TOSVERT VF-AS1
Torque control Instruction Manual

Toshiba Schneider Inverter Corporation

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1. Torque control

TOSVERT VF-AS1 supports the torque control that controls a power necessary for constant tension control such as winding control as well as speed control that controls the revolution of a motor.

TOSVERT VF-AS1 can use the control methods below:

- Sensorless vector control: VF-AS1 inverter only
- Vector control with sensor: VF-AS1 + encoder feedback option (VEC004Z to 007Z)

For a machine requiring torque accuracy, use the vector control with sensor (parameter: \( p_l = \beta \)).
2. What is torque control?

A combination of an inverter and a motor generally uses speed control. As shown below, it gives an inverter a command of a desired rotational speed so that the inverter can control the motor to rotate at the speed as commanded.

Compared with the speed control, the torque control gives the inverter a command of a torque to be applied to a load machine and the inverter controls, in accordance with the torque command, the speed in the inverter to automatically change so that the speed can match with the load torque.
3. Torque control setting

To operate the VF-AS1 under the torque control, set parameters following the procedure below:

- Related parameters
  - $\text{pt}$: V/f control mode selection
  - $f_{111}$ to $f_{118}$: Input terminal function selection 1 to 8 (use one of them)
  - $f_{420}$: Torque command selection

**Function**

It is set and used for the torque control through external operation (terminal input) or communication. At the same time, the setting allows switching between the speed control and torque control during operation.

1) V/f control mode selection
Set following parameters when torque control is performed;
- Without motor speed sensor: $\text{pt} = 4$
- With motor speed sensor: $\text{pt} = 8$

<table>
<thead>
<tr>
<th>Title</th>
<th>Function</th>
<th>Adjustment range</th>
<th>Default setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{pt}$</td>
<td>V/f control mode selection</td>
<td>0:Constant torque characteristics 1:Square reduction torque control characteristics 2:Automatic torque boost 3:Sensorless vector control 1 4:Sensorless vector control 2 5:V/f 5-point setting 6:PM control 7:PG feedback vector control 1 8:PG feedback vector control 2</td>
<td>0</td>
</tr>
</tbody>
</table>

* The control method to perform the torque control (vector control) requires the setting of a motor-related constant.
(Refer to Section 6.22 in the instruction manual (E65801301) attached to the inverter.)

2) Torque control selection
Torque control selection methods include:
- Method with a terminal signal
- Method with parameter setting
- Method with communication
**Torque control selection by means of terminal signals**

The method assigns the torque control switching signal to any of input terminals in the inverter and selects torque control/speed control by switching ON/OFF of the signal.

In the standard setting at factory shipping, a function of preset speed command 3 is assigned to the S3 terminal. To use it for a terminal for control switching, it is required to change the terminal assignment.

<table>
<thead>
<tr>
<th>Title</th>
<th>Function</th>
<th>Adjustment range</th>
<th>Default setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>( F , 1 , 1 , 7 )</td>
<td>Input terminal function selection 7</td>
<td>0 to 135</td>
<td>112</td>
</tr>
</tbody>
</table>

Note 1: If the S3 terminal is already used, assign the function to an unused terminal.

Note 2: It is possible to reverse the logics of ON/OFF. In this case, the setting value is 113.

Note 3: It also is possible that the setting always is for the torque setting.

\( \text{(} F \, 1 \, 1 \, 0 \, \text{ or } F \, 1 \, 2 \, 7 \, \text{ or } F \, 1 \, 2 \, 8 : \text{ assigned to Always ON function selection)} \)

**Control switching**

![Control switching diagram](image)

<table>
<thead>
<tr>
<th>Control switching</th>
<th>OFF between S3-CC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed command</td>
<td>RR-CC (default setting)</td>
</tr>
<tr>
<td>Control switching</td>
<td>ON between S3-CC</td>
</tr>
<tr>
<td>Torque command</td>
<td>RX-CC (default setting)</td>
</tr>
</tbody>
</table>

**Title**

- Torque control selection by means of terminal signals
- Control switching

**Diagram**

- Speed control
- Torque control

**Table**

<table>
<thead>
<tr>
<th>Title</th>
<th>Function</th>
<th>Adjustment range</th>
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Note 2: It is possible to reverse the logics of ON/OFF. In this case, the setting value is 113.

Note 3: It also is possible that the setting always is for the torque setting.

\( \text{(} F \, 1 \, 1 \, 0 \, \text{ or } F \, 1 \, 2 \, 7 \, \text{ or } F \, 1 \, 2 \, 8 : \text{ assigned to Always ON function selection)} \)
3) Torque command

- Related parameters
  - F420: Torque command selection
  - F435: Prohibition of rotation in any direction other than the specified one (F or R)
  - F201: VI/II input point 1 setting
  - F203: VI/II input point 2 setting
  - F210: RR/S4 input point 1 setting
  - F212: RR/S4 input point 2 setting
  - F218: RX input point 2 setting
  - F222: AI1 input point 1 setting
  - F224: AI1 input point 2 setting
  - F725: Operation panel torque command
  - F205: VI/II input point 1 rate
  - F206: VI/II input point 2 rate
  - F214: RR/S4 input point 1 rate
  - F215: RR/S4 input point 2 rate
  - F220: RX input point 1 rate
  - F221: RX input point 2 rate
  - F226: AI1 input point 1 rate
  - F227: AI1 input point 2 rate
  - F727: Operation panel tension torque bias
  - F728: Operation panel load sharing gain

- Function
  - Selecting a mode of torque command in torque control mode.

The command set with F420 is enabled. (Default setting: RX input)

<table>
<thead>
<tr>
<th>Title</th>
<th>Function</th>
<th>Adjustment range</th>
<th>Default setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>F420</td>
<td>Torque command selection</td>
<td>1: VI/II (voltage/current input)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2: RR/S4 (Potentiometer/voltage input)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3: RX (voltage input)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4: Operation panel input enabled</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5: Communication panel RS485 input enabled</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>6: Communication internal RS485 input enabled</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>7: Communications option input</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>8: AI1 (differential current input)</td>
<td></td>
</tr>
</tbody>
</table>

Note 1: Selecting 4 (panel input) activates the control panel torque reference F725.
Note 2: Use two-phase input type sensor when torque control is operated by vector control with a sensor.
Note 3: For sensorless vector control, “forward power running ↔ reverse regeneration,” and “forward regeneration ↔ reverse power running” cannot be operated. Use vector control with a sensor (two-phase) for these uses.
1) Current signal 4 to 20mAdc
⇒ VI/II input $F \, 108$ (analog input VI/II current/voltage switching) = $I$ (current input)

[Default setting]

- Torque produced: 0% at 4mAdc and 100% at 20mAdc.

2) Voltage signal 0 to 10Vdc ⇒ RR input
[Default setting]

- Torque produced: 0% at 0Vdc and 100% at 10Vdc.

3) Voltage signal 0 to ±10Vdc ⇒ RX input
[Default setting]

- Torque produced: -100% at -10Vdc, 0% at 0Vdc and +100% at 10Vdc.

★ The relationship between the torque command and the motor torque can be changed.

$F \, 201$ and $F \, 203$ settings: 0 and 100% correspond to currents of 0 and 20mAdc, respectively.

$F \, 210$ and $F \, 212$ settings: 0 and 100% correspond to voltages of 0 and 10Vdc, respectively.

$F \, 216$ and $F \, 218$ settings: 0 and ±100% correspond to voltages of 0 and ±10Vdc, respectively.
4. Concepts regarding torque control

4.1 Applied to application where the direction of rotation does not change

Polarities of torque command and torque limit

If the direction of rotation does not change continuously because of the machine characteristics, the torque control is used with \( F \neq 435 \) (Prohibition of rotation in any direction other than the specified one (F or R)) = 1 (enabled). The direction of rotation of the motor is set by a command: F (forward run signal) or R (reverse run signal).

In paper manufacturing lines and so on, once machines have been set up, the directions of rotation of their motors are fixed and not be changed in succession, and when controlling the operation of the entire system, the torque produced in the desired direction of rotation (direction specified by a rotation command) is assumed to be positive torque and the torque produced in the direction opposite to that specified by the rotation command is assumed to be negative torque. For example, as shown in the next figures (inverter 1 and 2), the directions of rotation of the motors that drive rolls arranged in a line and rotate to send materials in one direction along the manufacturing line differ according to whether they are placed on this side or other side of the rolls that they drive. In this example, a selection between F (forward) and R (reverse) commands is made for each inverter according to the circumstances under which the system is operated. (Inverter 1: forward run, inverter 2: reverse run) However, torque commands from the host control unit of the system to the inverters have unified polarity and the direction of rotation of each individual motor is ignored. For this reason, this setting is usually used for systems that use motors whose directions of rotation depend on the circumstances under which the system is operated and are not be changed in succession. To prevent a motor from rotating in the direction opposite to that specified by a command under normal conditions, this setting is used with parameter \( F \neq 435 \) (prohibition of rotation in opposite direction (F or R) set to 1. It can also be used for fixing the side from which a rewinder sends out the material: upper or lower side.
[Hint] In the system shown below in which the product is sent in a fixed direction, the direction of rotation of each motor is determined by the command (F or R) from the inverter, regardless of the operating status: power running or regenerative braking.

Note: In actual systems, torque control is not necessarily performed on all rolls.

When torque control is performed by inverter 1
- Rotational direction = Direction specified by command = Forward run
- Status: Forward/Regenerative
- Region: ④

When torque control is performed by inverter 2
- Rotational direction = Direction specified by command = Reverse run
- Status: Reverse run/Regenerative torque
- Region: ②

When torque control is performed by inverter 3
- Rotational direction = Direction specified by command = Forward run
- Status: Forward run/Power running torque
- Region: ①
4.2 Applied to application where the direction of rotation changes

■ Polarities of torque command and torque limit
If the direction of rotation of the motor changes continuously while the direction in which a force is applied does not change, the torque control is used with $F \neq R$ (Prohibition of rotation in any direction other than the specified one (F or R)) = 0 (disabled).

This setting is used for controlling a motor whose direction of rotation (polarity of torque, that is, power running or regenerative braking) is determined regardless of the command (F or R command) from the inverter.

[Hint]
In the system shown in the figures below, the direction of rotation of the motor, in other words, its operating status (power running or regenerative braking) may change in succession according to the circumstances.
5. Speed limits in torque control mode

- **Function**
  The function is to limit the rise in the output frequency of the inverter due to a drop of the load torque during operation in torque control mode. These functions are useful for protecting a machine.

### Setting with the operation panel

- **Forward speed limit level**: 
  - F425: Forward speed limit input selection
  - F426: Forward speed limit input level
- **Reverse speed limit level**: 
  - F427: Reverse speed limit input selection
  - F428: Reverse speed limit input level

### Diagrams

- **Torque command (Motor torque)**
- **Load torque**
- **Torque reference set by an external potentiometer**
- **Torque produced by motor**
- **Forward speed limit level**
- **Reverse speed limit level**
- **Speed**
- **Coast stop**

---

The speed varies according with the load torque.
[Setting of forward speed limit level]
\( F_{425} \) (Forward speed limit input selection): Set to \( 4 \) (value of \( F_{426} \))
\( F_{426} \) (Forward speed limit input level): Set a desirable forward speed limit level.

[Setting of reverse speed limit level]
\( F_{427} \) (Forward speed limit input selection): Set to \( 4 \) (value of \( F_{428} \))
\( F_{428} \) (Reverse speed limit input level): Set a desirable reverse speed limit level.

Setting by means of external signals
The speed limits can be changed arbitrarily by setting external signals.

[Selection of external signals]
\( RR/S4-CC : 0 \) to \( 10V \)
\( RX-CC : 0 \) to \( \pm 10V \)
\( VI/II-CC : 0 \) to \( 10V \)
\( VI/II-CC : 4(0) \) to \( 20mA \)

\( F_{425} \) and \( F_{427} \) settings

<table>
<thead>
<tr>
<th>Title</th>
<th>Function</th>
<th>Adjustment range</th>
<th>Default setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>( F_{425} )</td>
<td>Forward speed limit input selection</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0:Disabled</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1:VI/II (voltage/current input)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2:RR/S4 (potentiometer/voltage input)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3:RX (voltage input)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4:( F_{426} ) enabled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( F_{426} )</td>
<td>Forward speed limit input level</td>
<td>0.0 to ( UL )</td>
<td>6.00</td>
</tr>
<tr>
<td>( F_{427} )</td>
<td>Reverse speed limit input selection</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0:Disabled</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1:VI/II (voltage/current input)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2:RR/S4 (potentiometer/voltage input)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3:RX (voltage input)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4:( F_{428} ) enabled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( F_{428} )</td>
<td>Reverse speed limit input level</td>
<td>0.0 to ( UL )</td>
<td>6.00</td>
</tr>
</tbody>
</table>

[Speed limit with the center value specified by a reference]

<table>
<thead>
<tr>
<th>Title</th>
<th>Function</th>
<th>Adjustment range</th>
<th>Default setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>( F_{430} )</td>
<td>Speed limit (torque = 0) center value reference selection</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0:Disabled</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1:VI/II (voltage/current input)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2:RR/S4 (potentiometer/voltage input)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3:RX (voltage input)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4:( F_{431} ) enabled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( F_{431} )</td>
<td>Speed limit (torque = 0) center value</td>
<td>0 to ( FH )</td>
<td>0.0</td>
</tr>
<tr>
<td>( F_{432} )</td>
<td>Speed limit (torque = 0) band</td>
<td>0 to ( FH )</td>
<td>0.0</td>
</tr>
<tr>
<td>( F_{433} )</td>
<td>Speed limit (torque = 0) recovery time</td>
<td>0.00 to 2.50</td>
<td>0.20</td>
</tr>
</tbody>
</table>
6. Setting motor constants

The torque accuracy when torque control depends on setting of motor parameter. Please set these parameter by next flow-chart.

Set the following parameters, as specified on the motor nameplate.

- **V/f control mode**
  \[ P \varepsilon = 4 \text{ or } 8 \]

**Flow-chart**

1. **Is the motor Toshiba standard four-pole motor with the same capacity rating as the inverter?**
   - **YES**
   - **End**
   - **NO**

2. **Is the motor cable 30m or less in length?**
   - **YES**
   - **End**
   - **NO**

3. Set \( f \) at 4 (After execution, the setting returns to 0.)
4. \( \alpha \) or \( F407 \), and then set \( F400 \) to 3 again.
5. **The base frequency or the rated rotational speed of the motor is not set correctly. Check their settings.**
6. **The following parameters have been calculated and set.**
   - \( F410 \) Motor constant 1
   - \( F411 \) Motor constant 2
   - \( F412 \) Motor constant 3
   - \( F413 \) Motor constant 4
7. **Check the precautions to be taken when setting the auto-tuning parameter to 1 and no problem is found, then set \( F400 \) to 2 and next operation.**
8. **Parameters \( F410 \) and \( F412 \) use the values calculated automatically by the inverter.**
9. **End**

**Flow-chart notes**

- **2:** No problem even if the motor is not connected.
- **3:** It does not matter whether the motor is under load or no-load conditions.

**Table:**

<table>
<thead>
<tr>
<th>Motor used</th>
<th>Type</th>
<th>No. of motor poles</th>
<th>Capacity</th>
<th>Tuning required or not</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toshiba standard motor</td>
<td>4P</td>
<td>Same as the inverter capacity</td>
<td>Not required (tuned to factory defaults)</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>Other than 4P</td>
<td>Same as the inverter capacity</td>
<td>Required</td>
<td></td>
</tr>
</tbody>
</table>

*When using a long cable (guide: 30m or over), be sure to make auto-tuning 1 (\( F400 = 2 \)).