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TOSVERT VF-S11

V/F control functions

Toshiba Schneider Inverter Corporation

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1. Selecting control mode

P_t : **V/F control mode selection**

Function

With VF-S11, the V/F controls shown below can be selected.

- V/F constant! Variable torque

- Automatic torque boost control *1

- Vector control *1! Energy saving *1

- Dynamic energy-saving (for fans and pumps)

- PM motor control

(*1)   Parameter setting macro torque boost: au2 parameter can automatically set this parameter and auto-tuning at a time.

- Parameter setting

Title	Function	Adjustment range	Default setting
P_t	V/F control mode selection	0: V/F constant 1: Variable torque 2: Automatic torque boost control 3: Vector control 4: Energy-saving 5: Dynamic energy-saving (for fans and pumps) 6: PM motor control	0 or 2 [*1]

*1: The default setting value depends on "Software version" and "Inverter's type (WN or WP)".

[Setting V/F control mode selection to 3 (sensorless vector control)]

Key operated	LED display	Operation
	$0.\ \ 0$	Displays the operation frequency. (Perform during operation stopped.) (When standard monitor display selection $F710$ is set to 0 [Operation frequency])
(MODE)	AUH	The first basic parameter "AUH" (history function) is displayed.
(▲)	Pt	Press the $\triangle$ key to change the parameter to Pt (V/F control mode selection).
(ENT)	2	Press the ENTER key to display the parameter setting. (Standard default setting: 2 (automatic torque boost control)).
(▲)	3	Press the $\triangle$ key to change the parameter to 3 (vector control).
(ENT)	$3 <=> Pt$	Press the ENTER key to save the changed parameter. Pt and parameter set value "3" are displayed alternately.

Warning:
When setting the V/F control mode selection parameter (pt) to any number between 2 and 6, be sure to set at least the following parameters.

$F415$ (Motor rated current): See the motor's nameplate.

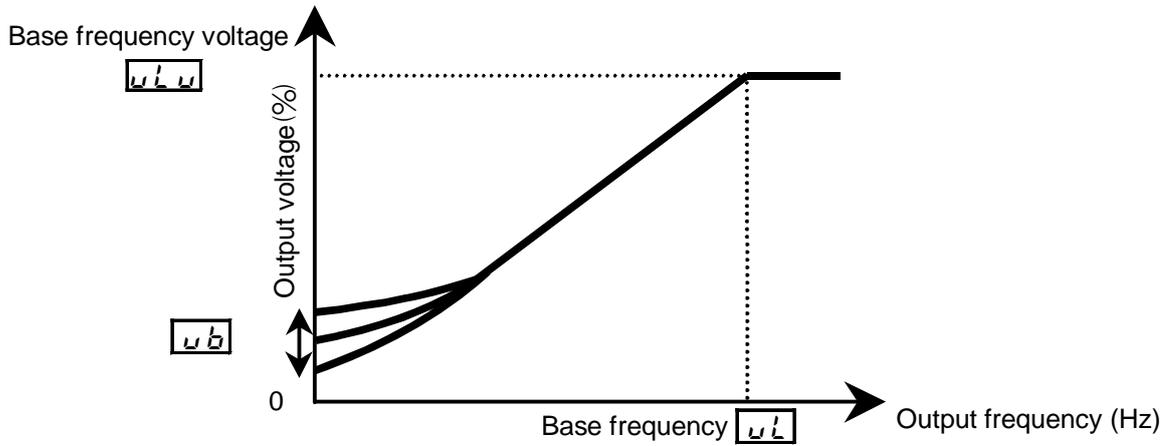$F416$ (No-load current of motor): Refer to the motor test report.

$F417$ (Rated rotational speed of motor): See the motor's nameplate.

Set also other torque boost parameters ($F401$ to $F496$), as required.

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1) Constant torque characteristics

> Setting of V/F control mode selection
> Pt to 0 (V/F constant)

This is applied to loads with equipment like conveyors and cranes that require the same torque at low speeds as at rated speeds.


Base frequency voltage `uLu`

Output voltage (%)

`ub`

0

Base frequency `uL`   Output frequency (Hz)

* To increase the torque further, increase the setting value of the manual torque boost ub .

2) Setting for fans and pumps

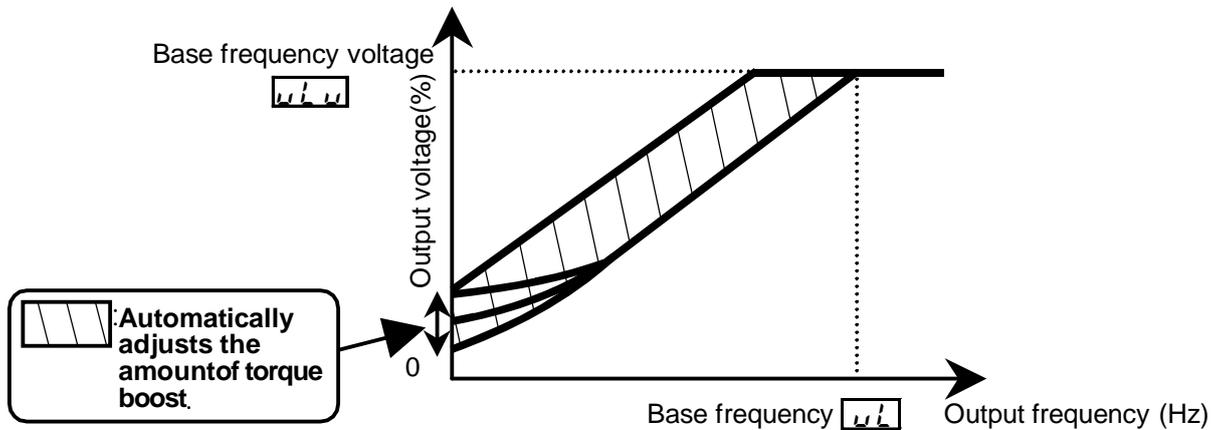> Setting of V/F control mode selection
> Pt to 1 (variable torque)

This is appropriate for load characteristics of such things as fans, pumps and blowers in which the torque in relation to load rotation speed is proportional to its square.

Base frequency voltage `uLu`

Output voltage(%)

`ub`

0

Base frequency `uL`   Output frequency (Hz)
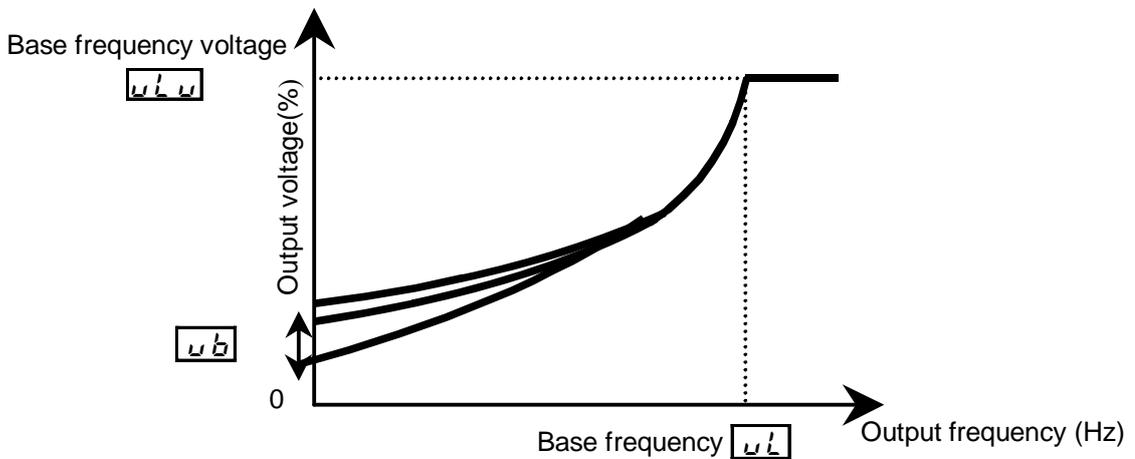
3) Increasing starting torque

> Setting of V/F control mode selection $P t$ to 2
> (automatic torque boost control)

Detects load current in all speed ranges and automatically adjusts voltage output (torque boost) from inverter. This gives steady torque for stable runs.

Note: This control system can oscillate and destabilize runs depending on the load. If that should happen, set V/F control mode selection $P t$ to 0 (V/F constant) and increase torque manually.

- Motor constant must be set

  If the motor you are using is a 4P Toshiba standard motor and if it has the same capacity as the inverter, there is basically no need to set the motor constant. In any other case, be sure to set the parameters $F415$ to $F417$ properly.

  Be sure to set $F415$ (rated current of motor) and $F417$ (rated speed of motor) correctly, as specified on the motor's nameplate. For the setting of $F416$ (no-load current of motor), refer to the motor test report.

  There are three procedures for setting the other motor constants.

  1) Auto torque boost and a motor constant (auto-tuning) can be set at once.
     To do so, set the basic parameter $Au2$ to 1.
  2) The motor constant can be automatically set (auto-tuning). Set the extended parameter $F400$ to 2.
  3) Each motor constant can be set individually.

4) Vector control - increasing starting torque and achieving high-precision operation.

> Setting of V/F control mode selection $P t$ to 3

Using sensor-less vector control with a Toshiba standard motor will provide the highest torque at the low speed ranges.

(1) Provides large starting torque.
(2) Effective when stable operation is required to move smoothly up from the low speeds.
(3) Effective in elimination of load fluctuations caused by motor slippage.

- Motor constant must be set
  If the motor you are using is a 4P Toshiba standard motor and if it has the same capacity as the inverter, there is basically no need to set the motor constant. In any other case, be sure to set the parameters $F415$ to $F417$ properly.
  Be sure to set $F415$ (rated current of motor) and $F417$ (rated speed of motor) correctly, as specified on the motor's nameplate. For the setting of $F416$ (no-load current of motor), refer to the motor test report.
  There are three procedures for setting the other motor constants.

  1) The sensorless vector control and motor constants (auto-tuning) can be set at a time.
     Set the basic parameter $AU2$ to 2.
  2) The motor constant can be automatically set (auto-tuning).
     Set the extended parameter $F400$ to 2.
  3) Each motor constant can be set individually.

5) Energy-saving

  | Setting of V/F control mode selection Pt to 4 (Energy-saving) |

  Energy can be saved in all speed areas by detecting load current and flowing the optimum current that fits the load.
- Motor constant must be set
  If the motor you are using is a 4P Toshiba standard motor and if it has the same capacity as the inverter, there is no need to set the motor constant. In any other case, be sure to set the parameters $F415$ to $F417$ properly.
  Be sure to set $F415$ (rated current of motor) and $F417$ (rated speed of motor) correctly, as specified on the motor's nameplate. For the setting of $F416$ (no-load current of motor), refer to the motor test report.
  There are three procedures for setting the other motor constants.
  1) Automatic energy-saving operation and a motor constant can be set at once. Set the basic parameter $AU2$ to 3.
  2) The motor constant can be automatically set (auto-tuning). Set the extended parameter $F400$ to 2.
  3)Each motor constant can be set individually.

6) Achieving further energy savings

  | Setting of V/F control mode selection Pt to 5 (Dynamic energy-saving) |

  More substantial energy savings than those provided by setting Pt to 4 can be achieved in any speed range by keeping track of the load current and passing a current appropriate to the load. The inverter cannot respond to rapid load fluctuations, so that this feature should be used only for loads, such as fans and pumps, that are free of violent load fluctuations.
- Motor constant must be set
  If the motor you are using is a 4P Toshiba standard motor and if it has the same capacity as the inverter, there is no need to set the motor constant. In any other case, be sure to set the parameters $F415$ to $F417$ properly.
  Be sure to set $F415$ (rated current of motor) and $F417$ (rated speed of motor) correctly, as specified on the motor's nameplate. For the setting of $F416$ (no-load current of motor), refer to the motor test report.
  For other types of motors, there are two ways to set a motor constant.
  1) The motor constant can be set automatically (auto-tuning). Set the extended parameter $F400$ to 2.
  2) Each motor constant can be set individually

7) Operating a permanent magnet motor

> Setting of V/F control mode selection Pt to 6 (PM motor control)

Permanent magnet motors (PM motors) that are light, small in size and highly efficient, as compared to induction motors, can be operated in sensor-less operation mode.
Note that this feature can be used only for specific motors. For more information, contact your Toshiba dealer.

8) Precautions on vector control
1) When exercising vector control, be sure to set the extended parameters $F415$ to $F417$ properly. Be sure to set $F415$ (rated current of motor) and $F417$ (rated speed of motor) correctly, as specified on the motor's nameplate. For the setting of $F416$ (no-load current of motor), refer to the motor test report.
2) The sensorless vector control exerts its characteristics effectively in frequency areas below the base frequency (uL). The same characteristics will not be obtained in areas above the base frequency.
3) Set the base frequency to anywhere from 40 to 120Hz during vector control ($Pt=3$).
4) Use a general purpose squirrel-cage motor with a capacity that is the same as the inverter's rated capacity or one rank below.
The minimum applicable motor capacity is 0.1kW.
5) Use a motor that has 2-8 P.
6) Always operate the motor in single operation (one inverter to one motor). Sensorless vector control cannot be used when one inverter is operated with more than one motor.
7) The maximum length of wires between the inverter and motor is 30 meters. If the wires are longer than 30 meters, set standard auto-tuning with the wires connected to improve low-speed torque during sensorless vector control.
However the effects of voltage drop cause motor-generated torque in the vicinity of rated frequency to be somewhat lower.
8) Connecting a reactor or surge voltage suppression filter between the inverter and the motor may reduce motor-generated torque. Setting auto-tuning may also cause a trip ($Etn1$) rendering sensorless vector control unusable.

9) The following table shows the relationship between the V/F control mode selection (Pt) and the motor constant parameter.
Under normal conditions, be sure to set or adjust the parameters marked with 'OO'.
When making detailed settings, adjust the parameters marked with 'O' as well, if necessary.
Do not adjust the parameters marked with 'X', because they are invalid.
(For instructions about how to adjust the parameter $F400$ and later.)

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-Relationship between V/F control mode selection ($P\,t$) and Motor constant parameter

OO,O: Valid   X: Invalid

Title	Functions	Parameter $P\,t$ (V/F control mode selection)						
		0 V/F constant	1 Variable torque	2 Automatic torque boost control	3 Vector control	4 Energy-saving	5 Dynamic energysaving	6 Operating a PM motor
$RU2$	Torque boost setting macro function	X	X	O	O	O	X	X
uL	Base frequency 1	OO	OO	OO	OO	OO	OO	OO
uLu	Base frequency voltage 1	OO	OO	OO	OO	OO	OO	OO
ub	Torque boost value 1	OO	OO	X	X	X	X	OO
$F170$	Base frequency 2	O	X	X	X	X	X	X
$F171$	Base frequency voltage 2	O	X	X	X	X	X	X
$F172$	Torque boost value 2	O	X	X	X	X	X	X
$F400$	Auto-tuning	X	X	O	O	O	O	O
$F401$	Slip frequency gain	X	X	X	O	X	X	X
$F402$	Automatic torque boost value	X	X	OO	OO	OO	OO	OO
$F415$	Motor rated current	O	O	OO	OO	OO	OO	OO
$F416$	Motor no-load current	X	X	O	O	O	O	X
$F417$	Motor rated speed	O	O	OO	OO	OO	OO	OO
$F418$	Speed control response coefficient	X	X	O	O	O	O	O
$F419$	Speed control stability coefficient	X	X	O	O	O	O	O
$F480$	Exciting current coefficient	X	X	O	O	X	X	X
$F485$	Stall prevention control coefficient 1	O	O	O	O	O	O	O
$F492$	Stall prevention control coefficient 2	O	O	O	O	O	O	O
$F494$	Motor adjustment coefficient	O	O	O	O	O	O	X
$F495$	Maximum voltage adjustment coefficient	O	O	O	O	O	O	O
$F496$	Waveform switching adjustment coefficient	O	O	O	O	O	O	O
$F910$	Step-out detection current level	X	X	X	X	X	X	O
$F911$	Step-out detection time	X	X	X	X	X	X	O
$F912$	High-speed torque adjustment coefficient	X	X	X	X	X	X	O

OO: Be sure to set and adjust the parameters.
O: Adjust the parameters if necessary.

2. Setting motor constants (Standard)

$\boxed{F400}$: **Auto-tuning**

$\boxed{F401}$: **Slip frequency gain**

$\boxed{F402}$: **Autmatic torque boost value**

$\boxed{F415}$: **Motor rated current**

$\boxed{F416}$: **Motor no-load current**

$\boxed{F417}$: **Motor rated speed**

$\boxed{F418}$: **Speed control response coefficient**

$\boxed{F419}$: **Speed control stable coefficient**

To use vector control, automatic torque boost and automatic energy saving, motor constant setting (motor tuning) is required. The following three methods are available to set motor constants.
1) Using the torque boost setting macro function ($AU2$) for setting the V/F control mode selection (Pt) and auto-tuning ($F400$) at the same time
2) Setting V/F control mode selection (Pt) and auto-tuning ($F400$) independently
3) Combining the V/F control mode selection (Pt) and manual tuning

- Check to be sure that the setting of the parameter uL and that of the parameter uLu agree with the base frequency (rated rotational speed) and base frequency voltage (rated voltage) of the motor to be operated, respectively. If not, set the parameters correctly.
- When using the inverter to control the operation of a motor smaller in capacity by one grade or more, be sure to set the motor rated current setting parameter ($F415$) properly.
- Vector control may not operate properly if the motor capacity differs from the applicable rated capacity of the inverter by more than two grades.
  If current waveforms oscillate during operation, increase the speed control stability factor ($F419$). This is effective in suppressing oscillation.

[Selection 1: Setting by parameter setting macro torque boost]
  <u>This is the easiest of the available methods.</u> It conducts vector control and auto-tuning at the same time.

Set $AU2$ to 1 (Automatic torque boost + auto-tuning)

Set $AU2$ to 2 (Vector control + auto-tuning).

Set $AU2$ to 3 (Energy-saving + auto-tuning)

[Selection 2: Setting vector control and auto-tuning independently]
  This method sets sensorless vector control or automatic torque boost, and auto-tuning independently.
  Specify the control mode selection parameter (Pt) and then set auto-tuning.

Set the auto-tuning parameter $F400$ to 2 (Auto-tuning enabled)

[Parameter setting]

Title	Function	Adjustment range	Default setting
$F400$	Auto-tuning	0: Auto-tuning disabled (use of internal parameters) 1: Application of individual settings of $F402$ (after execution: 0) 2: Auto-tuning enabled (after execution: 0)	0

Set $F400$ to 2 to before the start of operation. Tuning is performed at the start of the motor.

- **Precautions on auto-tuning**
  (1) Conduct auto-tuning only after the motor has been connected and operation completely stopped.
  If auto-tuning is conducted immediately after operation stops, the presence of a residual voltage may result in abnormal tuning.
  (2) Voltage is applied to the motor during tuning even though it barely rotates. During tuning, "$Atn1$" is displayed on the operation panel.
  (3) Tuning is performed when the motor starts for the first time after $F400$ is set to 2.
  Tuning is usually completed within three seconds. If it is aborted, the motor will trip with the dis-play of $Etn1$ and no constants will be set for that motor.
  (4) High-speed motors, high-slip motors or other special motors cannot be auto-tuned. For these motors, perform manual tuning using Selection 3 described below.
  (5) Provide cranes and hoists with sufficient circuit protection such as mechanical braking. Without sufficient circuit protection, the resulting insufficient motor torque during tuning could create a risk of machine stalling/falling.
  (6) If auto-tuning is impossible or an "$Etn1$" auto-tuning error is displayed, perform manual tuning with Selection 3.
  (7) If the inverter is tripped during auto-tuning because of an output phase failure ($EPHO$), check if the inverter is connected to the correctly. A check for output phase failures is made during auto-tuning, regardless of the setting of the output phase failure detection mode selection parameter ($F605$).

[Selection 3: Setting vector control and manual tuning independently]
If an "Etn" tuning error is displayed during auto-tuning or when vector control characteristics are to be improved, independent motor constants can be set.

Title	Function	Adjustment range	Default setting
$F401$	Slip frequency gain	0-150 (%)	50
$F402$	Automatic torque boost value	0.0-30.0 (%)	Depends on the capacity
$F415$	Motor rated current	0.1-100.0 (A)	
$F416$	Motor no-load current	10-90 (%)	
$F417$	Motor rated rotational speed	100-32000 (min^{-1})	1410 (WP) 1710 (WN, AN)
$F418$	Speed control response coefficient	1-150	40
$F419$	Speed control stability coefficient	1-100	20
tHr	Motor electronic thermal protection level 1	10-100 (%) / (A)	100

Setting procedure   Adjust the following parameters:

$F401$: Set the compensation gain for the slipping of the motor. A higher slip frequency reduces motor slipping correspondingly. After setting $F417$, set $F401$ to adjust in detail.

$F402$: Adjust the primary resistive component of the motor. Decreases in torque due to a possible voltage drop during low-speed operation can be suppressed by setting a large value in this parameter. (Perform adjustments according to the actual operation.)

$F415$: Set the rated current of the motor. For the rated current, see the motor's nameplate or test report.

$F416$: Set the ratio of the no-load current of the motor to the rated current. Enter the value in % that is obtained by dividing the no-load current specified in the motor's test report by the rated current.

$F417$: Set the rated rotational speed of the motor. For the rated current, see the motor's nameplate or test report.

$F418$: Using this parameter along with $F419$, adjust the speed of response to the frequency command.

$F419$: Using this parameter along with $F418$, adjust the speed of response to the frequency command.

* How to make adjustments according to the moment of inertia of the load
The moment of inertia of the load (including that of the motor shaft) was set at the factory on the assumption that it would be three times as large as that of the motor shaft.
If this assumption does not hold, calculate the values to be entered in $F418$ and $F419$, using the following equations.

$$F418 = 40 \times \sqrt{a/3}$$

$$F419 = 20 \times \sqrt{a/3}$$

Where 'a' is the times by which the moment of inertia of the load is larger than that of the motor.
After the above adjustments, if necessary, make fine adjustments as described below.
- To increase the response speed: Increase the setting of $F418$.
- To reduce the response speed: Decrease the setting of $F418$.
- If overshooting or hunting occurs: Increase the setting of $F419$.
- If reduction gears or the like squeak: Increase the setting of $F419$.
- If an over-voltage trip occurs on completion of acceleration: Increase the setting of $F419$.

When making the above adjustments, increase or decrease settings in steps of 10% or so while checking how things change.
Note also that, depending on the settings of $F418$ and $F419$, the frequency may exceed the upper-limit frequency if the inverter is set so as to accelerate the load in the shortest possible time.

tHr : If the rated capacity of the motor is one size smaller than that of the inverter, lower the thermal protective level according to the rated current of the motor.

* Sensorless vector control may not operate properly if the motor capacity differs from the applicable rated capacity of the inverter by more than two grades.

3. Setting motor constants 2 (Details)

$F480$: **Exciting current coefficient**

$F485$: **Stall prevention control coefficient 1**

$F492$: **Stall prevention control coefficient 2**

$F494$: **Motor adjustment coefficient**

$F495$: **Maximam voltage adjustment coefficient**

$F496$: **Waveform switching adjustment coefficient**

*The following parameters enable you to make adjustments more finely.

Title	Function	Adjustment range	Default setting
$F480$	Exciting current coefficient	100-130 (%)	100
$F485$	Stall prevention control coefficient 1	10-250	100
$F492$	Stall prevention control coefficient 2	50-150	100
$F494$	Motor adjustment coefficient	0-200	Depends on the capacity
$F495$	Maximam voltage adjustment coefficient	90-110 (%)	104
$F496$	Waveform switching adjustment coefficient	0.1-14.0(kHz)	0.2

$F480$: Used to fine adjust the magnetic field increase rate in low-speed range. To increase the torque in low-speed range, specify a larger value for $F480$. Note that this parameter should be adjusted only when enough torque cannot be obtained, even though auto-tuning ($F400=2$) was made after the setting of the parameters $F401$ through $F419$. Note also that adjusting this parameter may cause an increase in the no-load current in low-speed range. If the no-load current exceeds the rated current, do not adjust this parameter.

$F485$: Using this parameter along with $F492$ adjusts characteristics in a region in which the frequency is above the base frequency (region where the field is weak).

$F492$: Using this parameter along with $F485$ adjusts characteristics in a region in which the frequency is above the base frequency (region where the field is weak).

    * How to make adjustments in a region (region where magnetic field is weak) above the base frequency

    If a heavy load is applied instantaneously (or transiently), the motor may stall before the load current reaches the current set with the stall prevention level 1 parameter ($F601$). In many cases, this kind of stall can be avoided by gradually reducing the setting of $F485$. A drop in supply voltage may cause fluctuations of the load current or vibration of the motor. In some cases, such phenomena can be eliminated by changing the setting of $F492$ to between 80 and 90. However, this may cause an increase in load current, so that it is also necessary to adjust the setting of the electronic thermal protective level 1 parameter (tHr) properly according to the motor capacity.

$F494$: There is no need to adjust this parameter under normal conditions. (Do not change the setting, unless otherwise instructed by Toshiba technical staff)

$F495$: Specify a larger value for $F495$ to secure as high an output voltage as possible in a region (region where magnetic field is weak) above the base frequency. Setting $F495$ to a larger value may cause the motor to vibrate or gears to squeak. If such a phenomenon occurs, do not adjust this parameter.

$F496$: Specify a larger value for $F496$ if switching from a waveform to another results in a considerable increase in vibration and noise in middle-speed range (region between the start frequency and the base frequency). If no improvement can be made by specifying a larger value, do not adjust this parameter.