Additional function
For Version 2

Ver.2

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PM motor Drive

14.1.1 Limitation

There is a limitation in the PM drive. Please note it.

①About the specification

1. Please use for the application of reduced torque with the starting torque less than 50%. In case of use other than above, or in combination with the motor other than Hitachi standard motor, performance cannot be guaranteed to be sufficient.
2. It is not suitable for at the usage the constant-torque, the rapid acceleration/deceleration and low speed driving. Please never use it for the transportation machine, especially the gravity load usage such as elevators.
3. PM motor cannot be drive by the commercial power source.
4. The motor can drive at load moment of inertia 50 times or less the motor moment of inertia. When over 50 times the motor moment of inertia, you may not be able to obtain adequate motor characteristics.
5. Two or more motors cannot be driven with one inverter.
6. When the DC braking function is used and the inverter trips by over voltage, use a braking resistor.
7. Please let me drive the motor after the brake is released when there is a maintenance brake. The motor may generate out-of-step if timing is not suitable.
8. When starting, the motor may reverse. Please use the initial magnet position estimation function when Trouble is caused when reverse run.
9. When you use the inverter to drive a motor of which the rated current of the motor exceeds the rated current of the inverter, and the capacity is two classes lower than the maximum applicable capacity of the inverter, you may not be able to obtain adequate motor characteristics.
10. Please adjust the motor constant settings to the motor to be driven by the inverter. The motor constant data corresponding to the date of one phase of Y connection.
11. When the motor cable for the long (more than 20m as reference) distance, you may not be able to obtain adequate motor characteristics.
12. Please do not drive the motor that the maximum current of the motor (demagnetization level) falls below about 300% of the rated current of the inverter. The motor may be demagnetization. Degauss (magnetic conditioning).
    - Please note the effective value and the peak value. The rated current of the inverter in the manual is the effective value.
13. Please set carrier frequency (b083) 8.0kHz or higher.
14. Please set electric thermal setting (b012) to the rated current of motor (same as H105).

②About the function

1. When the motor rotating at the speed of 50% or less of the base frequency (A003) is used the restarting with active matching frequency, the motor may restart 0Hz at retry.
2. When use the restarting with active matching frequency, the motor may generate over current trip if the motor direction of the rotation changes in free running.
3. When use the restarting with active matching frequency at 120Hz or more, generated the over current trip.
4. When the motor cable for the long (more than 20m as reference) distance if use the restarting with active matching frequency, the motor may generate over current trip.
    Please restart after stopping the motor with the DC braking function or the external brake, etc.
5. A part of function cannot be used. Please refer to other material "14.1.2 Invalid functions" for details.

14.1.2 Invalid functions

The following functions invalids in the PM drive.

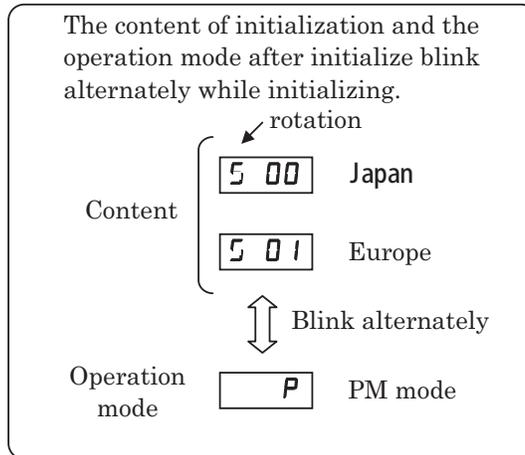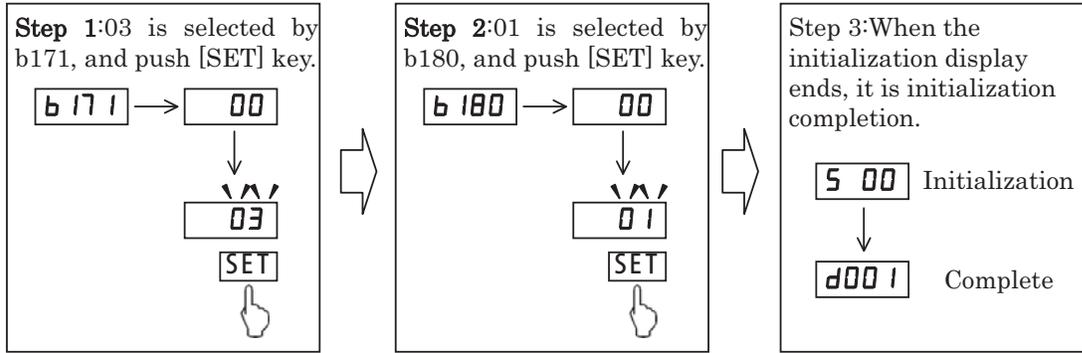| Function	Related code	Limitation method
2nd control	Item of *2**	
	Intelligent input terminal:SET(08)	
	Intelligent output terminal:SETM(60)	
Torque monitor・limit・control	C027,C028	02(Output torque)
	d009,d010,d012,b040~b045,C054~C059,P033,P034,P036~P041	
	Intelligent input terminal:TL(40),TRQ1(41),TRQ2(42),ATR(52)	
	Intelligent output terminal:OTQ(07),TRQ(10)	
Encoder feedback	P003	01(Encoder feedback)
	d008,d029,d030,H050,H051,P004,P011,P012,P015,P026,P027,P060~P073,P075,P077	
	Intelligent input terminal:PCLR(47),CP1(66)~CP3(68),ORL(69),ORG(70),SPD(73),EB(85)	
	Intelligent output terminal:DES(22),POK(23)	
Jog	A038,A039	
	Intelligent input terminal:JG(06)	
IM control	A041~A044,A046,A047,b100~b113,H002~H006,H020~H024,H030~H034	
V/f gain	A045	
AVR	A081,A083,A084	
Automatic energy-saving drive	A085,A086	
Restarting with active matching frequency	b001,b008	04(Restarting with active matching frequency)
	b088,C103	02(Restarting with active matching frequency)
	b028~b030	
Over current suppression	b027	
Reduced voltage start	b036	
Reverse run protection	b046	
Brake control	b120~b127	
	Intelligent input terminal:BOK(44)	
	Intelligent output terminal:BRK(19),BER(20)	
Offline auto-tuning	H001	02(Enable・rotation)
Dual Rating	b049	
Commercial power source switching	Intelligent input terminal:CS(14)	
LAD cancellation	Intelligent input terminal:LAC(46)	

14.1.3 PM mode switching

It changes to the PM mode by setting the initialization trigger (b180) to 01 after setting the inverter mode selection (b171) to 03, and initialization is executed.

■When using this mode, observe the following precautions.

① hen 01 is set on the initialization trigger (b180), and SET key is pressed, initialization starts immediately and there is not any way to restore the previous parameter setting.

② All data will be initialized regardless the setting of b094. b094

③ The settings of "P100" to "P131", running-time data, and power-on time data cannot be cleared.

④ When display is restricted by the function code display restriction function (b037) or software is locked by the software lock function (b031), you cannot initialize because the function codes of initialization are no-display. If you forget password that restrict setting (b031) and (b037), you cannot cancel it. (So you cannot initialize when software lock is active, you note that the setting password. (See section 7.6.11 the password function.))

Item	Function code	Data or range of data	Description
Inverter mode selection	b171	00	No
		03	PM mode
Initialization trigger	b180	00	No action
		01	Initialize

■ Way to PM mode switching

Step 1:03 is selected by b171, and push [SET] key.

`b 171` → `00`
↓
`03`
`SET`

Step 2:01 is selected by b180, and push [SET] key.

`b 180` → `00`
↓
`0 1`
`SET`

Step 3:When the initialization display ends, it is initialization completion.

`5 00` Initialization
↓
`d00 1` Complete

The content of initialization and the operation mode after initialize blink alternately while initializing.

↙ rotation

Content
`5 00` Japan
`5 0 1` Europe

⇕ Blink alternately

Operation mode
`P` PM mode

Note 1: For prevent from initializing by mistake, (b084) and (b180) restore 00 after initialize or Re-power supply. Every time, please set it every time if you initialize.

Note 2: Even if initialize, the initial data select (b085), the input span calibration (C081, C082), and the thermistor input (PTC) span calibration (C085) don't initialize.

Note 3: There is not any way to restore the previous parameter setting after initialize.

14.1.4 Motor constants selection

·When PM dive, adjust the motor constant settings to the motor to be driven by the inverter.

·You can select the motor constants from the following three types:

    (1) Motor constants of Hitachi standard motor

        ⇒ When 00 is set on PM motor code setting (H102), motor constants use (H106~H110). Initial values of (H106~H110) are set on motor constants of Hitachi standard motor.

    (2) Motor constants tuned by offline auto-tuning

        ⇒ When 01 is set on PM motor code setting (H102) after the offline auto-tuning allows, motor constants use automatically measure values (H111~H113) and Hitachi standard motor values (H109~H110).

    (3) Arbitrarily set motor constants

        ⇒ In above-mentioned both (1) and (2) cases, motor constants can be changed to the given value. Please change the value of (H106~H113) in the value of (H102).

Item	Function code	Data or range of data	Description
Base frequency (*1)	A003	30.0~Maximum frequency [Hz]	The base frequency of motor is set.
Maximum frequency (*1)	A004	Base frequency~400.0 [Hz]	The max frequency of motor is set.
PM motor code setting	H102	00	Hitachi standard (Use 106~H110 at motor constants)
		01	Auto-Tuning (Use 106~H110 at motor constants)
PM motor capacity (*2)	H103	0.1~18.5 [kW]	The capacity of motor is set.
PM motor pole setting	H104	2/4/6/8/···/48 [pole]	The pole of motor is set.
PM Rated Current	H105	(0.00~1.00)×Rated current of the inverter [A]	The rated current of motor is set.
Motor constants of Hitachi standard motor			Motor constants setting when auto-tuning don't use. The initial values are motor constants of Hitachi standard motor.
PM const R(Resistance)	H106	0.001~65.535 [Ω]	
PM const Ld(d-axis inductance)	H107	0.01~655.35 [mH]	
PM const Lq(q-axis inductance)	H108	0.01~655.35 [mH]	
PM const Ke(Induction voltage constant) (*3)	H109	0.0001~6.5535 [V/(rad/s)]	
PM const J(Moment of inertia) (*4)	H110	0.001~9999.000 [kgm²]	
Motor constants tuned by offline auto-tuning			Automatically measured motor constants when the offline auto-tuning is executed, and they are set. After auto-tuning, you can be changed to the given value.
PM const R (Resistance)	H111	0.001~65.535 [Ω]	
PM const Ld(d-axis inductance)	H112	0.01~655.35 [mH]	
PM const Lq(q-axis inductance)	H113	0.01~655.35 [mH]	

*1 The base frequency (the maximum frequency) calculates to the following by the rated revolution (the maximum revolution) of the motor and motor pole.

$$\text{Base frequency (Maximum frequency) [Hz]} = \frac{\text{Rated revolution (Maxmum revolution) } [\text{min}^{-1}] \times \text{pole}}{120}$$

*2 Please pay attention that settings of H104 to H110, A003 and A004 will be changed automatically, when PM

motor capacity (H103) is changed.

*3　PM induction voltage constant Ke is the peak voltage of one phase of per electrical angle speed (rad/s).

*4　PM moment of inertia J is value (kgm^2) that added the moment of inertia of the load machine that converting the moment of inertia into the motor shaft data to the moment of inertia of the motor.

14.1.5 PM offline auto-tuning function

PM offline auto-tuning automatically measures motor constants necessary for sensorless vector control at special driving pattern different from usually besides driving, and accuracy of vector control is improved. PM induction voltage constant Ke and PM moment of inertia J cannot measure because motor don't revolute. Please set the induction voltage constant is the peak voltage of one phase of per electrical angle speed (rad/s), and the moment of inertia is value (kgm^2) that added the moment of inertia of the load machine that converting the moment of inertia into the motor shaft data to the moment of inertia of the motor, by manual.

■When using this mode, observe the following precautions.

①When you use vector control by the motor that doesn't understand constants, please measure motor constants by offline auto-tuning.

②The measured motor constant is the data of one phase of Y connection.

③Please use auto-tuning with the motor has stopped. If the motor rotates, correct constant data may not be obtained. (In such cases, the auto-tuning operation may not be completed. If the auto-tuning operation is not completed, press the STOP/RESET key. The operation will end with an error code displayed.)

④Adjust the settings of base frequency (A003), maximum frequency (A004), AVR voltage select (A082), PM motor capacity (H103), PM motor pole setting (H104) and PM Rated Current (H105) to the motor specifications before use auto-tuning. When motor of outside set range of these parameters, correct constant data may not be obtained. (In such cases, the auto-tuning operation may not be completed. If the auto-tuning operation is not completed, press the STOP/RESET key. The operation will end with an error code displayed.)

⑤This function can properly apply to only the motors in the maximum applicable capacity class of your inverter or one class lower than the capacity class of your inverter. If this function is used for motors with other capacities, correct constant data may not be obtained. (In such cases, the auto-tuning operation may not be completed. If the auto-tuning operation is not completed, press the STOP/RESET key. The operation will end with an error code displayed.)

⑥Specify "00" (disabling) for the DC braking enable. (The default setting is "00".) If "01" (enabling) is specified for the DC braking enable (A051), motor constants cannot be measured by offline auto-tuning.

⑦When the motor cable for the long (more than 20m as reference) distance, correct constant data may not be obtained. Please set the motor cable length parameter (b033) according to the motor cable, and use auto-tuning. (The motor cable length parameter setting is a parameter that corrects the current detection accuracy by the difference of the length of the motor cable. The capacity of inverter of 11kW and 15kW need not be set.)

⑧The motor may rotate slightly during auto-tuning, but this is not abnormal behavior.

⑨The allophone and the vibration may generate during auto-tuning, but this is not abnormal behavior.

⑩Please do not use auto-turning with the shaft of the motor fixed with external brake etc. Otherwise correct motor constants may not be obtained.

⑪Please use auto-turning with the load machine attached to the motor. Otherwise right motor constants may not be obtained.

Item	Function code	Data or range of data	Description
Base frequency (*1)	A003	30.0~Maximum frequency [Hz]	The base frequency of motor is set.
Maximum frequency (*1)	A004	Base frequency~400.0 [Hz]	The max frequency of motor is set.
DC braking enable	A051	00	OFF
		01	ON
AVR voltage select	A082	200/215/220/230/240	When 200 V class inverter models.
		380/400/415/440/460/480	When 400 V class inverter models.
Motor cable length parameter	b033	5~20	According to the motor cable
Auto-tuning Setting	H001	00	OFF
		01	ON(STOP)
PM motor code setting	H102	00	Hitachi standard (Use 106~H110 at motor constants)
		01	Auto-Tuning (Use 106~H110 at motor constants)
PM motor capacity (*2)	H103	0.1~18.5 [kW]	The capacity of motor is set.
PM motor pole setting	H104	2/4/6/8/···/48 [pole]	The pole of motor is set.
PM Rated Current	H105	$(0.00~1.00) \times$ Rated current of the inverter [A]	The rated current of motor is set.
Motor constants of Hitachi standard motor			Motor constants setting when auto-tuning don't use. The initial values are motor constants of Hitachi standard motor.
PM const R(Resistance)	H106	0.001~65.535 [Ω]	
PM const Ld(d-axis inductance)	H107	0.01~655.35 [mH]	
PM const Lq(q-axis inductance)	H108	0.01~655.35 [mH]	
PM const Ke(Induction voltage constant) (*3)	H109	0.0001~6.5535 [V/(rad/s)]	
PM const J(Moment of inertia) (*4)	H110	0.001~9999.000 [kgm^2]	
Motor constants tuned by offline auto-tuning			Automatically measured motor constants when the offline auto-tuning is executed, and they are set. After auto-tuning, you can be changed to the given value.
PM const R (Resistance)	H111	0.001~65.535 [Ω]	
PM const Ld(d-axis inductance)	H112	0.01~655.35 [mH]	
PM const Lq(q-axis inductance)	H113	0.01~655.35 [mH]	

*1 The base frequency (the maximum frequency) calculates to the following by the rated revolution (the maximum revolution) of the motor and motor pole.

$$\text{Base frequency (Maximum frequency) [Hz]} = \frac{\text{Rated revolution (Maxmum revolution) } [min^{-1}] \times pole}{120}$$

*2 Please pay attention that settings of H104 to H110, A003 and A004 will be changed automatically, when PM motor capacity (H103) is changed.

*3 PM induction voltage constant Ke is the peak voltage of one phase of per electrical angle speed (rad/s).

*4 PM moment of inertia J is value (kgm^2) that added the moment of inertia of the load machine that converting the moment of inertia into the motor shaft data to the moment of inertia of the motor.

*5 Even if the auto-tuning has ended normally, you cannot operate the inverter with the tuning data left. If you intend to operate the inverter with the tuning data left, be sure to switch the setting of motor constant selection (H102) to "01".

*6 If the auto-tuning has ended abnormally, you confirm the motor cable and the parameter setting, and retry it.

*7 If you cancel the auto-tuning midway with a stop command (by pressing the STOP/RESET key or turning off the operation command), the constants set for auto-tuning may remain in the inverter. Before retrying the auto-tuning, initialize the inverter, and then readjust the settings for the auto-tuning. (Perform the same procedure also when you proceed to the normal inverter operation.)

■Operating procedure

Step 1:Set to motor capacity, motor pole and motor current according to the motor.

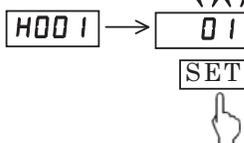| $H\,103$ | Motor |
| $H\,104$ | Motor pole |
| $H\,105$ | Motor |

⇨

Step 2:Set to base frequency, maximum frequency and motor voltage according to the motor.

$A003$	Base
$A004$	Maximum
$A082$	Motor voltage

⇨

Step 3:02 is set to Auto-tuning Setting (H001).

$H001$ → 01
SET
👆

⬇

After completing auto-tuning, display of auto-tuning result.

| $---o$ | Normal |
| $---\lrcorner$ | Abnormal |

⬅

Automatic driving begins.

⬅

Step 4:The operation command is input according to setting the run command source (A002). RUN
👆

⬇

Step 5:After completing auto-tuning, to clear the result display, press the STOP/RESET key.

STOP
👆

⬇

Step 6:Measured motor constants is reflected in driving data.

$H102$ → 01
SET
👆

When the operation command is input, the inverter performs an automatic operation in the following steps:

(1) Initial Magnet Position Estimation
      (Motor don't revolution)
↓
(2) First DC excitation (Motor don't revolution)
↓
(3) First AC excitation (Motor don't revolution)
↓
(4) Second AC excitation (Motor don't revolution)
↓
(5) Display of auto-tuning result

14.1.6 PM drive

·This function estimates magnet position of PM by output voltage and current of inverter and setting motor constants, and drive PM.

·Before using this function, be sure to make optimum constant settings for the motor with reference to Section 14.1.4, "Motor constant selection."

Item	Function code	Data or range of data	Description
Level of electric thermal (*1)	b012	(0.2~1.0)× Rated current of inverter [A]	
Carrier frequency (*2)	b083	2.0~15.0 [kHz]	
PM Speed Response	H116	1~1000 [%]	
PM Starting Current	H117	20.00~100.00 [%]	Current value for starting (100[%]=H105) (*3) (*4)
PM Starting Time	H118	0.01~60.00 [s]	Time of DC current passing for starting
PM Stabilization Constant	H119	0~120 [%]	(*5)
PM Minimum Frequency	H121	0.0~25.5 [%]	Frequency of control switching (100[%]=A003)
PM No-Load Current	H122	0.00~100.00 [%]	Current value for no-load (100[%]=H105)
PM Starting Method Select	H123	00	Normal
		01	Initial Magnet Position Estimation (*6) (*7)
PM Initial Magnet Position Estimation 0V Wait Times	H131	0~255	Number of times of 0V waiting in initial magnet position estimation.
PM Initial Magnet Position Estimation Detect Wait Times	H132	0~255	Number of times until current detecting in initial magnet position estimation.
PM Initial Magnet Position Estimation Detect Times	H133	0~255	Number of times of current detecting in initial magnet position estimation.
PM Initial Magnet Position Estimation Voltage Gain	H134	0~200	Output voltage gain in initial magnet position estimation.

*1 Please set electric thermal setting (b012) to the rated current of motor (same as H105).
*2 Please set carrier frequency (b083) 8.0kHz or higher.
*3 automatically reduces the carrier frequency according to the PM Starting Current setting.
*4 When too great setting, motor may generate overload trip.
*5 When too small setting, you may not be able to obtain motor torque, and motor generate impact or generate over current trip near H121 setting.
*6 The allophone may generate during initial magnet position estimation, but this is not abnormal behavior.
*7 When use initial magnet position estimation, please start with the motor has stopped. When start with the motor has rotated, motor may rotate greatly or generate out-of-step.

· When using this function, observe the following precautions:

① In combination with the motor other than Hitachi standard motor, performance cannot be guaranteed to be sufficient.

② If you cannot obtain the desired characteristics from the motor driven under the sensorless vector control, readjust the motor constants according to the symptom, as described in the table below

Operation status	Symptom	Adjustment method	Adjustment item
Starting	Trouble is caused when reverse run.	Enable to the initial magnet position estimation function. - The motor may rotate slightly, but this is not abnormal behavior.	H123
	Generate out-of-step. Generate over current trip.	Increase the starting current. - Note the electronic thermal protection function.	H117
		Increase the starting time.	H118
	Need for early starting.	Enable to the initial magnet position estimation function, and reduce the starting time.	H118,H123
Less than H121 (PM minimum frequency) setting	Motor runs unsteadily.	Increase the starting current - Note the electronic thermal protection function.	H117
	Motor generate hunting.	Reduce the motor constant R step by step from the set value down to 0.7 times as high as the set value.	H106,H111
		Increase the motor constant Ld step by step from the set value up to 1.3 times as high as the set value. Increase the motor constant Lq step by step from the set value up to 1.3 times as high as the set value. - Please adjust to Ld ≦ Lq.	H107,H112 H108,H113
Near H121 (PM minimum frequency) setting	Motor generates an impact. Generate over current trip.	Adjust the speed response.	H116
		Adjust the minimum frequency when a load changes.	H121
More than H121(PM minimum frequency) setting	Motor generate hunting.	Adjust the speed response.	H116
		Increase the no-load current.	H122
		Increase the carrier frequency current if low setting.	b083

Initial magnet position estimating	Need for short time of Initial magnet position estimation	Reduce the PM Initial Magnet Position Estimation 0V Wait Times. - When too small setting, motor may rotate greatly or generate out-of-step.	H131
		Reduce the PM Initial Magnet Position Estimation Detect Wait Times. - When too small setting, motor may rotate greatly or generate out-of-step.	H132
		Reduce the PM Initial Magnet Position Estimation Detect Times. - When too small setting, motor may rotate greatly or generate out-of-step.	H133
	Motor rotates greatly	Increase the PM Initial Magnet Position Estimation 0V Wait Times.	H131
		Increase the PM Initial Magnet Position Estimation Detect Wait Times	H132
		Increase the PM Initial Magnet Position Estimation Detect Times	H133
		Increase the PM Initial Magnet Position Estimation Voltage Gain step by step. - too great setting, may generate over current trip.	H134
	Generate over current trip.	Reduce the PM Initial Magnet Position Estimation Voltage Gain step by step. - When too small setting, motor may rotate greatly or generate out-of-step.	H134