TOSHIBA

E6581800②

# VF-nC3
# Motor Control instruction manual
# (detail edition)



This manual is deals with firmware “Ver110”.
The firmware will be updated without any notice.

# 目次

# 1 PARAMETERS FOR MOTOR CONTROL

Here after is the parameter list for VF-nC3 motor control.

nC3 motor parameter list

| | parameter | function | Pt control law | | | | | Accessible during running ? | For what ? |
|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | 1 | 2 | 3 | 4 | | |
| | | | V/f constant | Variable torque | Automatic torque boost | Vector control | Energy saving | | |
| Basic parameter | uL [Hz] | Basic frequency 1 | ★ | ★ | ★ | ★ | ★ | Yes | V/f ratio (rotor flux) |
| | uLu [V] | Basic voltage 1 | ★ | ★ | ★ | ★ | ★ | Yes | V/f ratio (rotor flux) |
| | F405 [kW] | Motor rated power | – | – | ★1 | ★1 | ★1 | No | Motor power |
| | F412 [%] | motor coefficient 1 | ○2 | ○2 | ○3 | ○3 | ○3 | No | Leakage coefficient |
| | F415 [A] | Motor rated current | ○ | ○ | ★1 | ★1 | ★1 | No | Motor rated current |
| | F416 [%] | Motor no load current | ○1 | ○1 | ○1 | ○1 | ○1 | No | Magnetizing current |
| | F417 [rpm] | Motor rated speed | ☆2 | ☆2 | ★2 | ★2 | ★2 | No | -Rated speed<br>-Rotor time constant |
| | ub [%] | Torque boost 1 | ☆3 | ☆3 | – | – | – | Yes | Stator resistance compensation |
| | F402 [%] | Automatic torque boost | – | – | ☆ | ☆ | ☆ | Yes | Stator resistance compensation |
| Adjust parameter | F401 [%] | Slip gain | – | – | – | ☆4 | – | Yes | Slip gain |
| | F480 [%] | motor coefficient 7 | – | – | ☆5 | ☆5 | ☆5 | No | Increasing flux at low speed |
| | F485 [%] | motor coefficient 8 | ○4 | ○4 | ○4 | ○4 | ○4 | No | Current limit at field weakening |
| | F495 [%] | motor coefficient 9 | ○5 | ○5 | ○5 | ○5 | ○5 | No | Over -modulation rate |
| | F491 or F657 [%] | motor coefficient 10 | ○ | ○ | ○ | ○ | ○ | No | Ramp rate for speed search |
| Speed loop adjust parameter | F459 | Load inertia | – | – | – | ☆6 | ☆6 | Yes | Load inertia |
| | F460 [Hz] | Motor special constant 3 | – | – | – | ☆6 | ☆6 | Yes | Speed loop gain |
| | F461 | Motor special constant 4 | – | – | – | ☆6 | ☆6 | Yes | Speed loop dumping coefficient |
| | F462 | Motor special constant 5 | – | – | – | ○ | ○ | Yes | Speed loop filter |
| | F467 | Motor special constant 6 | ○ | ○ | ○ | – | – | Yes | Current differential gain |
| | F652 [Hz] | OP stall gain | ○ | ○ | ○ | ○ | ○ | No | OP stall gain |
| | F654 [Hz] | Current differential time constant (inverse) | ○ | ○ | ○ | – | – | No | Current differential time constant (inverse) (Hz) |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Current loop gain | F458[Hz] | Current loop gain | ○ | ○ | ○ | ○ | ○ | No | Current loop gain |
| | Fb49 | Current loop dumping coefficient | ○ | ○ | ○ | ○ | ○ | No | Current loop dumping coefficient |

*1 depends on the setting of “Set up menu”. Please refer to the instruction manual 11.5.
*2 depends on product range. Please refer to the instruction manual 11.4.

★ : the parameter to be set mandatory
☆ : the parameter to be set automatically by auto-tuning
○ : the parameter to be set if necessary
― : the parameter not to be used

★1 : The parameters needed for the motor current of auto-tuning.
* it is necessary to set for special motor and small motor. It is also recommended to set for normal motor.

★2 : The parameters is used for “rated slip” and “rotor time constant”.
If V/f ratio is changed from nominal state, rated speed is needed to change as below.
Nr_new=Fn_new*60/P-Un/Fn*(Fn*60/P-Nr)*Fn_new/Un_new

☆3 : The parameter is used for the output torque performance at low speed.

☆4 : The parameter is to adjust slip compensation.
It is the rate for compensation to rated slip.

☆5 : The parameter is flux rate at low speed. It is for enhance output torque at low speed (first it is necessary to do auto-tuning)

☆6 : The speed loop gain is automatically adjusted by F459(load inertia) in case F460=0(default setting).

○1 : The parameter is used for the calculation of “rotor time constant”. Normally not need to set.
It is better to set in case the value is known (by motor test report).

○2 : The parameter is used for the calculation of “stator time constant”. Normally not need to set.
It effects dynamic performance of V/f control ramp stop .

○3 : The parameter is used for the calculation of output voltage and “stator time constant”.

○4 : It is necessary to set it for the improvement of speed stall at field weakening area.

○5 : In case this parameter is small, current vibration is reduced at field weakening area, however, motor current is increased which cause to motor maximum torque decrease.

# 2 ADJUSTMENT OF SPEED LOOP GAIN AT PT=3,4

## 2.1 Parameter setting

| parameter | function | range | Default setting |
|---|---|---|---|
| F459 | Load inertia (rate to rotor inertia) | 0.1～100 | 1 |
| F460 | Speed loop gain | 0～25 | 0 |
| F461 | Speed loop stability coefficient | 0.5～2.5 | 1.0 |
| F462 | The filter of speed reference | 0～100 | 35 |

Here after is the detail explanation of F459, and F460 which is different from AS1 .

### 2.1.1 About F459

F459 means the load inertia . it is the rate to the rotor inertia of Toshiba standard motor.
In case rotor inertia and total (load + rotor) inertia are both known, F459 can be calculated by the following equation.

$$J_{Total} = K_J \cdot J_{m0}$$

$$J_c = \frac{\left( \frac{J_{m0}}{p^2} \cdot \frac{1}{InMot} \right)}{\left( \frac{J_0}{p_0{}^2} \cdot \frac{1}{InMot_0} \right)}$$

$$F459 = K_J \cdot J_c$$

$K_J$ : load inertia rate to the rotor inertia
$J_{m0}$ : rotor inertia of target motor
$p$ : pole pair of target motor
$InMot$ : rated current of target motor
$J_C$ : compensation coefficient
$J_0$ : rotor inertia of Toshiba standard motor
$InMot_0$ : rated current of Toshiba standard motor

The table below shows the inertia of Toshiba standard 4 pole motors which is used as the base inertia of F459.
The data of 2 pole and 6 pole motors are reference data.

**note） 0.2 to 0.75kW are steel framed motor, 1.5 to 3.7kW are aluminium die-cast framed motor.**

■full closing type

| power (kW) | 2 pole Frame size | 2 pole inertia | 4 pole Frame size | 4 pole inertia | 6 pole Frame size | 6 pole inertia |
|---|---|---|---|---|---|---|
| 0.2 | 63M | 0.00037 | 63M | 0.00079 | 71M | 0.0011 |
| 0.4 | 71M | 0.00057 | 71M | 0.0012 | 80M | 0.0031 |
| 0.75 | 80M | 0.0011 | 80M | 0.0027 | 90L | 0.0043 |
| 1.5 | 90L | 0.0015 | 90L | 0.004 | 100L | 0.0067 |
| 2.2 | 100L | 0.0021 | 100L | 0.006 | 112M | 0.0105 |
| 3.7 | 112M | 0.0038 | 112M | 0.0078 | 132S | 0.0265 |

White cell: steel framed motor
Orange cell: aluminium die-cast framed motor

Even if Toshiba motor, inertia is possibly different in case the frame is different.
In such case, F459 setting is needed.
The table below is F459 setting in case of no load (motor only).

The value of F459 setting in case of no load (motor only)

| | | Motor 2Pole(kW) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0.2 | 0.4 | 0.75 | 1.5 | 2.2 | 3.7 |
| Inverter (kW) | 0.2 | 2.15 | | | | | |
| | 0.4 | 2.41 | 2.06 | | | | |
| | 0.75 | 1.81 | 1.55 | 1.63 | | | |
| | 1.5 | | 1.95 | 2.05 | 1.55 | | |
| | 2.2 | | | 1.95 | 1.48 | 1.46 | |
| | 3.7 | | | | 1.87 | 1.85 | 2.03 |

| | | Motor 4Pole(kW) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0.2 | 0.4 | 0.75 | 1.5 | 2.2 | 3.7 |
| Inverter (kW) | 0.2 | 1.00 | | | | | |
| | 0.4 | 1.12 | 1.00 | | | | |
| | 0.75 | 0.85 | 0.75 | 1.00 | | | |
| | 1.5 | | 0.95 | 1.26 | 1.00 | | |
| | 2.2 | | | 1.20 | 0.95 | 1.00 | |
| | 3.7 | | | | 1.20 | 1.26 | 1.00 |

| | | Motor 6Pole(kW) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0.2 | 0.4 | 0.75 | 1.5 | 2.2 | 3.7 |
| Inverter (kW) | 0.2 | | | | | | |
| | 0.4 | | 1.05 | | | | |
| | 0.75 | | 0.79 | 0.64 | | | |
| | 1.5 | | 0.99 | 0.81 | 0.64 | | |
| | 2.2 | | | 0.77 | 0.61 | 0.70 | |
| | 3.7 | | | | 0.77 | 0.89 | 1.41 |

In case the rate of load inertia and motor inertia is known, F459 can be set with the table above.
For example, Inverter is nC3-2037, motor is 2.2kW 2-pole Toshiba standard motor (aluminium frame) ,
Load inertia(with motor) is 3 times of motor inertia,
The recommended value of F459 is Kj * Jc = 1.85*3 = 5.6

### 2.1.2 About F460

F460 means speed loop gain (Hz).
In case F460=0(default setting), the gain is automatically calculated (it is described below in detail).
In case F460 is not 0, gain is equal to F460.
The speed loop gain has a limitation which is "150/F459" . For example, in case F459=100, the upper limitation of speed loop gain is 150/100=1.5Hz even if F460 is higher than 1.5Hz.

**Automatic adjustment of speed loop gain (F460=0)**
The speed loop gain is calculated by 2kinds of inputs.
One is speed ramp rate, and other is load inertia.
The gain from speed ramp rate is
F0_ramp = MAX(3Hz , 0.0255*FH / Min(ACC,DEC) )
The gain from load inertia is
F0_inertia = 30 * (InDefMotor / InMotor) / F459
(InDefMotor: rated current of same sized motor, InMotor: rated motor current)
Final result of the gain is smaller one of both, furthermore it is limited between 1Hz to 10Hz.
F0_out = MIN(10Hz, MAX(1Hz, MIN(F0_ramp, F0_inertia)))

For example,
Inverter: nC3-2022 , Motor: 4P 2.2kW , FH=80 ACC=DEC=0.5
A: total inertia (F459) is 5.0
F0_ramp = MAX(3Hz, 0.0255*80 / 0.5) = 4Hz
F0_inertia = 30 / 5 = 6Hz
F0_out = MIN(10Hz, MAX(1Hz, MIN(F0_ramp, F0_inertia))) = 4Hz
A: total inertia (F459) is 10.0
F0_ramp = MAX(3Hz, 0.0255*80 / 0.5) = 4Hz
F0_inertia = 30 / 10 = 3Hz
F0_out = MIN(10Hz, MAX(1Hz, MIN(F0_ramp, F0_inertia))) = 3Hz

### 2.1.3 Adjustment of F459, F460, F461

The figures below show the motor speed at each value of the parameter.
The figure 1 shows the motor speed trend at each F459 in case the total inertia is 6 times of motor inertia. In case F459 is smaller than 6.0, motor speed is overshoot. On the contrary, F459 is bigger than 6.0, motor speed is little bit delayed to be stabilized.

Fig. 1 F459 adjustment

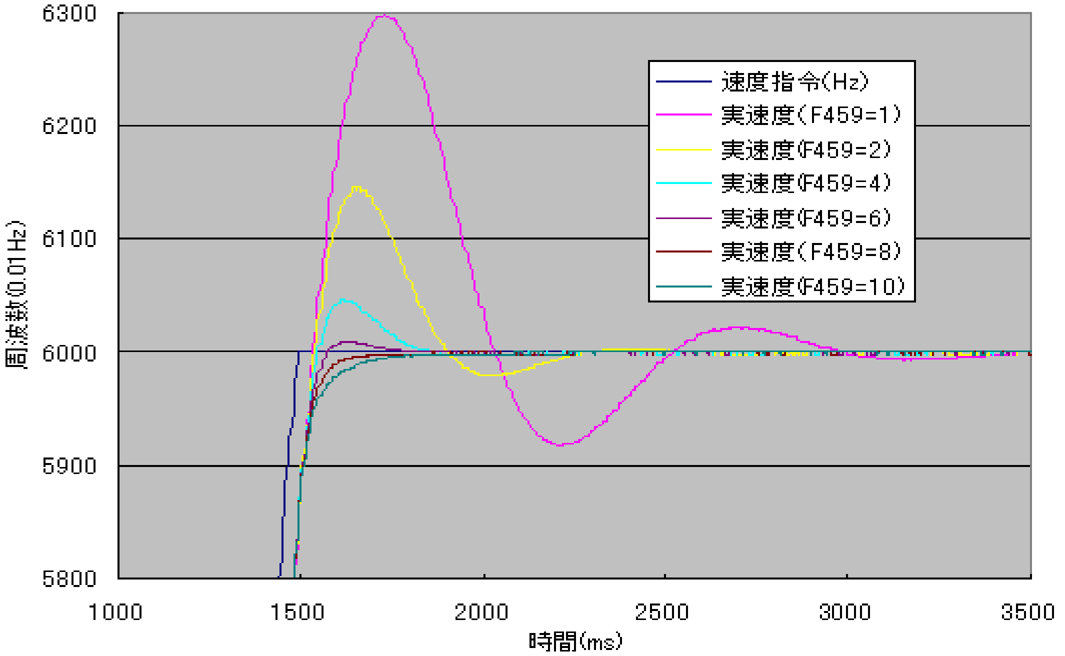



Figure 2 shows the motor speed trend at each F460 in case ACC=0.4sec. In case F460 is 0, F460 is automatically calculated to 5.0, motor speed is well tracked to speed reference. In case F460 is small, motor speed is delayed to speed reference.

Fig. 2 F460 adjustment

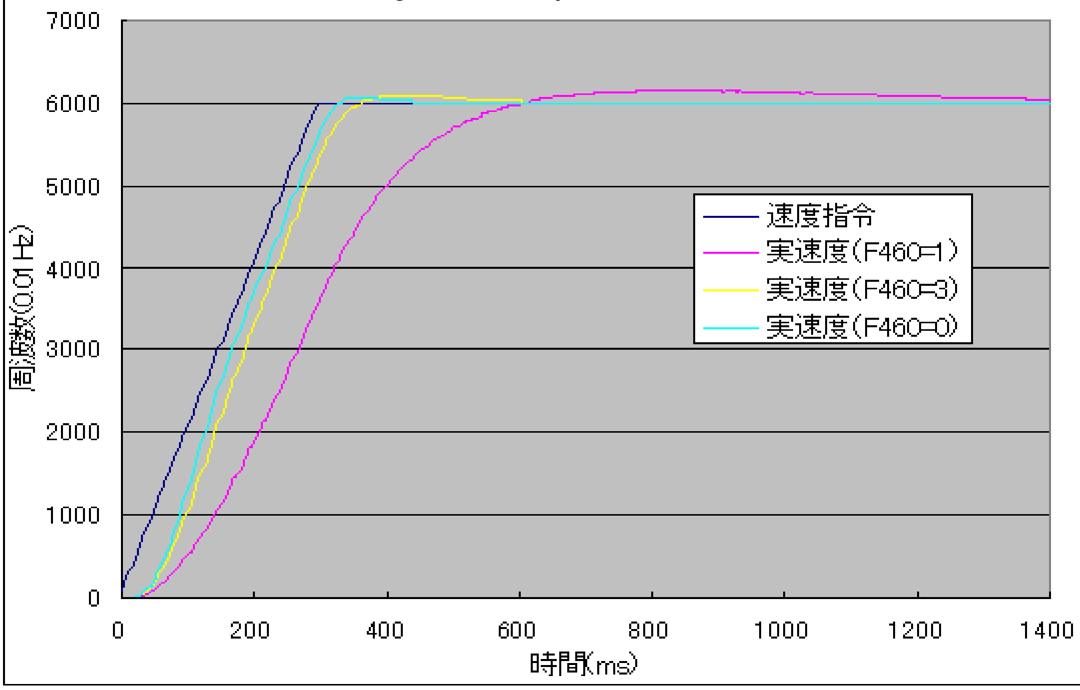
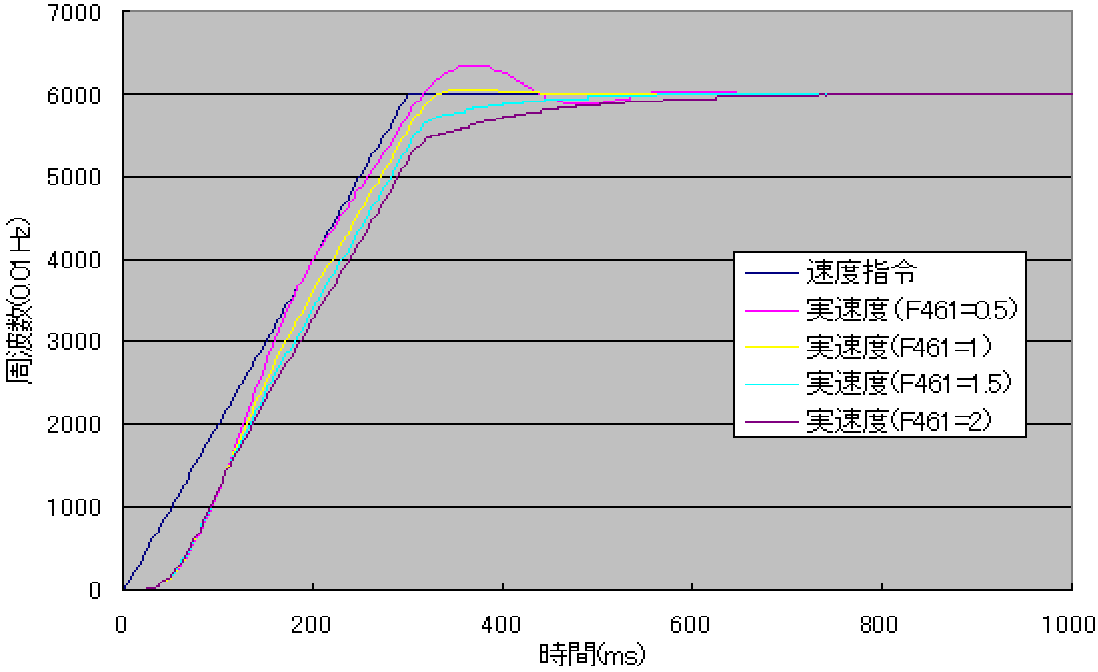


Figure 3 shows the motor speed trend at each F461. In case F461 is less than 1.0, motor speed is overshoot. On the contrary, in case F461 is bigger than 1.0, motor speed is delayed to be stabilized.

Fig. 3 F461 adjustment




Normally, the adjustment of speed loop gain is only set the F459.
In case of PT=4, the speed loop gain is the half value of PT=3 under the same condition .

## 2.2 parameter adjustment

| problem | countermeasure | Side effect |
|---|---|---|
| How to adjust F459 ? | - In case total inertia is known, F459 can be calculated from the equation on the section 2.1.1 | - |
| | - In case total inertia is unknown, it is helpful to take speed response as the figure 1 on section 2.1.3.<br>In case overshoot appears, F459 must be increase. | - |
| - Motor speed is overshoot after acceleration is finished.<br>- Motor speed is undershoot (goes round to opposite direction) before deceleration stop | -To adjust F459 (factory setting is 1.0) to the total inertia. | - |
| - Adjustment of disturbance response at acceleration | - To increase F461 every 0.1 (up to 1.30) | - In case F461 is big, the speed stabilization is delayed. |
| - Adjustment of disturbance response at constant speed | -To adjust F459<br>-To increase F460 (factory setting is 0.0) up to 10.0 . | -In case F460 is big, the speed is overshoot. |
| - Motor is overshoot after rapid acceleration | - To increase F461 every 0.1 (up to 1.30) | - |
| - E-13 trip occurs at torque disturbance or load is off at field weakening area | -To adjust F459<br>-To increase F460 (factory setting is 0.0) up to 10.0 .<br>-To increase F461(factory setting is 1.00) every 0.1 up to 1.30.<br>-To increase FH every 10Hz in case FH and speed command are same.<br>(it is in the case the problem still occurs even if these adjustment above are already done) | - In case F461 is big, the speed stabilization is delayed.<br>-In case F460 is big, the speed is overshoot. |

# 3 CURRENT DIFFERENTIAL GAIN FOR PT=0,1,2

## 3.1 parameter setting

| parameter | function | range | Default setting |
|---|---|---|---|
| F467 | Current differential gain | 0～100 | 10 |

## 3.2 parameter adjustment

To improve the motor unstable , it is effective to adjust F467, especially motor unstable at no load and small inertia condition .
The table below shows the tendency of phenomenon at each inertia and F467 conditions.
Generally, the possibility of motor vibration is increased in case inertia and F467 are both small.

| inertia | F467 | Acceleration performance | Deceleration performance | Disturbance response |
|---|---|---|---|---|
| small | small | Increase vibration | Increase vibration | Increase vibration |
| | big | Decrease vibration | Decrease vibration | Decrease vibration |
| big | small | Decrease speed overshoot | Current ripple is big | Fast response |
| | big | Increase speed overshoot | Current ripple is small | Slow response |

# 4 OVER VOLTAGE PREVENTION CONTROL

## 4.1 parameter setting

| parameter | function | range | Default setting |
|---|---|---|---|
| F305 | Over voltage prevention selection | 0: enabled<br>1: disabled<br>2: enabled (rapid deceleration)<br>3: enabled (dynamic rapid deceleration) | 2 |

## 4.2 validation

Here after is the result of the “stop distance(the distance from stop command is operated to finally stopped)” .

### 4.2.1 The relation deceleration time and stop distance (compared to nC1)

**Deceleration characteristics**

| VFNC3-2022P | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| FC=60Hz | F305=0 | | F305=1 | | F305=2 (Default) | | F305=3 | |
| | enable | | disable | | enable quick deceleration | | enable dynamic quick deceleration | |
| DEC [s] | Pt=0 | Pt=3 | Pt=0 | Pt=3 | Pt=0 | Pt=3 | Pt=0 | Pt=3 |
| 1.0 | same as F305=1 | | 11915 | 13011 | same as F305=1 | | same as F305=1 | |
| 0.5 | 6544 | 7277 | 6150 | 6951 | 6313 | 7058 | 6176 | 6955 |
| 0.4 | - | - | **5008** | **5622** | - | - | - | - |
| 0.3 | - | - | **OP2** | **OP2** | - | - | - | - |
| 0.1 | 5773 | 6219 | **OP2** | **OP2** | 4880 | 5091 | 3711 | 4102 |

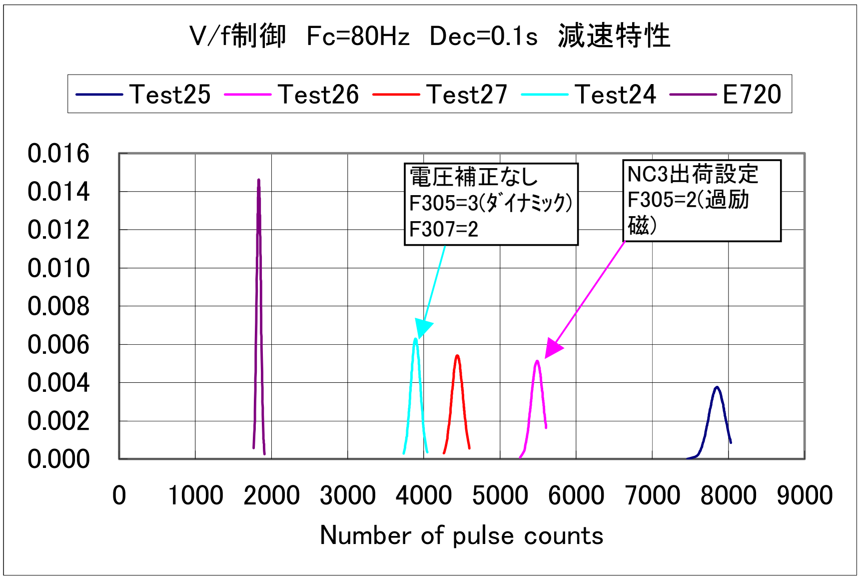
| VFNC1-2022P <FC=60Hz> | | | | | | |
|---|---|---|---|---|---|---|
| FC=60Hz | F305=0 (Default) | | F305=1 | | F305=2 | |
| | enable | | disable | | enable quick deceleration | |
| DEC [s] | Pt=0 | Pt=3 | Pt=0 | Pt=3 | Pt=0 | Pt=3 |
| 1.0 | same as F305=1 | | 12774 | 12534 | same as F305=1 | |
| 0.5 | same as F305=1 | | 7364 | 7186 | same as F305=1 | |
| 0.1 | 5822 | 5725 | **5431** | **5396** | 5900 | 5681 |

| VFNC3-2022P | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| FC=80Hz | F305=0 | | F305=1 | | F305=2 (Default) | | F305=3 | |
| | enable | | disable | | enable quick deceleration | | enable dynamic quick deceleration | |
| DEC [s] | Pt=0 | Pt=3 | Pt=0 | Pt=3 | Pt=0 | Pt=3 | Pt=0 | Pt=3 |
| 1.0 | same as F305=1 | | 20925 | 22465 | same as F305=1 | | same as F305=1 | |
| 0.8 | - | - | **16831** | **18330** | - | - | - | - |
| 0.7 | - | - | **OP2** | **OP2** | - | - | - | - |
| 0.5 | 16840 | 18334 | **OP2** | **OP2** | 13587 | 14114 | 10731 | 11886 |
| 0.1 | **16303** | 16732 | **OP2** | **OP2** | **11453** | 11637 | **8525** | **9469** |

| VFNC1-2022P | | | | | | |
|---|---|---|---|---|---|---|
| FC=80Hz | F305=0 (Default) | | F305=1 | | F305=2 | |
| | enable | | disable | | enable quick deceleration | |
| DEC [s] | Pt=0 | Pt=3 | Pt=0 | Pt=3 | Pt=0 | Pt=3 |
| 1.0 | same as F305=1 | | 21580 | 21609 | same as F305=1 | |
| 0.8 | - | - | 17533 | 17483 | - | - |
| 0.7 | - | - | **15635** | **15582** | - | - |
| 0.6 | - | - | **OP2** | **OP2** | - | - |
| 0.5 | 15187 | 15084 | **OP2** | **OP2** | 15027 | 14719 |
| 0.1 | 12522 | 12695 | **OP2** | **OP2** | 12265 | 12262 |

### 4.2.2 The relation the parameter F305,F307 and stop distance

Here after is the test result comparing several combination of F305 and F307 on nC3.
Test condition: PT=0, Fc=80Hz, DEC=0.1s
In case F307=3, stop distance depends on F305.
In case F307=2, stop distance is independent of F305.




| Test No | F305 | F307 |
|---|---|---|
| 25 | 0 | 3 def |
| 26 | 2(def) | |
| 27 | 3 | |
| 24 | 3 | 2 |

# 5 F480（FLUX ENHANCEMENT AT LOW SPEED）

## 5.1 parameter setting

| parameter | function | range | Default setting |
|---|---|---|---|
| F480 | Flux enhancement rate at low speed | 100%～150% | 120% |

## 5.2 parameter adjustment

It is necessary to set PT=2 or 3, to set motor parameters from motor nameplate, and to do auto-tuning when high output torque at low speed is needed.
If more output torque is needed after doing this procedure, to increase F480 is effective.
In case F480 is large, the magnetizing current at low speed is increased, therefore flux is increased and motor torque is possible to increase.
The increase of magnetizing current is only at the increase of torque current, therefore motor current is not increased at no load condition.
However, even if F480 is large, motor flux is not linearly increased because of flux saturation.

# 6 F485(STALL REDUCTION AT FIELD WEAKENING AREA)

## 6.1 parameter setting

| parameter | function | range | Default setting |
|---|---|---|---|
| F485 | Stall reduction at field weakening area | 10-250 | 100 |

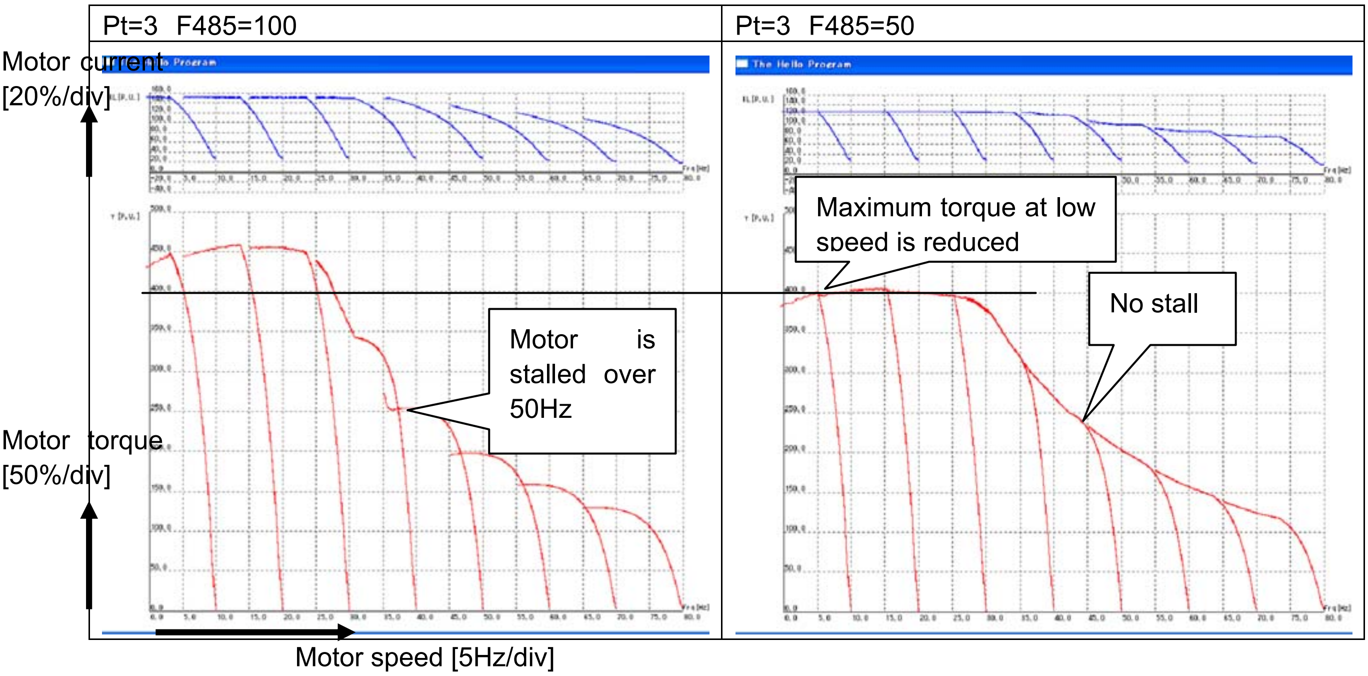
## 6.2 parameter adjustment

In case of the driving at field weakening area, motor flux is reduced therefore motor maximum torque is also reduced. In such condition, when instant torque is obtained motor is stalled even if motor current is less than current limitation.
There are 2 conditions for field weakening area. One is over the base frequency, the other is DC bus voltage reduction. Especially single phase inverter, DC bus voltage is reduced in case of heavy load.
In such case, reduction of F485 every 5 is effective.

| problem | countermeasure | Side effect |
|---|---|---|
| Motor is stalled in case of the driving with input voltage reduction, or at field weakening area | To reduce F485 every 5 | Maximum torque at low speed is reduced |

## 6.3 the example of adjustment

system：INV：nC3-2007　Motor：0.4kW-200V-60Hz
input voltage：165V



# 7 F495(OVER MODULATION / MAXIMUM VOLTAGE ADJUSTMENT)

## 7.1 parameter setting

| parameter | function | range | Default setting |
|---|---|---|---|
| F495 | over modulation / maximum voltage adjustment | 90-110 | 104 |

## 7.2 parameter adjustment

To increase maximum torque at nominal point, the default value of F495 is 104% which is little bit “over modulation”. But, in over modulation area, output voltage is not complete sinusoidal, therefore the possibility of current oscillation is increased.
To reduce F495 is effective for

| problem | countermeasure | Side effect |
|---|---|---|
| Motor is oscillated at field weakening area | To reduce F495 to 100, ->95, -> 90 | - Out put voltage is reduced at field weakening area.<br>- Motor current is increased at field weakening area. |

# 8 POWER RIDE THROUGH

## 8.1 parameter setting

| parameter | function | range | Default setting |
|---|---|---|---|
| F302 | Power ride through selection | 0: disabled<br>1: bus maintain<br>2: ramp stop | 0 |

Bus maintain(F302=1) : The function which makes driving continue using the regenerative energy from the motor, when the power failure occurs.

Ramp stop(F302=2) : The function which makes driving stop using the regenerative energy from the motor, when the power failure occurs.

## 7.2 parameter adjustment

In case motor vibration or OP trip occurs during power ride through, these parameters below could be adjusted.

| parameter | function | range | Default setting |
|---|---|---|---|
| F412 | Leakage inductance | 0-20 | 5 |
| FB54 | Inverse of current differential filter time constant(Hz) | 1-250 | 20 |

| problem | countermeasure | Side effect |
|---|---|---|
| - OP trip occurs during “ramp stop”<br>- Motor is vibrating and MOFF occurs during “bus-maintain”<br>(for PT=0,1,2) | - To set F412=10.0<br>- To decrease FB54 every 5 (in case FB54 is reduced, F467(current differential gain) must not to be decreased.) | - motor current is oscillated at field weakening area in case of rapid deceleration |

# 9 SPEED SEARCH

## 9.1 parameter setting

| LED display | Com. number | function | Unit convert | unit LED / com | range | Default |
|---|---|---|---|---|---|---|
| F415 | 0415 | Motor rated current | A | 0.01/0.01 | 0.10-30.00 | *1 |
| F491 or Fb57 | 0491 or FB57 | motor coefficient 10 (Ramp rate for speed search) | % | 1/1 | 10-200 | *1 *2 |

*1 default value is different at each range

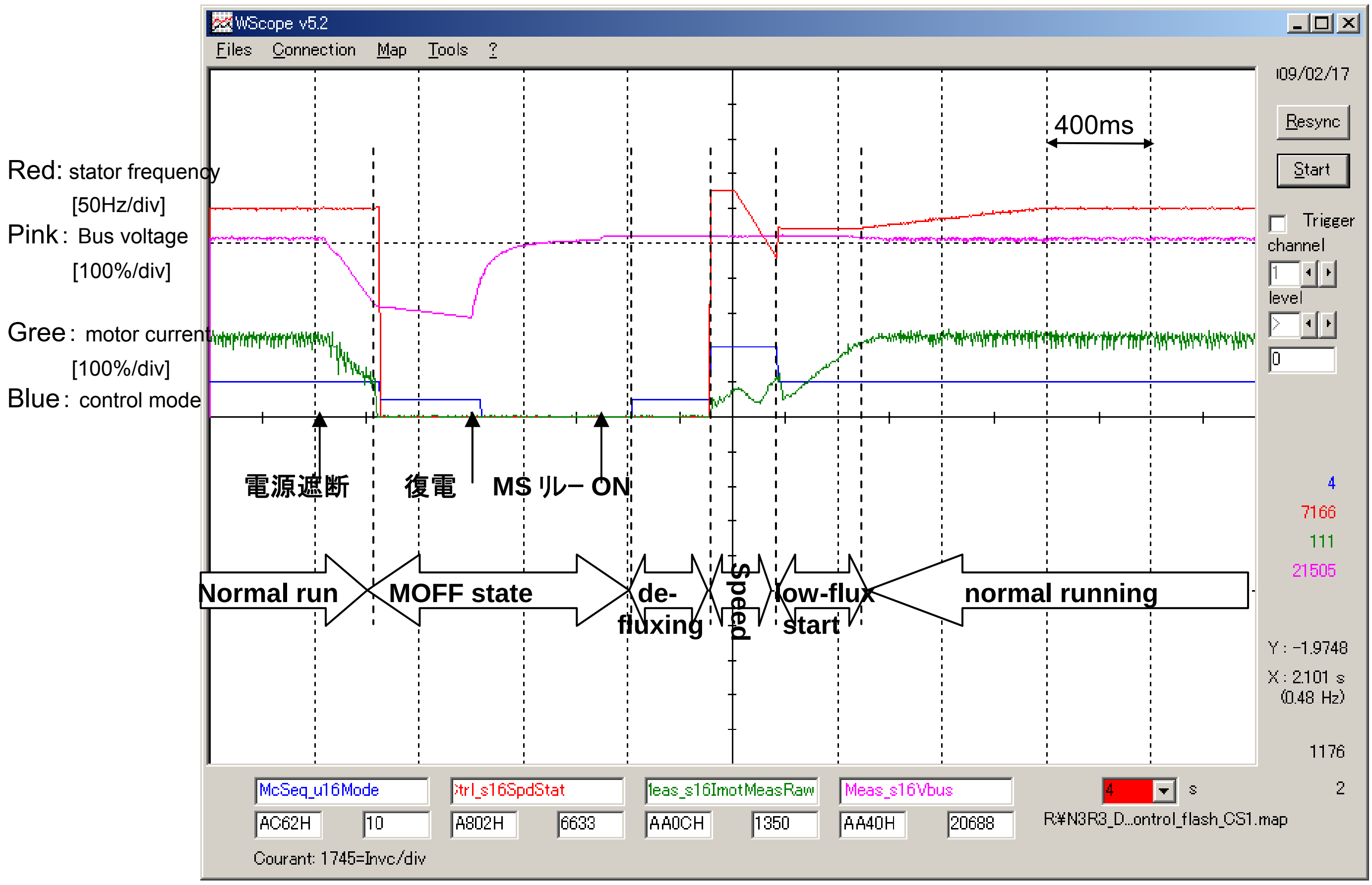
*2 After Software version V108, F491(FP) was added, and it corresponds to FB57.(FB57 still remains.)
So, please read FB57 as F491 in this paragraph 9. Moreover, the factory setting of the parameter was set to 133 for all models.

## 9.2 parameter adjustment

| problem | countermeasure | Side effect |
|---|---|---|
| - Motor speed can not be detected and start to 0Hz. | - To set FB57=70 in case FB57=0.<br>- To reduce FB57 every 5 in case FB57 is not 0 | - In case FB57 is small, the possibility of motor rotation during speed search is increased. |
| - Motor is little bit rotated during catch on fly | - NO countermeasure in case FB57=0.<br>- To increase FB57 every 5 in case FB57 is not 0 | - In case FB57 is large, the possibility to detect 0Hz is increased. |
| - Motor speed can not be detected only at speed upper limit(UL) | - To set F415(motor rated current) correctly | - In case F415 is small, , the possibility to detect 0Hz is increased. |

＊ After Software version V108, please read FB57 as F491 in this table.

## 9.3 The sequence of speed search




De-fluxing: - wait 300ms just after MS relay is ON
- in case gate block time is less than "FB71+300ms", wait until the total waiting time is "FB71+300ms"

Speed search: Initial voltage is that frequency is "FH+5Hz", flux is 1/7 of rated flux
The ACC/DEC time is 0.5sec(0Hz to VL) (if FB57 is not 0, (0.5*100/FB57)sec).
The frequency is reduced from "FH+5Hz" to 0Hz to "-FH-5Hz" , and torque current is detected during frequency transition. The point that the polarity of torque current is changed, it is estimated as "motor speed".

| | V106 or before | V108 |
|---|---|---|
| INV | FB57 | F491 or FB57 |
| x001 – x007 | 0(100) | 133 |
| x015 | 50 | 133 |
| x022 | 55 | 133 |
| x037 | 70 | 133 |

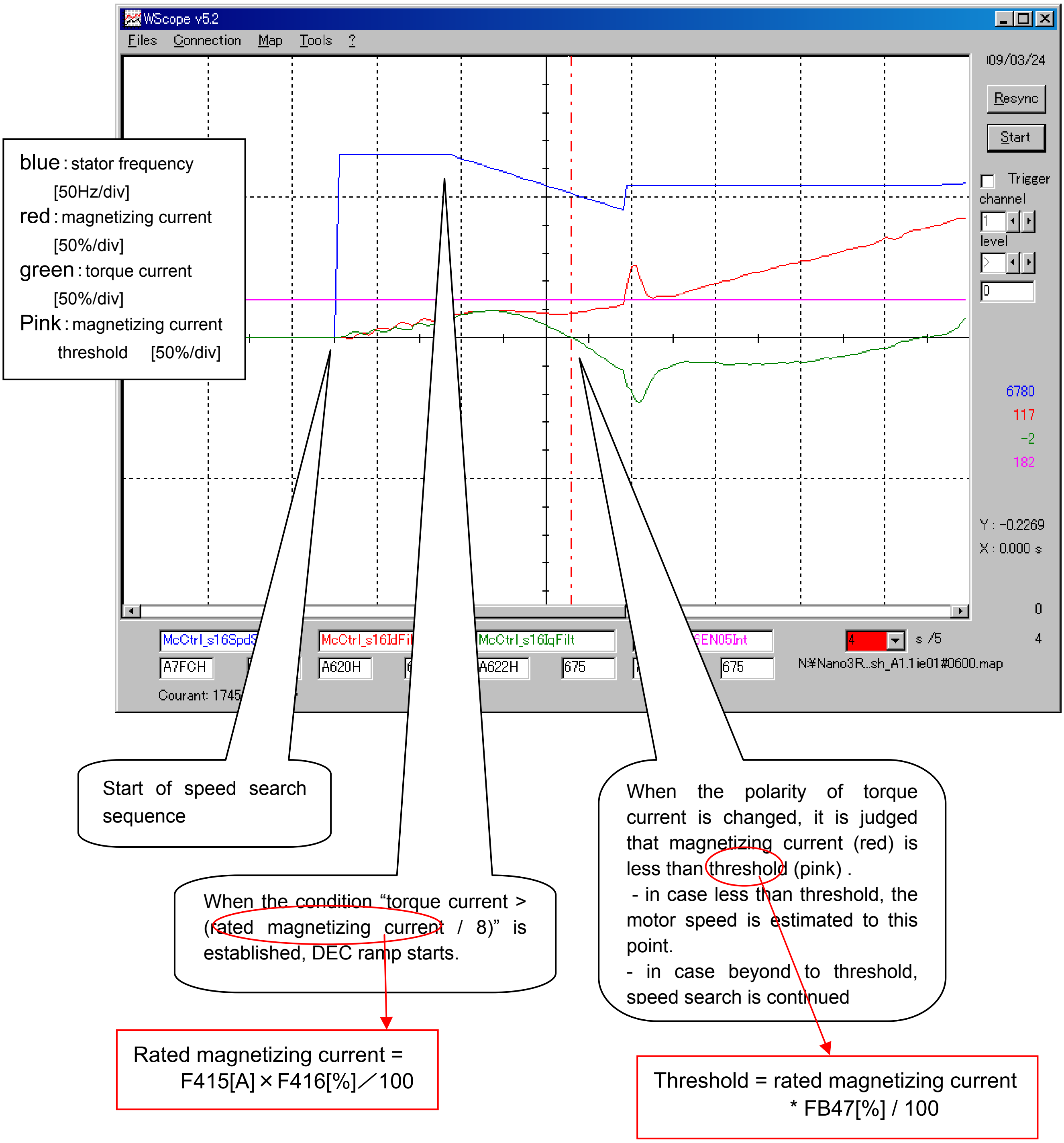
x:
2:200VClass

Low-flux start:

(PT=0,1,2)
- The motor is driven at "estimated speed" for the time "FB71*1.5"
- The flux is increased during the drive from 1/4 of rated flux to rated flux

(PT=3,4)
- The motor is driven at "estimated speed" for the time "FB71"
- The flux is increased during the drive from 1/2 of rated flux to rated flux

## 9.4 Speed search detailed sequence related to parameters




* The ramp for speed search is fast, the point that the polarity of torque current is changed is different from that of magnetizing current is minimum. (the point that magnetizing current is minimum comes first. At the point the polarity of torque current is changed, magnetizing current is increased , therefore it is beyond to threshold. It is one of the speed search failure.)
To avoid this situation, it is necessary to adjust FB57.

# 10 CARRIER FREQUENCY

## 10.1 parameter setting

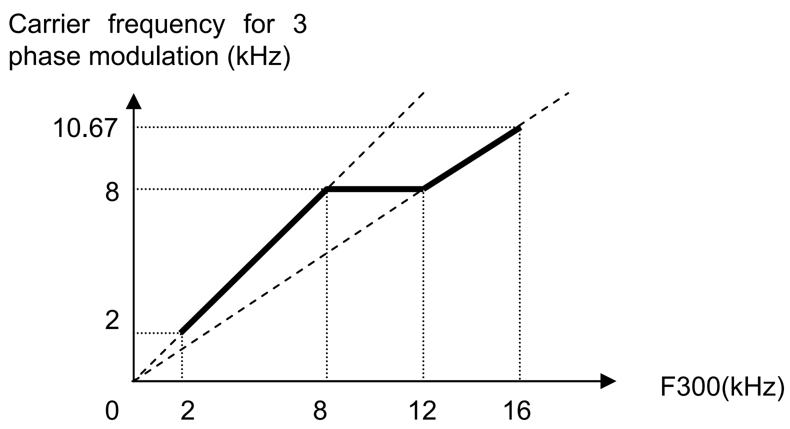
| LED display | Com. number | function | Unit convert | unit LED / com | range | Default |
|---|---|---|---|---|---|---|
| F300 | 0300 | Carrier frequency | kHz | 1/1 | 2-16 | 12 |
| F312 | 0312 | Random PWM | — | 1/1 | 0: disabled<br>1: enabled | 0 |
| F316 | 0316 | Carrier reduction | — | 1/1 | 0: disabled<br>1: enabled | 1 |

## 10.2 carrier frequency for 3 phase modulation

**- 2 phase / 3 phase modulation change point**

3 phase -> 2phase modulation change point : modulation rate = 55%
2 phase -> 3phase modulation change point : modulation rate = 45%

**- carrier frequency for 3 phase modulation**



・real carrier frequency selection at 3 phase modulation （valid from Ver110）

To add the parameter F315(real carrier frequency selection of 3phase modulation range) which takes the possibility to select real carrier frequency at 3phase modulation range.

- real carrier frequency at each condition under F315<4(compatible to present situation)

| Carrier frequency Setting (F300) | Modulation rate | |
|---|---|---|
| | ～50% | 50%～ |
| F300≦8kHz | 3ph- F300 | 2ph- F300 |
| 8kHz＜F300≦12kHz | 3ph- 8kHz | 2ph- F300 |
| F300＞12kHz | 3ph- F300×2/3 | 2ph- F300 |

- real carrier frequency at each condition under F315≧4

| Carrier frequency Setting (F300) | Modulation rate | | |
|---|---|---|---|
| | ～(F315)% | (F315)%～50% | 50%～ |
| F300≦8kHz | 3ph- F300 | 3ph- F300 | 2ph- F300 |
| 8kHz＜F300≦12kHz | 3ph- 8kHz | 3ph- F300 | 2ph- F300 |
| F300＞12kHz | 3ph- F300×2/3 | 3ph- F300 | 2ph- F300 |

＊ F315 is only valid at 3 phase modulation area.
In case F315>50%, it is same to current situation.

**(caution)**

There are some risk below in case F315 is modified.

- main IGBT is possibly broken under long drive at low speed high current, because of heat concentration on main IGBT due to 3 phase modulation – high carrier frequency at low speed.
- Drive overheat possibly occurs under long drive at middle speed high current, because of heat concentration on main IGBT due to 3 phase modulation – high carrier frequency at middle speed.

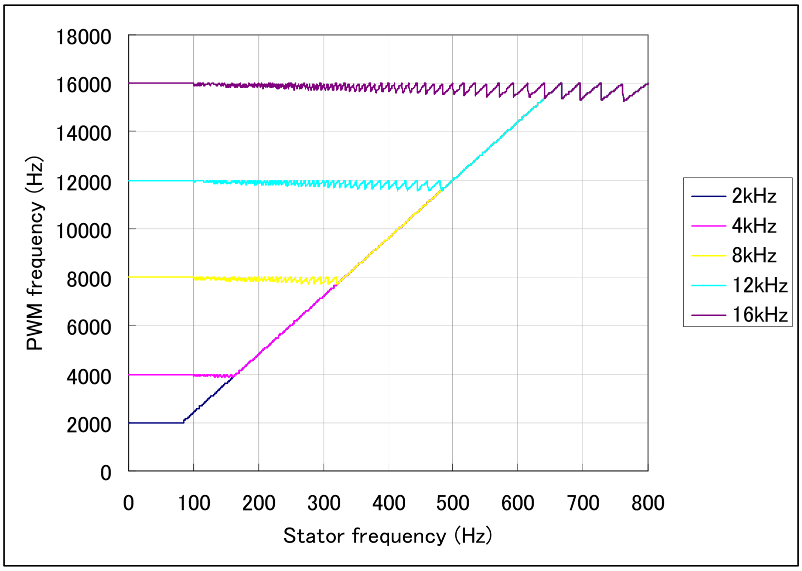
**Before to set F315, you HAVE TO discuss with (TSIJ) design team to confirm whether it is possible or not to set F315.**
**In case you change the value of F315, it is strongly recommended to set the value above 25.**

## 10.3 carrier frequency at synchronized PWM

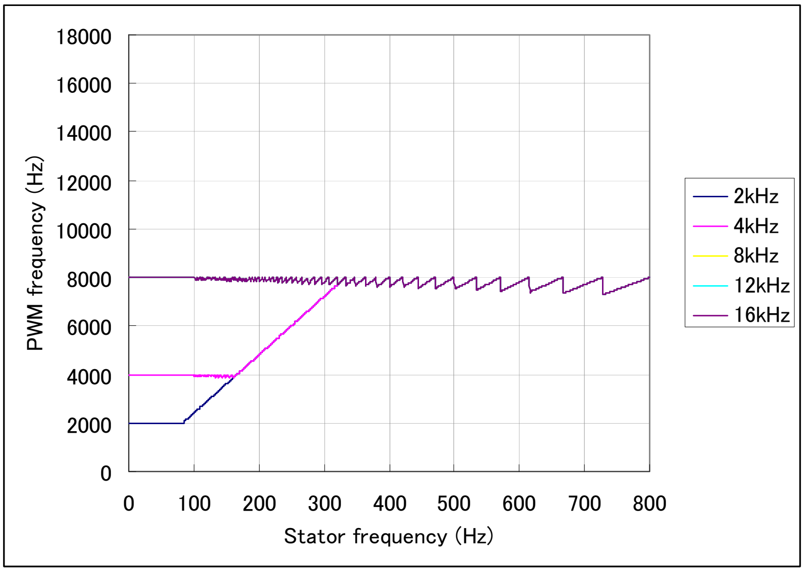
Start frequency of synchronized PWM : 105Hz
End frequency of synchronized PWM : 95Hz

The relation between carrier frequency and stator frequency at synchronized PWM

- synchronized PWM means that carrier frequency depends on stator frequency that these relation is "carrier frequency = n * stator frequency (n is integer)".
- In case stator frequency is beyond to "start frequency", synchronous PWM is enabled.
- In case stator frequency is less than "end frequency", synchronous PWM is disabled.
- In case "stator frequency * 24" is beyond to upper limit of carrier frequency, carrier frequency transits as "carrier frequency = stator frequency * 23, 22, 21… "
- In case "stator frequency * 12" is beyond to upper limit of carrier frequency, carrier frequency transits as "carrier frequency = stator frequency * 12"




f_start = 100Hz
$F_{pwm}$_limit = 16kHz (no limitation)

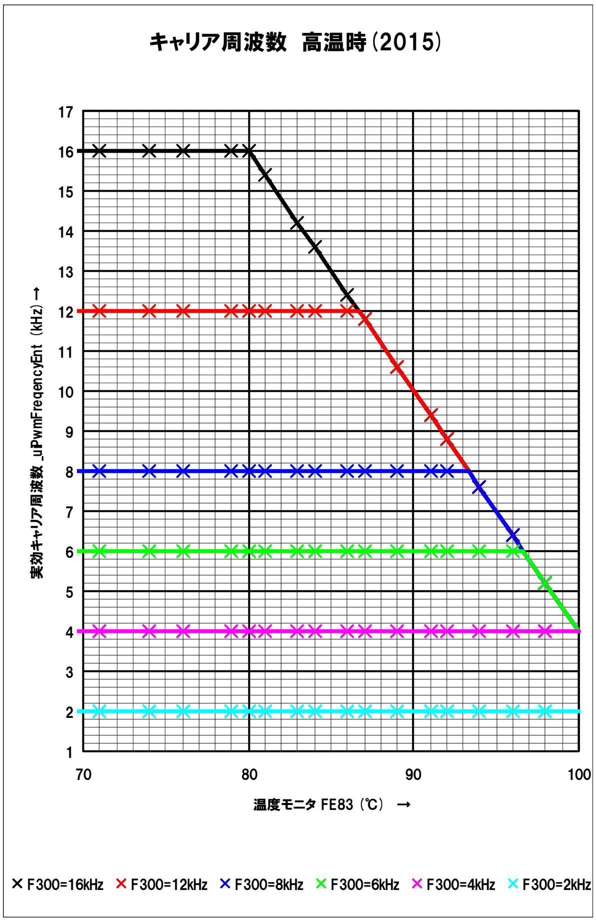


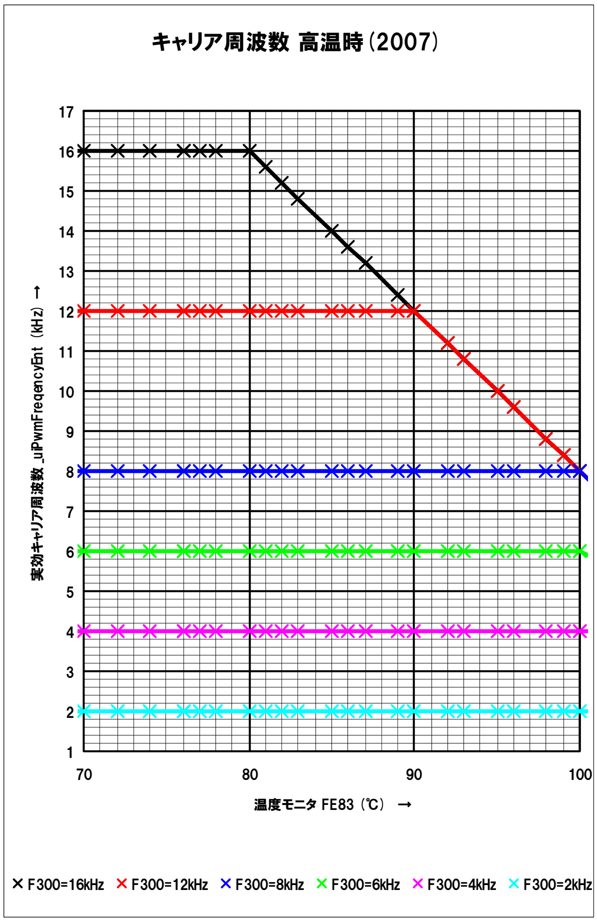

f_start = 100Hz
$F_{pwm}$_limit = 8kHz (with limitation)

## 10.4 carrier frequency reduction

In case F316=1, carrier frequency is reduced under the condition below.

- The temperature of inverter heat sink is beyond 80 degree C
  (depend on carrier frequency as below).




- The estimated temperature rising is beyond to 45 degree C for inverter IGBT.
  Carrier frequency is reduced the estimation is lower than 45 degree C

# 11 OVER TORQUE TRIP

## 11.1 parameter setting

| LED display | function | Unit / selection | note |
|---|---|---|---|
| F615 | Over torque trip / alarm selection | 0 : alarm | Output TB 28,29 |
| | | 1 : trip | OT blink display |
| F616 | Over torque detection level | 0.01% | 0 means disabled the function |
| F618 | Over torque detection time | 0.1s | 0 means fastest(4ms) detection |
| F619 | Hysteresis of over torque detection level | 0.01% | |

## 11.2 detection level

- over torque trip(alarm) level = F616
- over torque trip(alarm) recover level = F616 – F619

## 11.3 details of detection

The time that motor torque (12ms filtered) is beyond to “over torque trip(alarm) level” is cumulated.
The cumulated time is beyond to “over torque detection time (F618)”, over torque trip or alarm is output.
Alarm is output in case F615=0, “OT” trip is output in case F615=1.
In case that motor torque (12ms filtered) is less than “over torque trip(alarm) recover level” , the cumulated time is reset .

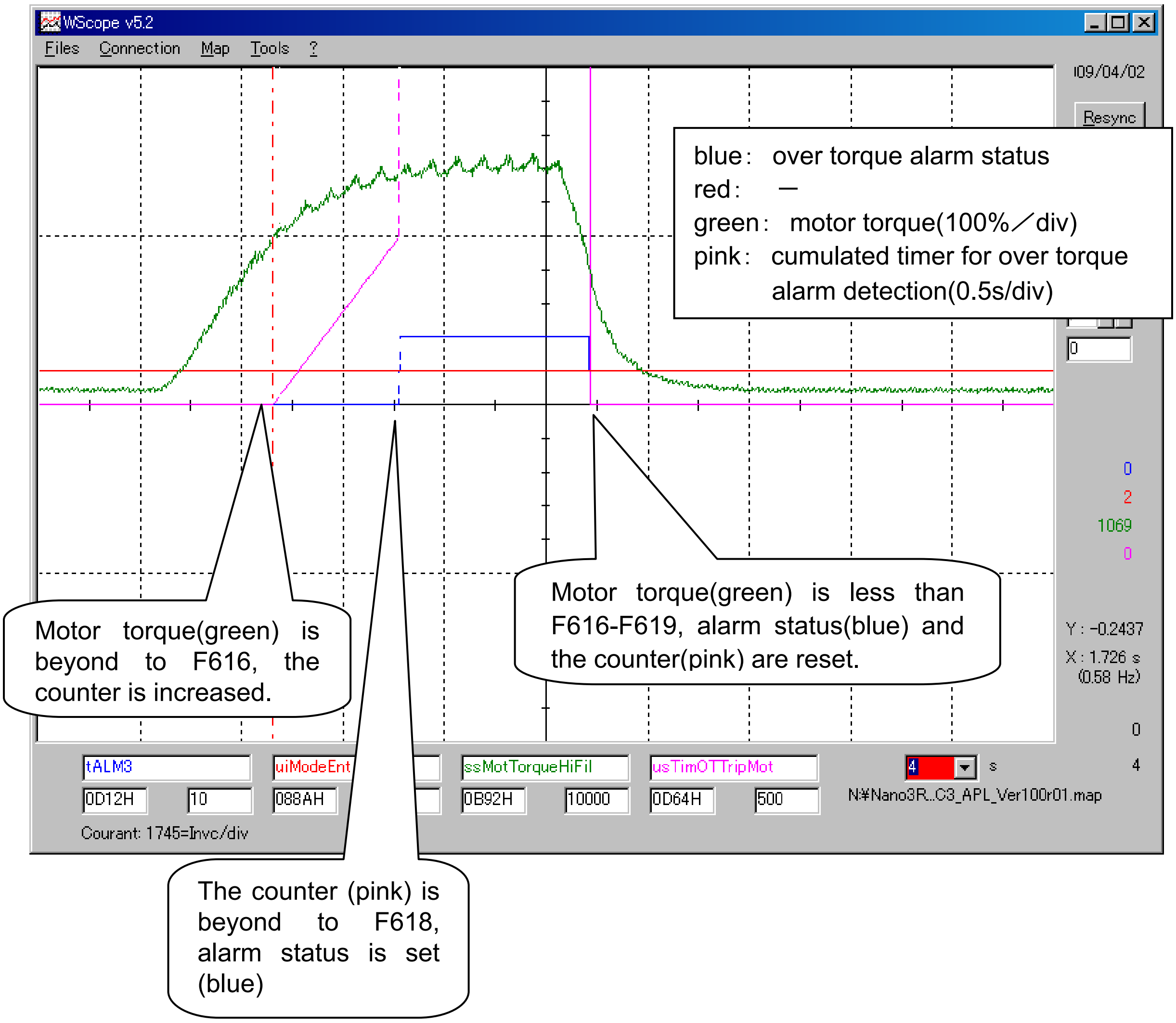
**The definition of rated torque**

The rated torque[N.m] means “motor power[W] * 9.55 / motor synchronized speed[rpm]”.
For example, in case the motor rate is 4pole-60Hz-3.7kW,
Rated torque = 3700 * 9.55 / {60*120/4} = 19.63[N.m]

## 11.4 validation

Parameter setting： F615=0(alarm)、F616=100%、F618=0.5s、F619=20%

The figure below shows the over torque alarm state at “no load -> 150% load -> no load” during 50Hz running.



# 12 DC INJECTION

## 12.1 parameter setting

| LED display | Com. number | function | Unit convert | unit LED / com | range | Default |
|---|---|---|---|---|---|---|
| f250 | 0250 | Motor control bits | Hz | 0.1 / 0.01 | 0.0-FH | 0.0 |
| f467 | 0467 | Current differential gain | - | 1 / 1 | 0-100 | 10 |

## 12.2 parameter adjustment

| problem | countermeasure | Side effect |
|---|---|---|
| - motor is little bit rotated to opposite direction | - To increase F250 every 0.5Hz up to rated slip frequency (in case F250 is small)<br>- To reduce F467 every 5 (in case PT=0,1,2) | - The possibility that motor is little bit rotated to forward direction is increased.<br><br>- refer to the section 3.3 |

In case the stator frequency just before DC injection is started is negative (opposite direction), it is kept during “reducing remaining voltage” the primary part of DC injection . It causes the problem.

# 13 ACCELERATION/DECELERATION OPERATION AFTER TORQUE LIMIT

## 13.1 parameter setting

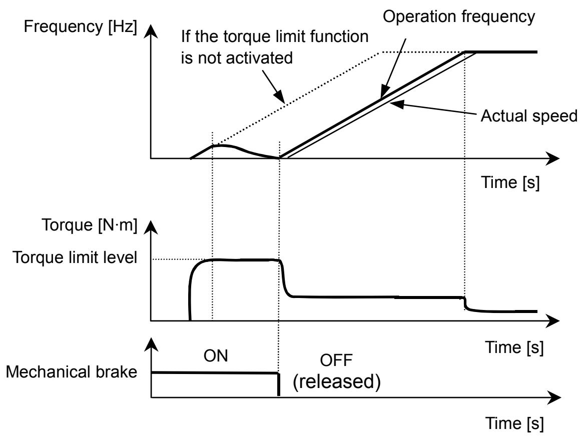
| LED display | Com. number | function | Unit convert | unit LED / com | range | Default |
|---|---|---|---|---|---|---|
| F b 8 1 | FB81 | Motor control bits | - | 1 / 1 | 0-FFFFh | 0 |

## 13.2 parameter adjustment

| problem | countermeasure | Side effect |
|---|---|---|
| - After recovery from current (torque) limitation state, speed is not rapidly recovered. (want to recover the speed as fast as possible) | - To set FB81 to 32768. | - During OP stall, frequency monitor goes down to "start-up frequency", even if motor speed is still high.<br>- During OC stall, frequency monitor is not decreased even if motor speed is low. |

(1) F b 8 1=0 (In sync with acceleration/deceleration)

The increase in operation frequency is inhibited by the activation of the torque limit function. In this control mode, therefore, the actual speed is always kept in sync with the operation frequency. The operation frequency restarts to increase when torque decreases as a result of the release of the mechanical brake, so the time required for the specified speed to be reached is the sum of the delay in operation of the mechanical brake and the acceleration time.



(2) F b 8 1=3 2 7 6 8 (In sync with min. time)

The operation frequency keeps increasing, even if the torque limit function is activated.

In this control mode, the actual speed is kept in sync with the operation frequency, while torque is held at a limit level when it decreases as a result of the release of the mechanical brake. The use of this function prevents the load from failing and improves the motor's response during inching operation.