☐ kV, Frequency ☐ Hz,
  Speed ☐ r/min, Current ☐ A

5.Speed range

☐ r/min ~ ☐ r/min

6.Speed/frequency setting

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

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

8.Ambient conditions

- Indoor use
- Humidity
- Temperature
- Altitude
- Provision of air conditioning
- Limit on carrying-in

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