ABB Drives

Supplement to Firmware Manual

for ACS800 Standard Control Program 7.x

Permanent Magnet Synchronous Machine Drive Application Program

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Safety

Overview

Follow all safety instructions delivered with the drive.

The safety instructions must be followed when installing, operating and servicing the drives. Study the complete safety instructions carefully.

Installation and Maintenance Safety

These safety instructions are intended for all who work on the drive. Ignoring these instructions can cause physical injury or death.

WARNING! All electrical installation and maintenance work on the drive should be carried out by qualified electricians.

Any installation work must be done with power off, and power is not to be reconnected unless the installation work is complete. Dangerous residual voltages remain in the capacitors when the disconnecting device is opened. Wait for 5 minutes after switching off the supply before starting work. Always ensure by measuring that the voltage between the terminals UDC+ and UDC- and the frame is close to 0 V and that the supply has been switched off before performing any work on the equipment or making main circuit connections.

If the main circuit of the inverter unit is live, the motor terminals are also live even if the motor is not running!

Open the disconnect switches of all parallel connected inverters before doing installation or maintenance work on any of them. These switches are not included in the ACx 8x7 drives.

When joining shipping splits, check the cable connections at the shipping split joints before switching on the supply voltage.

If the auxiliary voltage circuit of the drive is powered from an external power supply, opening the disconnecting device does not remove all voltages. Control voltages of 115/230 VAC may be present in the digital inputs or outputs even though the inverter unit is not powered. Before starting work, check which circuits remain live after opening of the disconnecting device by referring to the circuit diagrams for your particular delivery. Ensure by measuring that the part of the cabinet you are working on is not live.

Control boards of the converter unit may be at the main circuit potential. Dangerous voltages may be present between the control boards and the frame of the converter unit, when the main circuit voltage is on. It is critical that the measuring instruments, such as an oscilloscope, are used with caution and safety as a high priority. The fault tracing instructions give special mention of cases in which measurements may be performed on the control boards, also indicating the measuring method to be used.

Live parts on the inside of doors are protected against direct contact. Special safety attention shall be paid when handling shrouds made of sheet metal.

Do not make any voltage withstand tests on any part of the unit while the unit is connected. Disconnect motor cables before making any measurements on motors or motor cables.

WARNING! Fans may continue to rotate for a while after the disconnection of the electrical supply.

WARNING! Some parts like heatsinks of power semiconductors and toroidal cores on motor cables inside the cabinet remain hot for a while after the disconnection of the electrical supply.

When Working on the Supply Section

WARNING! Disconnect the mains voltage from the incoming supply. Open also the AC main switch and close the earthing switch if present. Disconnect all control voltages (check the control diagrams to find all voltage sources).

Ensure by measuring that all voltages of the incoming supply section have been disconnected and discharged.

Drive Section

WARNING! Close switch fuses of all parallel connected inverters before starting the drive.

Do not open the drive section switch fuses when the inverter is running.

Permanent Magnet Synchronous Machine Drive

Installation and Maintenance Work

WARNING! Do not work on the drive when the Permanent Magnet Synchronous Machine (PMSM) is rotating. When rotating, the PMSM feeds power to the intermediate circuit of the drive and also the supply connections become live (even when the inverter is stopped!).

Before starting work in the inverter cubicle:

- Stop the motor.
- Isolate the inverter from the intermediate circuit of the ACS800 multidrive by opening the inverter switch-fuse or by removing the DC fuses. Alternatively isolate the ACS800 multidrive from the AC power supply by using the main disconnecting device. Lock the disconnector to open position.
- Ensure the motor cannot rotate during work.
- Ensure that there is no voltage present on converter power terminals:
  Alternative 1)
  Isolate the converter from motor. Ensure by measuring that there is no voltage present on the motor side converter input or output terminals (UDC+, UDC- or U2, V2, W2) or motor input terminals (U1, V1, W1).
  Alternative 2)
  Ensure by measuring that there is no voltage present on the motor side converter input or output terminals (UDC+, UDC- or U2, V2, W2) or motor input terminals (U1, V1, W1) and temporarily ground the converter output.
  Alternative 3)
  Isolate, measure and temporary ground when possible.

Operation

Do not run the machine above the rated speed. Machine overspeed leads to overvoltage, which may damage or even explode the capacitors in the intermediate circuit of the drive.

Table of Contents

Chapter 1 - Introduction

Overview

This chapter describes:

- the intended audience of the supplement
- what the supplement contains
- some limitations, machine requirements and recommendations that should be taken into account when using Permanent Magnet Synchronous Machine (PMSM) drive.

Intended Audience

The reader of this manual is excepted to be familiar with the ACS800 and the basics of AC machines.

What This Supplement Contains

This supplement points out those PMSM Drive Application Program features that differ from the ACS800 Standard Control Program. To get the full picture, the supplement should be used together with *Firmware Manual for ACS800 Standard Control Program 7.x* (Code: 3AFE64527592 [English]).

Safety, instructions are featured in the first few pages of this manual. Safety instructions describe the formats for various warnings and notations of the drive.

Chapter 1 - Introduction, the chapter you are reading, introduces you to this manual and describes some basic information about the PMSM drive.

Chapter 2 - Permanent Magnet Synchronous Machine, describes the structure and basic features of a permanent magnet synchronous machine.

Chapter 3 - Start-up, explains the start-up procedure.

Chapter 4 - Software Description, explains the operation of the PMSM Drive Application Program and describes the main differences between the ACS800 Standard Control Program and the PMSM Drive Application Program.

Chapter 5 - Signals and Parameters, lists the signals and parameters that differ from the signal and parameter list in *Firmware Manual for ACS800 Standard Control Program 7.x*.

Chapter 6 - Service and Maintenance, describes special considerations regarding e.g. permanent magnet machine back-voltage hazard as well as pulse encoder use and replacing in PMSM drive.

Chapter 7 - Fault Tracing, explains PMSM drive specific fault and alarm messages.

Chapter 8 - Terms, lists the PMSM drive specific terms and abbreviations.

Some Limitations, Machine Requirements and Recommendations

The PMSM Drive Application Program is designed for applications in which the drive runs a Permanent Magnet Synchronous Machine (PMSM). The program is based on the ACS800 Standard Control Program. Most of the features are the very same.

- The PMSM drives are typically used in industrial applications. The greatest advantage of the PMSM drive is gained in a low-speed gearless drive such as propulsion, lift, crane, conveyor and reeler drive.
- The maximum output frequency of the inverter is 400 Hz. However, the maximum frequency is limited by software so that no more than $1.4U_{\mathrm{DC,nom}}$ voltage can be rectified to the intermediate circuit by the permanent magnets. Frequency limits are calculated according to nominal open circuit voltage created by the permanent magnets at nominal frequency. Frequency limitation protects the inverter intermediate circuit and the power switches from break down. A calculation example of the frequency limits is presented in *Chapter 4 - Software Description*.
- Make sure the drive has sufficient output voltage capability for the MAX SPD & MAX TORQUE required by the application at that speed:

$$\text{Max Output Voltage=.95 Input voltage=}\sqrt{\left(Ke\frac{MaxSpd}{1000}+1.3R_{motlohms}*\frac{MaxTq}{K_T}\right)^2+\left(\frac{Poles*Lmotmh*MaxSpd*\frac{MaxTq}{Kt}}{1910}\right)^2}$$

- For the best possible performance in starting, the machine should have some saliency for the purpose of finding the rotor position. Also magnetic saturation is needed to decide the polarity of the permanent magnet. The structural effects of a permanent magnet synchronous machine are explained in more detail in *Chapter 2 - Permanent Magnet Synchronous Machine* (PMSM).

- It is **not** recommended to use the PMSM Drive Application Program with servo motors or with other machines which have a low inductance rate (causes ripple to current and torque due to low switching frequency). It is recommended that the stator phase inductance (unit [H]) fulfils condition

  $$L_{\mathrm{s\,phase}} \geq \frac{8 \cdot 10^{-5} \cdot U_{\mathrm{N,\,inv}}}{I_{\mathrm{N,\,mot}}} \cdot [\mathrm{s}] \qquad \text{(Y-connection),}$$

  or

  $$L_{\mathrm{s\,phase}} \geq \frac{24 \cdot 10^{-5} \cdot U_{\mathrm{N,\,inv}}}{I_{\mathrm{N,\,mot}}} \cdot [\mathrm{s}] \qquad \text{(D-connection).}$$

Product and service inquiries

Address any inquiries about the product to your local ABB representative, quoting the type designation and serial number of the unit in question. A listing of ABB sales, support and service contacts can be found by navigating to www.abb.com/drives and selecting *Sales, Support and Service network*.

Product training

For information on ABB product training, navigate to www.abb.com/drives and select *Training courses*.

Providing feedback on ABB Drives manuals

Your comments on our manuals are welcome. Go to www.abb.com/drives and select *Document Library – Manuals feedback form (LV AC drives)*.

Chapter 2 - Permanent Magnet Synchronous Machine

Overview

In this chapter, the structure and basic properties of a permanent magnet synchronous machine (PMSM) are described.

Structure of a PMSM

PMSMs are synchronous AC machines. The stator of a PMSM usually incorporates a normal three-phase winding, like in squirrel-cage machines, but the rotor winding is replaced with permanent magnets. This means that a rotor flux coupling always exists. The magnets can be located on the surface or inside of the rotor. Different kinds of rotor structures are shown in figure below.

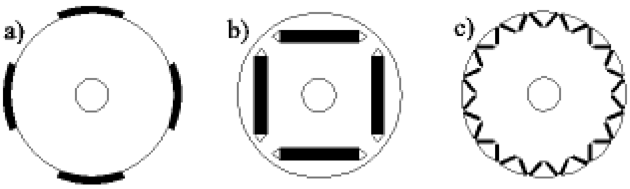


Figure 2 - 1 Different kinds of rotor structures:
a) surface magnets
b) buried tangential magnets
c) buried inclined magnets with a special rotor pole form

A machine equipped with surface magnets has a wide effective air gap because permanent magnet material has almost the same permeability as air. This results in low magnetising inductance and poor possibilities to affect the machine's electromagnetic state from the stator. In case of surface magnets, the machine has no saliency (some saliency may exist if the rotor iron saturates).

If the magnets are buried, the properties of the machine differ essentially from the properties of a machine with surface magnets. In case of buried magnets, the magnetic flux has two different routes in the rotor: direct (d) and quadrature (q) direction. Thus, the machine is a salient-pole PMSM. The magnetising inductance is higher than in a machine with surface magnets. The higher inductance enables operation further in the field weakening area.

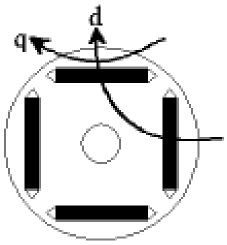


Figure 2 - 2. d- and q-direction paths of magnetic flux in a 4-pole rotor. The permanent magnets magnetise the machine in the d direction.

For finding the permanent magnet flux direction when starting from standstill without encoder feedback, PMSM drive makes inductance measurements. For a smooth starting, the machine should have some saliency (i.e. difference in the d- and q-direction inductances) and also magnetic saturation should happen in the d-direction in order to find the permanent magnetising direction of the rotor.

A rotor damper winding is not necessary in an inverter driven permanent magnet synchronous machine, but damping may improve the dynamic properties of the machine.

Field Weakening of a PMSM

In field weakening, demagnetising current is fed to the stator of a PMSM. Current neutralises the effect of permanent magnet flux linkage and therefore the magnetic field and the machine back-emf are reduced, this enabling higher speed. If demagnetising stator current is lost due to a fault situation, the inverter has to sustain the voltage caused by permanent magnet back-emf proportional to the machine speed. This is why the speed range is limited in the PMSM drive (see *Chapter 4 - Software Description*). In practise, low machine inductance may limit the speed range because of excessive current needed for field weakening.

Chapter 3 - Start-up

Overview

This chapter describes the basic start-up procedure of the drive. The instructions are given as a step-by-step table. A more detailed description of the parameters involved in the procedure is presented in the Chapter 5 - Signals and Parameters and in *Firmware Manual for ACS800 Standard Control Program 7.x* (Code: 3AFE64527592 [English]).

There are a few changes in starting up a PMSM drive compared to a normal drive. During the start-up, follow the instructions in this manual.

General Start-up Instructions

The drive can be operated:

- locally from its Control Panel or from the DriveWindow PC tool.
- externally via the I/O or fieldbus connection.

The start-up procedure presented uses the DriveWindow program. (For information on the functions of the DriveWindow, see its on-line help.) However, parameter settings can also be given via the Control Panel. To display references without Data Logger, connect and scale the analogue output to an oscilloscope.

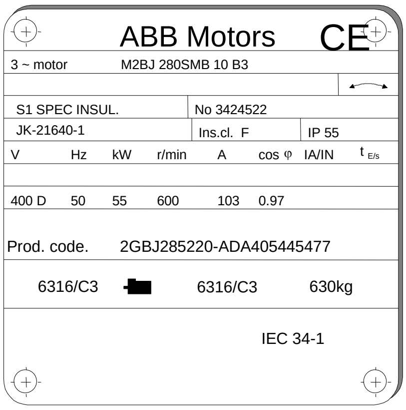
The start-up procedure includes actions that need only be taken when powering up the drive for the first time in a new installation (e.g. entering the motor data). After the start-up, the drive can be powered up without using these start-up functions again. The start-up procedure can be repeated later if the start-up data needs to be altered.

Refer to the Chapter 7 - Fault Tracing if problems should arise. In case of a major problem, disconnect mains power and wait for 5 minutes before working on the unit, the machine, or the motor cable.

START-UP PROCEDURE

⚠	**Follow the safety instructions during the start-up procedure.** **The start-up procedure should only be carried out by a qualified electrician.**
☐	Check the installation. See the installation checklist in the appropriate hardware or installation manual.
☐	Connect optical cables temporarily between the RDCO board channel CH3 and the DDCS communication (NISA or PCMCIA) card in the PC. When using a PCMCIA board, follow the instructions included in the DriveWindow kit.
☐	Disconnect the overriding system link from channel CH0 of the RDCO board (if applicable).
1.	***POWER-UP***
☐	Power up the drive.
☐	Start the DriveWindow program.
☐	Switch the DriveWindow program into Local control mode.

START-UP PROCEDURE

2.	***START-UP DATA***	
2.1	***Entering and Checking Data***	
☐	Open the parameter list.	
☐	Select the language (if available). Reload the parameter and signal list from the Drive menu.	**99.01 LANGUAGE** ______________
☐	Enter the machine data from the motor nameplate into the following parameters (Parameter Group 99): 	**99.05 MOTOR NOM VOLTAGE** Recommendation is to use here permanent magnet nominal back-emf value (*E*) instead of the nominal voltage value (*U*) in the nameplate. This results in more exact operation. $V_{nom} = K_V \times \frac{NOMSPEED}{1000}$ ______________ **99.06 MOTOR NOM CURRENT** ______________ **99.07 MOTOR NOM FREQ** ______________ **99.08 MOTOR NOM SPEED** ______________ **99.09 MOTOR NOM POWER** ______________
☐		The Alarm Message **"ID MAGN REQ"** is displayed.
2.2	***Activating the Optional Modules***	
☐	Activate all optional modules.	**Parameter Group 98** **OPTION MODULES**
2.3	***Checking the I/O Communication***	
☐	Check the possible I/O signal selections.	**Parameter Groups 10…15**

START-UP PROCEDURE

3. MOTOR ID RUN = MOTOR IDENTIFICATION RUN

3.1 Checking the Speed Measurement and Rotation Direction

With a pulse encoder			
↓	**Without a pulse encoder**		
☐		Set the number of pulses per revolution for the encoder.	**50.01 PULSE NR.**
☐		Set to INTERNAL (default value).	**50.06 SPEED FB SEL**
☐		Set to NO POS FB (default value).	**50.16 POSITION FB SEL**
☐		Check the other parameter settings in Parameter Group 50.	Parameter Group 50 **ENCODER MODULE**
☐	☐	Reset and start the motor. The stator resistance and other electrical losses are identified and stored into FPROM memory. The machine shaft is not rotating during the FIRST START.	**DriveWindow Drives Panel** The Alarm Message "**ID MAGN"** is displayed.
☐	☐	The motor stops after the FIRST START has been performed.	The Alarm Message **"ID DONE"** is displayed.
☐	☐	Start the motor again.	**DriveWindow Drives Panel**
☐	☐	Enter a small (e.g. 50 rpm) value for the speed reference.	**DriveWindow Drives Panel**
☐		Check that the machine shaft actually turns to the correct direction and the polarity of the speed measurement is correct.	

START-UP PROCEDURE

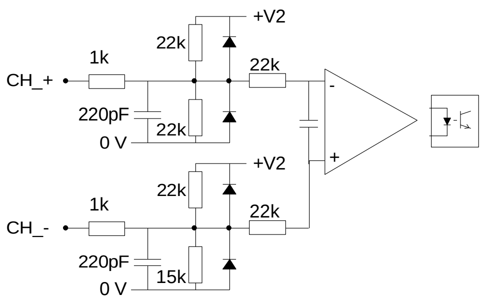
☐

When the motor is rotating in the correct direction and the speed reference is positive, the actual speed in Signal **2.18 SPEED MEASURED** must be positive as well and equal to Signal **2.17 SPEED ESTIMATED**. If this is not the case, the incorrect connection can be located as follows:

- If the direction of rotation is correct and signal **2.18 SPEED MEASURED** is negative, the phasing of the pulse encoder channel wires is reversed.
- If the direction of rotation is incorrect and signal **2.18 SPEED MEASURED** is negative, the motor cables are connected incorrectly.
- If the direction of rotation is incorrect and signal **2.18 SPEED MEASURED** is positive, both the motor and the pulse encoder are connected incorrectly.

Changing the direction:

- Disconnect mains power from the drive, and wait about 5 minutes for the intermediate circuit capacitors to discharge! Be sure that the rotor is not able to move during the action.
  WARNING! Prevention of unexpected start does not disconnect the voltage from the main and auxiliary circuits. Therefore, maintenance work on electrical parts can only be carried out after switching off the mains supply of the drive system. The possible movement of the drive’s shaft has to be eliminated during maintenance work because rotation of the machine induces voltage proportional to speed.
- Complete the necessary changes and verify by applying mains power and starting the motor again.
  Check that the speed actual value is positive.



An input channel connection of the RTAC-01.

☐	☐	Stop the motor.	
☐		Set to ENCODER.	**50.06 SPEED FB SEL**
☐		Set to ENC OR RESOL.	**50.16 POSITION FB SEL**
☐		Start the motor.	

START-UP PROCEDURE

☐		Check that the signals SPEED ESTIMATED and SPEED MEASURED are the same.	**2.17 SPEED ESTIMATED** **2.18 SPEED MEASURED**
☐		Stop the motor.	

3.2 Selecting the Motor ID Run Mode

⚠	**WARNING!** The motor will run at up to 90% of nominal speed during the Motor ID Run. BE SURE THAT IT IS SAFE TO RUN THE MOTOR BEFORE PERFORMING THE MOTOR ID RUN!	
☐	Select the Motor ID Run. During the Motor ID Run, the drive will identify the characteristics of the motor for optimum motor control. The ID Run takes about two minutes depending on ramp times. **Select the *STANDARD OR REDUCE*D ID Run if** • maximum dynamic torque performance and accuracy is required (motor model optimisation). **Select the *FIRST START* ID Run if** • it is a pump or fan application and the motor cannot easily be uncoupled from the driven machine. The Standard Motor ID run can also be performed if the machinery is coupled and there is only inertia but no continuous load. If acceleration up to 90% of nominal speed during the ID run takes longer than 40 seconds, the ID run will fail. **WARNING!** If the Standard ID run is to be performed with the machinery coupled to the motor, make sure the machinery is able to withstand nominal torque step during the ID Run. Otherwise select the Reduced ID Run.	**99.10 MOTOR ID RUN MODE** **1= ID MAGN (FIRST START)** The Motor ID Run is not performed. If the start command has been given, the motor model is calculated by the drive by magnetising the motor for 20 s at zero speed. **2 = STANDARD** Performing the Standard Motor ID Run guarantees the best possible control accuracy. The machine and the driven equipment must be uncoupled for the Standard ID Run. In order to get the best possible control accuracy, PT100 measurement (if in use) should be coupled before Standard ID Run. If the encoder feedback is used, the Standard ID Run is highly recommended. **3 = REDUCED** The Reduced ID Run should be selected (instead of Standard) if mechanical losses are higher than 20% (i.e. the machine cannot be uncoupled from the driven equipment). If the encoder feedback is not used, the Reduced ID Run is adequate in most cases. The Alarm Message **"ID RUN SEL"** is displayed.
⚠	If you select the Standard ID Run, uncouple the driven equipment from the machine!	**99.10 MOTOR ID RUN MODE**
⚠	Check that starting of the machine does not cause any danger!	
☐	Start the motor.	The Alarm Message **"MOTOR STARTS"** is displayed.

START-UP PROCEDURE

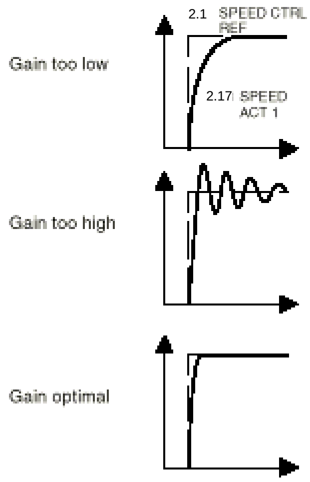
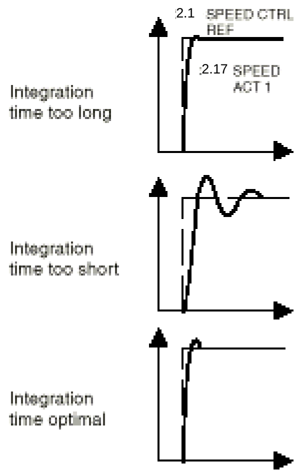
☐	**The motor stops after the ID Run has been performed.** When the ID Run has been successfully performed, **AUX STATUS WORD** signal 3.03 B7 IDENTIF_RUN_DONE is set to 1. Parameter **99.10 MOTOR ID RUN MODE** also changes back to NO. Signal **1.50 ROT INIT ANGLE OK** is set to 1, if pulse encoder is used (zero pulse is used for calibration of the rotor position).	**3.03 ASW Bit 7 = 1** **99.10 = ID MAGN** **1.50 ROT INIT ANGLE OK = TRUE**
⚠	**Note:** If the Motor ID Run has not been successfully performed (for example it does not finish), see chapter *Fault Tracing* in *Firmware Manual for ACS800 Standard Control Program 7.x.*	**FAULT MESSAGE "ID RUN FLT"**

4.	***OPTIMISING THE STARTING TIME AND TORQUE***	
☐	Select the start function. *The fastest starting* is achieved with selection 1 (AUTO, flying start). *The position angle of the rotor's permanent magnet can be located* with DC current with selection 2 (= constant DC magnetising). **Note:** The rotor has to be freely rotatable during constant DC magnetising start mode!	**21.01 START FUNCTION** Start functions are described in detail in *Chapter 4 - Software Description*
☐	Set the limit parameters according to process requirements.	**Parameter Group 20 LIMITS**

START-UP PROCEDURE			
5. MOTOR PROTECTIONS			
5.1 Motor Thermal Model Protection			
☐	Select the motor thermal model protection mode.		**30.05 MOT THERM P MODE**
With USER MODE set according to motor manufacturer data.			
↓	**With DTC mode**		
☐		Select the protection function for the motor thermal model protection. FAULT / WARNING / NO.	**30.04 MOTOR THERM PROT**
☐		Set the time for 63% temperature rise	**30.06 MOTOR THERM TIME**
☐	☐	Set the motor load curve current.	**30.07 MOTOR LOAD CURVE**
☐	☐	Set the zero speed load. Especially with forced cooling of the motor.	**30.08 ZERO SPEED LOAD**
☐	☐	Set the break point value for motor load curve.	**30.09 BREAK POINT**
☐	☐	Set the rated rotor temperature rise.	**30.23 ROT NOM TEMP RISE**
☐	☐	Set the motor temperature rise without load.	**30.24 MOT NOLOAD TEM RIS**
☐	☐	Set the stator to rotor thermal time coefficient.	**30.25 STAT → ROT TEMP TC**

START-UP PROCEDURE		
6.	***TUNING THE SPEED CONTROLLER***	
	When tuning the drive, change one parameter at a time, then monitor the response (possible oscillations) to a speed reference step. To achieve the best possible result, the step response tests should be carried out at different speeds, from minimum speed up to maximum speed.	
	The speed control values obtained depend mainly on: • Flux reference. • The relationship between the motor power and the rotating mass. • Backlashes in the drive mechanical structure (filtering).	
	Note: The Thyristor Supply Unit TSU may have to be set to the normal operation mode for step response tests (signal 10407=0). If the TSU is in the diode bridge mode, an overvoltage alarm may trip the drive section when a stepped change down is given. Extra "jumps" may also appear in the step when the DC voltage rises, because no braking occurs.	
6.1.	***Step Response Test***	
	Automatic Tuning	
	The speed controller includes an automatic speed tuning function Parameter **23.06 AUTOTUNE RUN**. The function is based on an estimate of the mechanical time constant. If this does not bring a satisfactory result, manual tuning can be performed as well.	
	Manual Tuning	
☐	Select, for example, the following signals on the DriveWindow Monitoring Tool: • **1.05 TORQUE**, actual torque • **2.18 SPEED MEASURED**, actual speed	
☐	Start the motor. Increase the speed slightly. Give a speed reference step and monitor the response. Repeat at a few test values across the whole speed range.	**DriveWindow Drives Panel**
☐	Set step changes of 1% or 2% from the maximum speed of the drive for DriveWindow.	
☐	Optimise the P-part of the speed controller. Set the integration time to the maximum value. This turns the PI controller into a P-controller.	**23.02 INTEGRATION TIME**
☐	Give a step change up, e.g. 20 rpm. When the speed is stabilised, give a step change down e.g. 20 rpm.	

START-UP PROCEDURE

☐	Increase the relative gain until the response is sufficient.	**23.01 GAIN** 
☐	Reduce the integral time constant until overshoot is observed in the response. The integral time constant is then adjusted so that there is no overshoot or only a slight overshoot (depending on the drive application). The function of the integral part is to remove the difference caused by the proportional control between the reference and the actual value as quickly as possible.	**23.02 INTEGRATION TIME** 
	If the drive is stable and allows a high proportional gain, the integral time constant can be set short and an overcompensated step response is obtained.	

START-UP PROCEDURE

7.	CONTROLLING THE DRIVE BY USING AN OVERRIDING SYSTEM	
☐	Select the data sets used in the overriding system.	**98.02 COMM MODULE LINK**
☐	Connect the overriding system optic fibres to the channel CH0 of the NAMC board.	
☐	Select the addresses for received and transmitted data according to the application of the overriding system. **Note** the different update intervals. See tables in the *Chapter 4 - Software Description*.	**Parameter Groups** **90…92** **D SET REC ADDR** **D SET TRA ADDR**
☐	Test the functions with received and transmitted data.	
	See the appropriate *Installation and Start-up Guide.* Set up the fieldbus communication with parameters of Group 51.	**Parameter Group 51** **COMM MODULE DATA**

START-UP PROCEDURE		
8.	***CONTROLLING THE DRIVE BY USING THE I/O SIGNALS***	
	The drive can be controlled, instead of an overriding system, by using I/O signals.	
☐	Select the I/O control mode (1=NO). Digital inputs are selected in Group 10 Digital Inputs. To see the analogue selections, see description of Parameter **98.06 AI/O EXT MODULE.** An mA type speed reference signal can be selected with the parameter **11.03 EXT REF1 SEL**.	**98.03 DI/O EXT MODULE 1** **98.04 DI/O EXT MODULE 2** **98.05 DI/O EXT MODULE 3** **98.06 AI/O EXT MODULE**

START-UP PROCEDURE		
9.	***UNDERVOLTAGE CONTROL***	
9.1	***Activating the Undervoltage Control***	
	It is possible to keep the drive running during a short power supply failure (max. 5 seconds) on the following provisions: • The inverter is permitted to run for max. 5 seconds without inverter fans. Please contact an ABB representative for more information.	
☐	Check that the auxiliary control circuit functions correctly during power supply failures.	
☐	Activate the undervoltage controller.	**20.06 UNDERVOLTAGE CTRL**

START-UP PROCEDURE

10.	***AUTO RESTART FUNCTION***	
10.1	***Activating the AUTO RESTART Function***	
	It is possible to restart the drive automatically after a short power supply failure by using the AUTO RESTART function.	
☐	Activate the AUTO RESTART function if required. It is possible to restart the drive after a short power supply failure (max. 5 seconds) on the following provisions: • The inverter is permitted to run for max. 5 seconds without inverter fans.	**PARAMETER GROUP 31** **AUTOMATIC RESET**

Chapter 4 - Software Description

Drive Functions

This chapter presents the functions of the PMSM Drive Application Program, which differ from the Standard Control Program functions described in *Firmware Manual for ACS800 Standard Control Program 7.x* (Code: 3AFE64527592 [English]).

Main Differences between the Standard Application Program and the PMSM Drive Application Program

PMSM drive is based on the Direct Torque Control method (DTC) which is described in *Firmware Manual for ACS800 Standard Control Program 7.x.*

Differences:

- Scalar control selection is not available. DTC is the only control mode in PMSM drive.
- Multimotor drives are not allowed. Only one permanent magnet synchronous machine can be connected to the inverter.
- Only two start functions, AUTO and CNST DCMAGN, are available (**21.01 START FUNCTION**) (DCMAGN start mode has no physical base in the PMSM drive control due to rotor's permanent magnetisation).
- Because of permanent magnetisation, the PMSM drive has a limitation for maximum speed other than the maximum output frequency of the inverter (**20.02 MAXIMUM SPEED** and **20.01 MINIMUM SPEED**). In the field weakening the permanent magnet flux linkage is weakened by stator current. If stator current would be removed by a coast stop command or a trip, the back-emf of the permanent magnets could damage the inverter intermediate circuit and the power switches. This is why the machine absolute speed limits are defined so that no more than $1.4U_{DC,nom}$ voltage is rectified to the intermediate circuit by the permanent magnets. In case of an active load (e.g. wind turbine), the load should be equipped with a braking mechanism preventing the speed limit exceeding, or with an auxiliary device that protects the intermediate circuit (e.g. brake resistor). The absolute maximum frequency for the inverter is 400 Hz.

Calculation Example of the Frequency Limits

Inverter output frequency limit f_{limit} is calculated by the software as follows:

$$f_{limit} = (f_{nom,mot} / E_{nom,mot}) 1.4 U_{inv,nom},$$

where $f_{nom,mot}$ is machine nominal frequency, $E_{nom,mot}$ is machine nominal open circuit voltage (back-emf as idling generator) and $U_{inv,nom}$ is inverter nominal voltage.

Example: If the machine nominal open circuit voltage is 350 V, machine nominal frequency 50 Hz and inverter nominal voltage 415 V, the inverter output frequency limit is 83 Hz. If the machine has two polepairs the frequency corresponds to 2490 rpm.

Note: When the drive is far in field weakening above the frequency limit and the back-emf of the permanent magnets is dangerously high, only the following 'fatal' faults are allowed to cause an immediate tripping of the drive: These fatal faults are considered to be:

- PPCC fault (**3.06 FW_2 bit 11**)
- overcurrent (**3.05 FW_1 bit 1**)
- short circuit (**3.05 FW_1 bit 0**)
- overflow (**3.05 FW_1 bit 7**)

If some other fault, e.g. motor overtemperature, is active, the drive is forced to a ramp stop until the speed is within safe limits (< f_{limit}), after which a normal fault handling is made. While the frequency is above the limit f_{limit}, the alarm message **"HIGH FREQ"** is displayed.

Start Functions

In AUTO start (**21.01 START FUNCTION**) the direction and frequency of permanent magnet flux are identified by currents measured during short-circuit switchings, and the machine is started directly if the machine is found to be rotating (flying start). If the detected current is below the flying start current limitation (**21.11 FLYSTART CURR LIM**), the machine is concluded to be standing still. If the rotor position is received from a pulse encoder measurement, flying start routine is applied to a standstill machine, too. In a case of unknown rotor position, position location function is used to identify the rotor position by transient inductance measurements. After that, flying start is made. If AUTO start function cannot be used due to the machine structure (e.g. non-salient-pole machine) a CNST DCMAGN start mode can be applied.

In CNST DCMAGN start, the PMSM is not DC magnetised if the rotor is found to be rotating. DC magnetisation of a rotating synchronous machine produces pulsating torque and can damage the mechanics. In case of a rotating machine, the flying start routine is used for starting. If the machine is standing still, a position location function is used to identify the unknown rotor position. After position location, the machine is DC magnetised to the identified direction for a constant time (**21.02 CONST MAGN TIME**) to verify the position and then started. If the position location method does not work properly, the machine shaft must be freely rotatable by the DC magnetisation to get the right initial position when starting.

Flux Optimization

Flux optimization (**26.01 FLUX OPTIMIZATION**) in the PMSM drive is done by minimising stator current. The minimum stator current is achieved with greater stator magnetic flux than the permanent magnet flux (i.e. $\psi_S > \psi_{PM}$), whereas the total losses of the machine are not minimised at the point of minimum stator current due to increased iron losses caused by increased flux. Because exact estimation of iron losses is difficult, the optimal flux reference is assumed to be the one that gives the minimum stator current.

The optimal flux reference is calculated internally by the software. If the **26.01 FLUX OPTIMIZATION** is enabled, calculation of optimal flux overrides the flux reference given by the user. Active field weakening control overrides the flux optimisation. By default the flux optimization is not enabled.

Chapter 5 - Signals and Parameters

Overview

This chapter describes signals and parameters which are supplemented or removed from the signal and parameter list in *Firmware Manual for ACS800 Standard Control Program 7.x* (Code: 3AFE64527592 [English]). Also the changes in parameter values are presented.

Added Signals and Fault Words

1	Group name:	*ACTUAL SIGNALS*			
	Description:	Measured or calculated values			
46 Index		**ROTOR TEMP EST**			
	Description:	Estimated rotor temperature.			
unit: °C	type: R	Min:	Max:	Integer scaling: 1 == 1°C	
47 Index		**MOTOR LOAD ANGLE**			
	Description:	Calculated load angle of the machine, i.e. the angle between the rotor permanent magnetisation direction and the stator magnetic flux direction. This angle is limited between -90…90 deg by a machine pull-out prevention function. 90 deg corresponds to maximum output torque of the machine.			
unit: deg	type: R	Min: -360	Max: 360	Integer scaling: 100 == 1 deg	
48 Index		**MOT COS(PHI) ACT**			
	Description:	Calculated power factor of the machine.			
unit:	type: R	Min: 0	Max: 1.0	Integer scaling: 100 == 1.0	
49 Index		**ROT POS MEASURED**			
	Description:	Measured mechanical angle between the stator A-phase magnetisation direction and the rotor permanent magnetisation direction.			
unit: deg	type: R	Min: 0	Max: 360	Integer scaling: 65536 == 360 deg	
50 Index		**ROT INIT ANGLE OK**			
	Description:	When pulse encoder is used this parameter indicates if rotor initial angle has been initialised and operating properly. Parameter is ineffective in case of encoderless control. 0 = **FALSE** 1 = **TRUE**			
unit:	type: B	Min: 0	Max: 1	Integer scaling: 1 == 1 unit:	
51 Index		**MEAS POS ERR EST**			
	Description:	Difference between the measured and the estimated rotor electrical angle. This signal is forced to zero when position feedback is used in control.			
unit: deg	type: R	Min:	Max:	Integer scaling: 360 deg == 32768	
Def:		r	DYN	Address: r_angle_diff	
52 Index		**ZERO PLS REJECTED**			
	Description:	Counter for rejected zero pulses. When a zero pulse is detected at unexpected position it is assumed to be triggered by noise and rejected. The next zero pulse is taken as a reference.			
unit:	type: R	Min: 0	Max: 0	Integer scaling: 1 == 1	
Def: 0		r/w	DYN	Address: n_zero_pls_rejected	

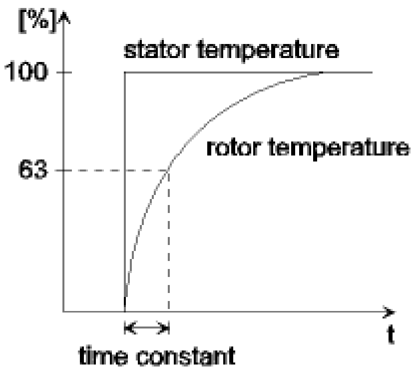
3	Group name:	*FAULT WORDS*			
	Description:	Fault signals of the drive.			
31		**ALARM WORD PMSM**			
Index	Description:	B0 = **HI PM BACK EMF** Machine speed has exceeded a value where permanent magnet back-emf is dangerously high. B1 = **ENCOD Z MISS** Parameter **50.15 ENCODER ZERO PULS** is set to YES but zero pulse has not been detected during one shaft revolution.			
unit:	type: I	Min: -32768	Max: 32767	Integer scaling:	
32		**FAULT WORD PMSM**			
Index	Description:	B0 = **LOCATE POS** The location of the direction of the permanent magnet flux during start has failed.			
unit:	type: I	Min: -32768	Max: 32767	Integer scaling:	

Parameters

Supplemented

21	Group name:	*START/STOP FUNC*			
	Description:	Start and stop functions.			
01		**START FUNCTION**			
Index	Description:	1 = **AUTO** This setting enables immediate starting of a rotating machine (Flying Start), and immediate starting of a standstill machine after initial position location function. If the rotor position is known from the encoder signal, the machine is started immediately without initial position location. 2 = **CNST DCMAGN** Constant time direct current magnetisation can be used before the actual starting to turn the permanent magnetised rotor to a known position to ensure smooth starting. This setting is recommended if the machine has no saliency or magnetic saturation and thus the initial position location function does not work correctly. In this case, the machine shaft should however be freely rotatable (at worst the shaft turns 180 electrical degrees to either direction during DC magnetisation). The pre-magnetising time is defined by parameter **21.02 CONST MAGN TIME**. If the machine is rotating or if the rotor position is known from the encoder signal, AUTO starting (Flying Start) is executed without DC magnetisation, and the selection is thus ineffective.			
unit:	type: I	Min: 1	Max: 2	Def: 1	Integer scaling:
11		**FLYSTART CURR LIM**			
Index	Description:	Flying start current limitation as percentage of the machine nominal current. If machine current during short circuit switchings is above the limit, flying start is assumed. Otherwise, the machine is concluded to be standing still and the rotor initial position location function is executed. The parameter has no effect when the encoder feedback with zero pulse is used because then flying start is always assumed.			
unit: %	type: R	Min: 0	Max: 200	Def: 1.8%	Integer scaling: 10 == 1%

30	Group name:	*FAULT FUNCTIONS*			
	Description:				
23		**ROT NOM TEMP RISE**			
Index	Description:	Rated rotor temperature rise.			
unit: °C	type: R	Min: 0°C	Max: 300°C	Def: 70°C	Integer scaling: 1 == 1°C

24		**MOT NOLOAD TEM RIS**			
Index	Description:	Machine temperature rise without load.			
unit: °C	type: R	Min: 0°C	Max: 300°C	Def: 20°C	Integer scaling: 1 == 1°C
25		**STAT → ROT TEMP TC**			
Index	Description:	Stator to rotor thermal time coefficient. As the stator temperature changes, 63% of the change takes place in the rotor temperature within the time specified by this parameter. 			
unit: s	type: R	Min: 16 s	Max: 9999 s	Def: 16 s	Integer scaling: 1 == 1s
26		**TRIP CURRENT**			
Index	Description:	Current limit defined by user. User can set the trip current limit lower than the maximum inverter trip current e.g. to protect the motor.			
unit: A	type: R	Min:	Max:	Def:	Integer scaling:
27		**ROT NOM TEMP RISE**			
Index	Description:	Rated rotor temperature rise.			
unit: °C	type: R	Min: 0 °C	Max: 300 °C	Def: 70 °C	Integer scaling: 1 == 1 °C

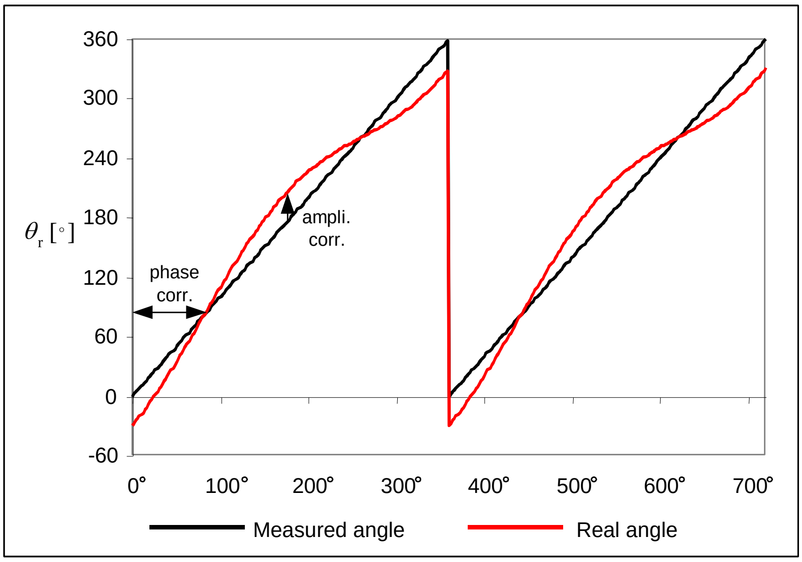
<table>
<tr><td>50</td><td>Group name:</td><td colspan="4">ENCODER MODULE</td></tr>
<tr><td>02
Index</td><td></td><td colspan="4">SPEED MEAS MODE</td></tr>
<tr><td></td><td>Description:</td><td colspan="4">Selects the measurement type for the pulse encoder mode.
0 = A_-B DIR Positive edges for speed; channel B: direction.
1 = A_-_ Note: This selection is not available in PMSM drive.
2 = A_-_B DIR Positive and negative edges for speed; channel B: direction.
3 = A_-_B_-_ Channels A and B: positive and negative edges for speed and direction.</td></tr>
<tr><td>unit:</td><td>type: I</td><td>Min: 0</td><td>Max: 3</td><td>Def: 3</td><td>Integer scaling:</td></tr>
<tr><td>15
Index</td><td></td><td colspan="4">ENCODER ZERO PULS</td></tr>
<tr><td></td><td>Description:</td><td colspan="4">This setting enables encoder zero pulse reading by RTAC-01 incremental encoder interfaces to get rotor’s absolute position information for flux and torque estimation of a PMSM. It is recommended to use encoder zero pulse if it is available. If the encoder has no zero pulse, this setting should be set to NO. Otherwise, alarm text ENCOD Z MISS will be displayed after one complete shaft revolution.
0 = NO
1 = YES

WARNING! If encoder is replaced or temporarily removed from the shaft or if the phase order of the machine has been changed, position of the encoder zero pulse changes in respect of the magnetising direction of rotor permanent magnets. This leads to incorrect operation of the machine as torque and magnetic flux are estimated incorrectly. Encoder absolute position calculation must then be re-initialised either by setting 50.17 INIT POSITION FB = YES and starting the drive from standstill, or by performing the Motor ID Run. At worst, incorrectly initialised rotor position feedback may lead to unstable torque control and machine rushing!</td></tr>
<tr><td>unit:</td><td>type: B</td><td>Min: 0</td><td>Max: 1</td><td>Def: YES</td><td>Integer scaling: 1 == 1</td></tr>
<tr><td>16
Index</td><td></td><td colspan="4">POSITION FB SEL</td></tr>
<tr><td></td><td>Description:</td><td colspan="4">Selection 1 disables use of encoder position feedback for flux and torque estimation. Position feedback is disabled automatically if the encoder feedback signal is not available or not functioning properly.
0 = ENCODER
1 = NO ENC FB</td></tr>
<tr><td>unit:</td><td>type: B</td><td>Min: 0</td><td>Max: 1</td><td>Def: NO POS FB</td><td>Integer scaling: 1 == 1</td></tr>
<tr><td>17
Index</td><td></td><td colspan="4">INIT POSITION FB</td></tr>
<tr><td></td><td>Description:</td><td colspan="4">Initialisation of absolute position feedback calculation. Enables forced rotor zero angle positioning in the next start from standstill after Start Command during the start proceedings. Parameter is effective only when encoder position feedback is used and the machine is not running. Initialisation of the absolute position feedback is needed when the encoder zero pulse is used and the encoder has been replaced or temporarily removed from machine shaft or when the phase order of the motor cables has been changed. Rotor position feedback is always initialised during the Motor First Start and the Motor ID Run, so separate setting of this parameter in those cases is not needed. Parameter value is automatically set to NO after starting and power-up.
0 = NO
1 = YES</td></tr>
<tr><td>unit:</td><td>type: B</td><td>Min: 0</td><td>Max: 1</td><td>Def: NO</td><td>Integer scaling: 1 == 1</td></tr>
<tr><td>18
Index</td><td></td><td colspan="4">EXT POS FB INIT</td></tr>
<tr><td></td><td>Description:</td><td colspan="4">Absolute position feedback calculation can be initialised from an external absolute encoder via application interface using parameters 50.19 EXT ROT POSITION and 50.20 EXT ZERO POSITION. This function requires external absolute encoder and communication interface.
0 = NO
1 = YES

WARNING! Incorrect initial value for rotor position may lead to unstable torque control and machine rushing.</td></tr>
<tr><td>unit:</td><td>type: B</td><td>Min: 0</td><td>Max: 1</td><td>Def: NO</td><td>Integer scaling: 1 == 1</td></tr>
</table>

50	Group name:	*ENCODER MODULE*					
19		**EXT ROT POSITION**					
Index	Description:	Rotor shaft position coming from an external absolute encoder. Position is scaled as a 16-bit integer value, i.e. 65536 corresponds to one shaft revolution from a zero position. Absolute position feedback information can be initialised externally using this parameter when **50.18 EXT POS FB INIT** is set to YES. Value must be non-zero, otherwise position feedback is not initialised by this parameter. See also **50.20 EXT ZERO POSITION**.					
unit:		type: PB	Min: 0	Max: 65535	Def: 0	Integer scaling: 1 == 1	
20		**EXT ZERO POSITION**					
Index	Description:	Offset in measured initial position **50.19 EXT ROT POSITION** coming from external absolute encoder via application interface. Parameter 50.20 should be set equal to **50.19 EXT ROT POSITION** when the angle between the stator A-phase magnetising direction and the rotor permanent magnetising direction is zero (i.e. the rotor is in zero position). Value is a 16-bit integer, 65536 corresponds to one shaft revolution.					
unit:		type: PB	Min: 0	Max: 65535	Def:	Integer scaling: 1 == 1	
21		**RESOLVER POS FB**					
Index	Description:	This parameter is locked and should normally not be changed by the user. It will be set automatically to YES if resolver module is selected by parameter **98.01 ENCODER MODULE**. Parameter **50.16 POSITION FB SEL** overrides this parameter, i.e. position feedback is not used for motor control if 50.16 is set to NO POS FB. 0 = NO Resolver feedback not used. 1 = YES Resolver feedback is used. Resolver adapter is selected by 98.01.					
unit:		type: B	Min: 0	Max: 1	Def: NO	Integer scaling:	
24		**RESOLV POLE PAIRS**					
Index	Description:	Number of resolver pole pairs. The number of machine pole pairs divided by the resolver pole pairs must be an integer number. For example [machine pole pairs] / [resolver polepairs] = 10/2 = 5 is suitable, but 3 pole pair resolver is not, since 10/3 = 3.33 is not an integer number and the direction of the permanent magnet cannot be calculated explicitly. Same rule applies also to situation where the machine shaft and the resolver are connected mechanically by a toothed belt or by cogwheels with ratio unequal to one: resolver electrical speed must be a factor of machine electrical speed.					
unit:		type: R	Min: 1	Max: 16	Def: 1	Integer scaling: 1==1	

50	Group name:	*ENCODER MODULE*
25		**RESOLV PHASE CORR**
Index	Description:	Resolver position error phase. Error in the rotor position measured by a resolver can be compensated with this parameter together with the parameter **50.26 RESOLV AMPLI CORR**. The error changes sinusoidally as a function of the resolver electrical angle, and the error phase shift and the amplitude remain constant.



Tuning hint: monitor speed error signal and motor current while the drive is running slowly at a constant speed (for example 50 rpm). If there is a clear variation in these signals at resolver rotation frequency (= mechanical frequency multiplied with the resolver pole pair number), the compensation parameters need tuning. Set some small correction amplitude, for example **50.26 RESOLV AMPLI CORR** = 2°, and then try different phases in **50.25 RESOLV PHASE CORR** for example with 10° steps from 0 … 360°. In **50.25 RESOLV PHASE CORR** set the value that gives minimum variation in speed and current. Then fine tune the correction amplitude **50.26 RESOLV AMPLI CORR** to remove as much of speed and current variation as possible.

unit: deg	type: R	Min: -360 deg	Max: 360 deg	Def: 0	Integer scaling: 32768 == 360°

26		**RESOLV AMPLI CORR**
Index	Description:	Resolver position error magnitude. See the description of parameter **50.25 RESOLV PHASE CORR**.

unit: deg	type: R	Min: -5 deg	Max: 5 deg	Def: 0	Integer scaling: 32768 == 360°

27		**ENC GEAR RATIO**
Index	Description:	Gear ratio [encoder rotation speed] : [motor rotation speed]. This information is needed when an encoder with a gear ratio unequal to one and zero channel pulse is used to prevent zero pulse rejection as otherwise it would come at unexpected position. See also parameter **1.52 ZERO PLS REJECTED**.

unit:	type: R	Min: 1	Max: 100	Def: 1	Integer scaling: 1 == 1
		r/w		Address: enc_gear_ratio	

Changes to Parameter Values

21	Group name:	*START / STOP*			
	Description:	Start and stop functions.			
02 Index		**CONST MAGN TIME** (default value changed to 2000ms)			
	Description:	Defines the magnetising time in the constant magnetising mode. See parameter 21.01. After the start command, the drive automatically premagnetises the motor the set time.			
unit: ms	type: R	Min: 30	Max: 10000	Def: 2000	Integer scaling: 1==1

98	Group name:	*OPTION MODULES*			
	Description:	Activation of the option modules.			
01 Index		**ENCODER MODULE**			
	Description:	Pulse encoder or resolver module interface selection. The module is connected into the position marked Slot 1 or Slot 2 on the RMIO board or alternatively onto external I/O Module Adapter (AIMA-01) with DDCS communication module. Setting the node ID is not required when the module is mounted into Slot 1 or Slot 2 on the RMIO board. 0 = **NTAC** Pulse encoder module interface activated. 1 = **NO** Pulse encoder module interface **not** activated. 2 = **RTAC-SLOT1** Pulse encoder module connected into Slot 1 on the RMIO board. 3 = **RTAC-SLOT2** Pulse encoder module connected into Slot 2 on the RMIO board. 4 = **RTAC-DDCS** Pulse encoder module connected with DDCS communication module onto external I/O Module Adapter. 5 = **RRIA-SLOT1** Resolver module connected into Slot 1 on the RMIO board. 6 = **RRIA-SLOT2** Resolver module connected into Slot 2 on the RMIO board. 7 = **RRIA-DDCS** Resolver module connected with DDCS communication module onto external I/O Module Adapter. 8 = **RRIA-S2+NTAC** Resolver module connected into Slot 2 and pulse encoder module NTAC-02 with DDCS communication. 9 = **RRIA-DD+NTAC** Resolver module connected with DDCS communication onto external I/O Module Adapter and pulse encoder module NTAC-02 with DDCS communication. 10 = **RTACS1+RRIS2** Encoder module RTAC-01 is connected into Slot 1 and resolver module RRIA-01 into Slot 2 on the RMIO board. 11 = **FEN11 ABS** EnDat type absolute encoder is connected to an FEN-11 Absolute Encoder Interface. The FEN-11 is connected to an FEA-01C extension module, which in turn is connected to channel CH1 of the RMIO board with fibre optic cable. The control program supports only the reading of position and speed information from an EnDat absolute encoder. The TTL encoder input and emulation output of the FEN-11 are not supported. For more information on the FEN-11 absolute encoder interface, see *FEN-11 Absolute Encoder Interface User's Manual* (3AFE68784841 [English]).			
unit:	type: I	Min: 0	Max: 10	Def: 1	Integer scaling:

99	Group name:	*START-UP DATA*			
	Description:	Parameters for setting up the motor information.			
04		**MOTOR CTRL MODE**			
Index	Description:	Motor control mode selection. 0 = **DTC** Direct Torque Control mode. 1 = **SCALAR. Note:** This selection is not available in PMSM Standard Application software			
unit: V	type: B	Min: 0	Max: 1	Def: DTC	Integer scaling:
05		**MOTOR NOM VOLTAGE**			
Index	Description:	Back-electromotive force (or open-circuit voltage) created by the permanent magnets, when the PMSM is idle running at nominal speed. Depending on the machine manufacturer, this value may be the same as the machine nominal voltage *U* in the rating plate, or marked separately e.g. as *E* or *E0*. It is not possible to start the ACS800 PMSM drive without setting this parameter. **Note:** It is not allowed to connect a machine with nominal back-emf less than 1/2 * UN or more than 2 * UN of the ACS800.			
unit: V	type: R	Min: 207	Max: 830	Def: 0 V	Integer scaling: 1 == 1V

Removed AMC Table Signals and Parameters

Group 21	**START/STOP FUNCTIONS**
21.04	DC HOLD
21.05	DC HOLD SPEED
21.06	DC HOLD CURRENT
21.08	SCALAR FLY START

Chapter 6 - Service and Maintenance

Overview

This chapter describes PMSM drive specific service and maintenance actions.

Induced Back-Voltage in a PMSM

If a permanent magnet synchronous machine is rotated by an active load or if it is free-wheeling along with inertial mass, it induces back-voltage proportional to speed to the motor terminals and thus also to inverter and intermediate circuit and to auxiliary equipment connected to these.

Note: Follow the safety instructions on the first pages of this manual.

WARNING! Disconnect the motor terminals from inverter (safety switch (see section *Permanent Magnet Synchronous Machine Drive* in chapter *Safety*)) or ensure that an active load cannot rotate the machine shaft and that the machine is not free-wheeling before doing any maintenance work on the converter.

Pulse Encoder Replacement or Motor Cable Order Change

In a PMSM drive pulse encoder feedback is not used only to get the speed feedback signal but also the rotor position feedback signal. Use of position feedback enables best possible torque accuracy and stability also at zero speed. For reliable and accurate position feedback, the pulse encoder zero channel pulse should be connected and used to achieve absolute information of the rotor permanent magnet flux orientation.

WARNING! If the pulse encoder is replaced or disconnected during maintenance work or if the order of the motor phase cables is changed, the encoder zero pulse position changes with respect to the rotor permanent magnet orientation. This can lead to unstable torque control and machine rushing and cause damage to the drive hardware. Once the pulse encoder is re-installed to the machine shaft, the encoder feedback zero position must be relocated according to the following instructions.

Position Feedback Initialisation

Position feedback signal is initialised automatically in the First Start and in the Motor ID Run if the encoder is connected properly. However, the machine shaft must be freely rotatable during the Reduced and Standard Motor ID Run. If this is not possible, the position feedback can also be initialised without Motor ID Run according to the following checklist (though torque accuracy can be poorer than after the Standard Motor ID Run):

1. Install the pulse encoder to the machine shaft (if not already installed).
2. Set **98.01 ENCODER MODULE** to **YES** (if not already selected).
3. Set **50.01 ENCODER PULSE NR** to correct value.
4. Set **50.06 SPEED FB SEL** to **ENCODER**.
5. Set **50.16 POSITION FB SEL** to **ENCODER**.
6. Set **50.17 INIT POSITION FB** to **YES** or if possible set **99.10 MOTOR ID RUN** to **STANDARD** (or **REDUCED**).
7. Start the drive from standstill. According to the selection, the position initialisation is made either during the start proceedings or during the Motor ID Run. Check that the rotation and speed measurement directions are correct (see *Chapter 3 - Start-up*). Run the drive at least one revolution so that at least one encoder zero pulse is received, and the position feedback initialisation is ready.

Note: Repeat the position feedback initialisation every time the encoder is re-installed to the shaft or when the motor cable order is changed. If the pulse encoder A and B channels need to be changed (due to wrong measurement direction), position feedback must be initialised again after that.

Chapter 7 - Fault Tracing

Overview

This chapter describes the fault tracing of the PMSM drive. Only the PMSM specific fault and alarm messages are presented. The other fault and alarm messages are described in *Firmware Manual for ACS800 Standard Control Program 7.x* (Code: 3AFE64527592 [English]).

Fault and Alarm Messages

Fault Message Table

FAULT MESSAGES		
Alarm/Fault Text	**Cause**	**What to do**
POSIT LOCATE 3.32 FW_PMSM, bit 0	Rotor permanent magnet position location during start has failed.	Start the drive again. If the fault keeps appearing, try CNST DCMAGN start mode (**21.01 START FUNCTION**) or/and change the value of **21.11 FLYSTART CURR LIM**.

Alarm Message Table

ALARM MESSAGES		
Alarm Message	**Cause**	**What to do**
HIGH FREQ 3.31 AW_PMSM, bit 0	Machine speed has exceeded a value where permanent magnet back-emf is dangerously high.	Decrease the value of the speed limits (**20.01 MINIMUM SPEED** and **20.02 MAXIMUM SPEED**) so that maximum speed reference does not cause alarm. If there is an active load, machine speed can accelerate so that alarm message is displayed even if the maximum speed limit is under the alarm limit. If alarm message is displayed the drive is in a dangerous area where fault situation may cause inverter breakdown (see *Chapter 3 - Start-up*).
ENCOD Z MISS 3.31 AW_PMSM, bit 1	Encoder zero pulse is chosen (**50.15 ENCODER ZERO PULS**) but zero pulse has not been detected during one shaft revolution.	Check the wiring of the zero pulse. If encoder's zero pulse isn't available, set **50.15 ENCODER ZERO PULS** = NO. Check that **50.04 ENCODER PULSE NR** is set correctly. After these proceedings rotor angle initialisation has to be done by setting parameter **50.17 INIT POSITION FB** to YES or by performing the Motor ID Run.

Problems Concerning Encoder Initialisation

After phase order change of the motor cables or the encoder wires, or after encoder replacement or temporary removal from the shaft, the absolute position calculation needed for the torque and magnetic flux estimation must be re-initialised. Otherwise torque estimation works incorrectly, and the drive may behave unexpectedly, e.g. taking more current than usual, jamming to zero speed or in the worst case leading to unstable torque control and machine rushing. For re-initialising of encoder position feedback, see *Chapter 6 - Service and Maintenance*.

Chapter 8 - Terms

Terms	Full Name	Description
ACU	Auxiliary Control Unit	
CDP 312	Common Drives Panel 312	Control Panel is used to parameterise and monitor drive using Modbus-protocol.
DriveWindow		PC tool for operating, controlling, parametrising and monitoring ABB drives.
emf	Electromotive Force	Voltage created by rotating permanent magnets between the motor terminals. This voltage is of opposite direction compared to inverter output voltage, thus the term 'back-emf' is commonly used.
MCW	Main Control Word	
PMSM	Permanent Magnet Synchronous Machine	Synchronous AC machine where rotor excitation is created by permanent magnets.

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