“FUJI” Inverter

- Standard Specifications

❖ **Norminal applied motor**

The rated output of a general-purpose motor, stated in kW. That is used as a standard motor.

❖ **Rated capacity**

The rating of an output capacity, or the apparent power that is represented by the rated output voltage times the rated output current, which is calculated by solving the following equation and is stated in kVA:

Rated capacity (kVA) =

$\sqrt{3}$ x Rated output voltage (V) x Rated output current (A) x 10^{-3}

The rated output voltage is assumed to be 220V. for 200V-class equipment and 440V. for 400V-class equipment.

❖ **Rated output voltage**

A fundamental wave rms equivalent of the voltage that is generated across the output terminal when the AC input voltage (supply voltage) and frequency meet their rated conditions and the output frequency of the inverter equals the base frequency.

❖ **Rated output current**

A total rms equivalent of the current that flows through the output terminal under the rated input and output conditions (the output voltage, current, frequency, and load factor meet their rated conditions). Essentially, equipment rated at 200V. covers the current of a 50Hz. 6-pole motor and equipment rated at 400V. covers the current of a 50Hz. 4-pole motor.

- **Overload capability**

  The overload current that an inverter can tolerate, expressed as a percentage of the rated output current and also as a permissible energization time.

- **Voltage / frequency variations**

  Variations in the input voltage or frequency within permissible limits. Variations outside these limits might cause an inverter or motor failure.

- **Voltage unbalance**

  A condition of an AC input voltage (supply voltage) that states the voltage balance of each phase in an expression as :

$$\text{Voltage unbalance (\%)} = \frac{\text{Maximum voltage (V)} - \text{Minimum voltage (V)}}{\text{Three-phase average voltage (V)}} \times 67$$

(Conforming EN61800-3 (5.2.3))

- **Required power supply capacity**

  The capacity required of a power supply for an inverter. This is calculated by solving either of the following equations and is stated in kVA :

  Required power supply capacity (kVA)

$$= \sqrt{3} \times 200 \times \text{input rms current (200V., 50Hz.)}$$

or = $\sqrt{3}$ x 220 x input rms current (220V., 60Hz.)

Required power supply capacity (kVA)

= $\sqrt{3}$ x 400 x input rms current (400V., 50Hz.)

or = $\sqrt{3}$ x 440 x input rms current (440V., 60Hz.)

❖ **Momentary voltage dip capability**

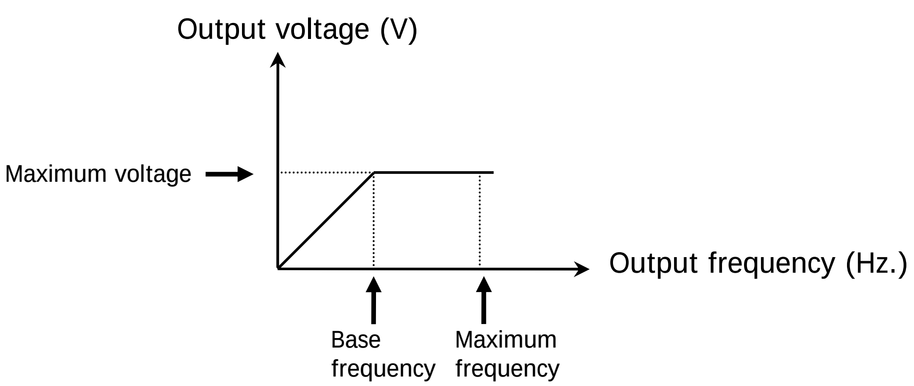
The minimum voltage (V) and time (ms) that permit continued rotation after a momentary voltage drop (instantaneous power failure).

❖ **Maximum output frequency**

The output frequency in the wake of the input of the maximum value of a frequency setup signal (for example, 10V. for a voltage input range of 0 to 10V. or 20mA. For a current input range of 4 to 20mA.)

❖ **Base frequency**

The frequency at which an inverter delivers a constant voltage in the output V/F pattern.



❖ **Starting frequency**

The minimum frequency at which an inverter starts its output (not the frequency at which a motor starts rotating).

❖ **Carrier frequency**

The frequency used to modulate a modulated frequency to establish a pulse width under the PWM control system. The higher the carrier frequency, the closer the inverter output current approaches a sinusoidal waveform and the quieter the motor becomes.

❖ **Frequency accuracy (stability)**

The percentage of variations in output frequency to a predefined maximum frequency, which is primarily influenced by ambient temperature.

❖ **Frequency resolution**

The miminum step, or increment, in which output frequency is varied, rather than continuously.

❖ **Voltage/frequency characteristic**

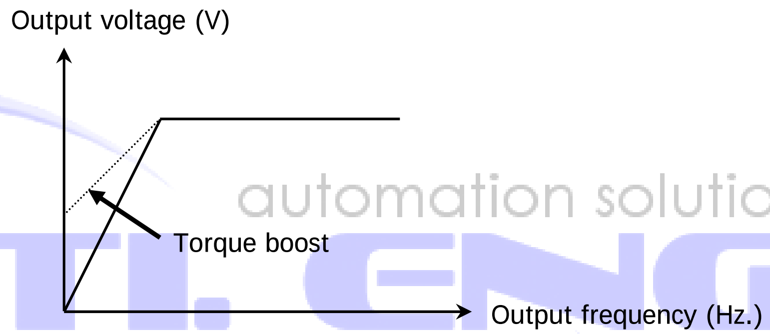
A characteristic representative of the variations in output voltage (V), and relative to variations in output frequency (f). To achieve efficient motor rotation, the voltage/frequency characteristic helps produce a motor torque matching the torque characteristics of a load.

❖ **AVR control**

A facility that keeps an output voltage constant regardless of variations in the input supply voltage or load.

❖ **Torque boost**

If a general-purpose motor is run with an inverter, voltage drops would have a pronounced effect in a low-frequency region, reducing the motor output torque to a level significantly lower than that available if the motor would be run from a commercial power supply. In a low-frequency range, therefore, to minimize the loss of the motor output torque, it is necessary to increase the voltage to compensate for voltage drops. This process of voltage compensation is called torque boost.



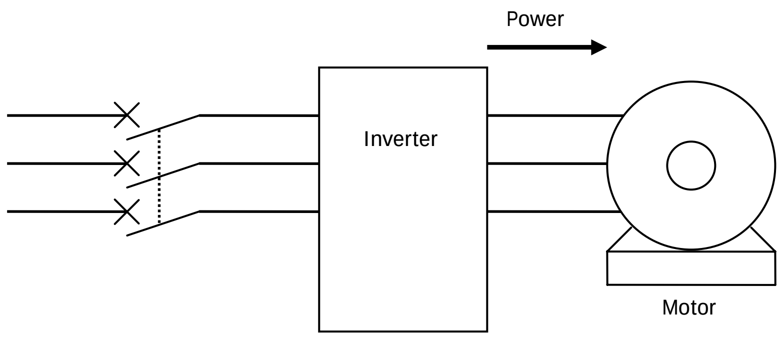
❖ **Starting torque**

The torque that a motor produces when it starts (or the power with which the motor can run a load).

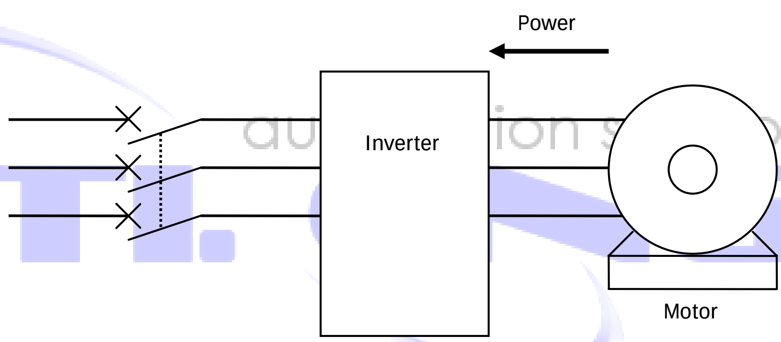
❖ **Braking torque**

Torque that works in a direction that will stop a motor from rotating (or the power that is required to stop toe motor).

(During accelerating or running at constant speed)



(During decelerating)



If the time for decelerating an inverter is set shorter than the natural stopping time for a load machine, the motor works as a generator when it decelerates, causing the kenetic energy of the load to be converted to electric energy that is returned to the inverter from the motor. If this power (regenerative power) is consumed by the inverter, the motor generates a braking force called "braking torque."

- ❖ **DC injection braking**

An inverter cuts its output at an output frequency of 0.2Hz. when the motor decelerates. If a load having a large moment of inertia is stopped or the motor is decelerated abruptly, however, the speed of the motor might not be fully reduced when the inverter reaches the output frequency of 0.2Hz. Rather, inertial force would keep the motor rotating even after the inverter output has been cut. If the motor must be stopped completely, DC injection braking should be selected to cause DC current to flow through the motor to stop it completely.

- **Protective structures**

  Protective structures of inverters as defined in IEC60529 "Degrees of protection provided by enclosures (IP Code)."

Common Specfications

- **V/F Control**

  The rotating speed N of a motor can be stated in an expression as

$$N = \frac{120f}{p}(1-s) \quad \text{(r/min)}$$

f	:	Input frequency
p	:	Number of poles
s	:	Slippage

On the basis of this expression, varying the input frequency varies the speed of the motor. However, simply varying the input frequency (f) would result in an overheated motor or would not allow the motor to demonstrate its optimum utility if the input voltage (V) remains constant. For this reason, the input voltage (V) must be varied with the input frequency (f) by using an inverter. This scheme of control is called V/F control

❖ **Dynamic torque-vector control**

Calculation of the output matched to the status of a load at high speed to maximize the torque of the motor so as to optimize the current and voltage vectors. Dynamic torque vector control calculates faster than previous methods of torque-vector control, providing a greater degree of control.

❖ **Vector control with PG**

Used to achieve positioning with greater accuracy.

❖ **KEYPAD operation**

To use a keypad panel to run an inverter.

❖ **External potentiometer**

A variable resistor (optional) that is used to set frequencies.

❖ **Analog input**

Used to set frequencies with external current and voltage input.

❖ **Reversible operation**

An inverter can be made to go forward or in reverse according to the polarity of an externally supplied voltage.

Polarity	FWD	REV
+	Forward	Reverse
-	Reverse	Forward

- **Inverse operation**

  To invert an analog input signal.

  Example :

  0 to +10V.DC./ 0 to max. output frequency (Hz.)

  → +10 to 0V.DC./ 0 to max. output frequency (Hz.)

  4 to 20mA.DC./ 0 to max. output frequency (Hz.)

  → 20 to 4mA.DC./ 0 to max. output frequency (Hz.)

- **Multistep frequency selection**

  To preset frequencies (up to 16 stages), then select them at some later time.

- **12-bit parallel signals (12-bit binary)**

  A variation of inverter control signals.

- **T-link**

  Fuji Electric's exclusive in-house linkage system used to control inverters by way of communications.

- **Open bus**

  The following are some of the communications protocols used outside Japan.

  - Profibus-DP
  - Interbus-S
  - Devicenet
  - Modbus Plus

- **JPCN1**

  This is a communications protocol used in Japan.

- **Pattern operation**

  An operation consisting of iterative cycles of running seven different stages (stages 1 to 7) in sequence.

- **Jogging operation**

  An extraordinary mode of operation in which a motor is made to go forward or in reverse at a frequency lower than usually.

- **Transistor output**

  A control signal that generates predefined data from within an inverter via a transistor (open collector).

- **Relay output**
- **Relay output multipurpose signal**

  A signal that is output via NO contact. The same data item as a transistor output can be generated.

- **Batch alarm output / Alarm output (for any fault)**

  A no-voltage contact signal (1SPDT) that is generated by an inverter when it is halted by an alarm.

- **Analog output**

  See the definition of terminal functions.

- **Pulse output**

  See the definition of terminal functions.

- **Bias frequency**

  The frequency set with an analog input frequency plus a bias frequency are combined to produce an output frequency.

- **Gain (for frequency setting)**

  A frequency setting gain enables varying the slope of the output of the frequency set with an analog input frequency.

- **Jump frequencies**

  Normally, the frequency of inverter output is continuous. However, output can become discontinuous within certain frequency ranges, called jump frequencies.

- **Pick-up operation**

  An operation that smoothly initiates an inverter operation sequence without shutting down the motor even though the fan or other component is rotating under the influence of natural phenomena such as wind.

- **Line / Inverter switching operation**

  A built-in circuit in an inverter that switches between commercial and inverter operations.

- **Slip compensation control**

  A mode of control in which the output frequency of an inverter plus an amount of slip compensation is used as an actual output frequency to compensate for motor slippage.

- **Torque limiting**

  A mode of control in which a limit value is set for the torque so the frequency is varied to hold the torque within that value.

❖ Droop control

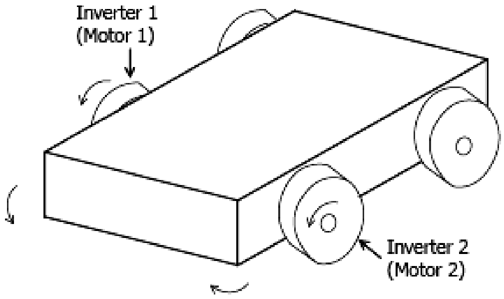
A mode of control in which a balance is maintained between two motors used to drive a single load by using a negative amount of slip compensation.

Two concurrently running motors never have identical load factors because they have their own specific mechanical variations. The difference in load factors produces motor slippage, causing them to run at different speeds in an unbalanced manner.

As a result, either a motor could have a greater load than the other or could run erratically.

To control this phenomenon, the speed of either motor (for example, motor 1) is set higher than the other motor (motor 2), and inverter 1 is set to provide a negative amount of slip compensation (droop).

Whichever motor having the higher rpm (motor 1) will slip because it has a greater load factor than the other. Further, the negative amount of slip compensation adds to the slow-down of the motor, so that motor 1 will ultimately run at an rpm that is well-balanced with motor 2, in terms of load.



- **PID control**

  The scheme of control that brings controlled objects to a desired value quickly and accurately, and which consists of three categories of action : proportional, integral and derivative.

  Proportional action : Minimizes errors from a set point.

  Integral action : Resets errors from a desired value to 0.

- **Automatic deceleration**

  A mode of control in which deceleration time is automatically extended to prevent the inverter from tripping due to an overvoltage where a braking resistor is not used.

- **Fan stop operation**

  A mode of control in which the cooling fan is shut down (where inverter is shut down) if the internal temperature in the inverter is low when no operation command is issued.

- **Motor synchronous speed**

  Number of revolutions per minute (r/min) of a motor is stated in an expression as :

  $$N = \frac{120f}{p} \quad \text{(r/min)}$$

  f : Inverter output frequency (Hz.)

  p : Number of poles of the motor (4 at factory setting)

- **Line speed**

  Number of revolutions per minute (r/min) of a line load, such as a conveyor.

- **Load shaft speed**

  Number of revolutions per minute (r/min) of a rotating load, such as a fan.

- **Trip**

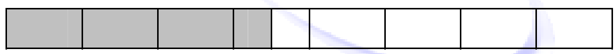
  In response to an overvoltage, overcurrent, or any other unusual condition, actuation of an inverter's protective circuit to cut off the inverter output.

- **Alarm**

  On an inverter, a coded indication of the cause of an interruption in the inverter output (inverter shut-down caused by a trip).

- **Bar graph**

  A graphic representation of the output frequency, output current, and output torque of an inverter on its LCD screen.



- **Electronic thermal overload relay**

  To safeguard a motor, calculations made within an inverter based on internal data about the characteristics of the motor.

- **PTC thermistor**

  Type of thermistor designed to safeguard a motor.

- **Stall**

  Although expected to stop, an inverter fails to produce the required torque due to a trip, such as one caused by overcurrent.

- **Tuning**

  A facility for implementing optimized control of a motor manufactured by other than Fuji Electric. Tuning deserves special notice for situations where there is a difference of three or more frames between the inverter and the motor.

- **On-line tuning**

  Constant detection and calculation of motor constants to provide optimized control.

- **Stopping frequency**

  The output frequency at which an inverter cuts its output.

- **S-curve acceleration/deceleration (weak)**

  See function H07 ACC/DEC pattern in Sections 2, Chapter 2.

- **S-curve acceleration/deceleration (strong)**

  See function H07 ACC/DEC pattern in Sections 2, Chapter 2.

- **Curve acceleration/deceleration (squared torque)**

  See function H07 ACC/DEC pattern in Sections 2, Chapter 2.

- **Reverse phase sequence lock**

  Function to prevent a motor from accidentally reversing as a result of an unintended KEYPAD operation or external input.

- **Coast-to-stop**

  If inverter output is cut while a motor is rotating, the motor continues rotating due to inertial force. This state is called coast-to-stop

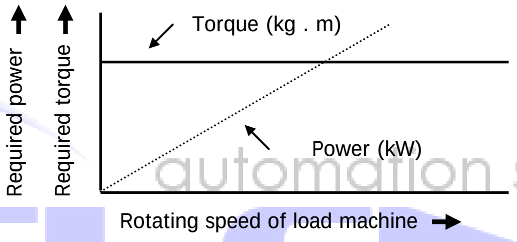
❖ **Thermal time constant**

A detailed electronic thermal setting adjusted to meet the characteristics of a motor not manufactured by Fuji Electric.

❖ **Constant torque load**

A constant torque load is characterized by :

- A requirement for an essentially constant torque, regardless of changes in the number of revolutions per minute.
- A power requirement that decreases in proportion to decreases in the number of revolutions per minute.

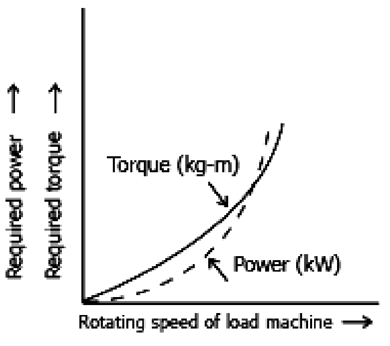


❖ **Squared torque load (Square low speed torque load)**

A squared torque load is characterized by :

- A change in the required torque in proportion to the square of the number of revolutions per minute.
- A power requirement that decreases in proportion to the cube of decreases in the number of revolutions per minute.

$$\text{Required power (kW)} = \frac{\text{Rotating speed (r/min) x Torque (N.m)}}{9.55}$$



Examples : Fans, pumps

❖ Constant output load

A constant output load is characterized by :

- An increase in the required torque in inverse proportion to a decrease in the number of revolutions per minute
- An essentially constant power requirement