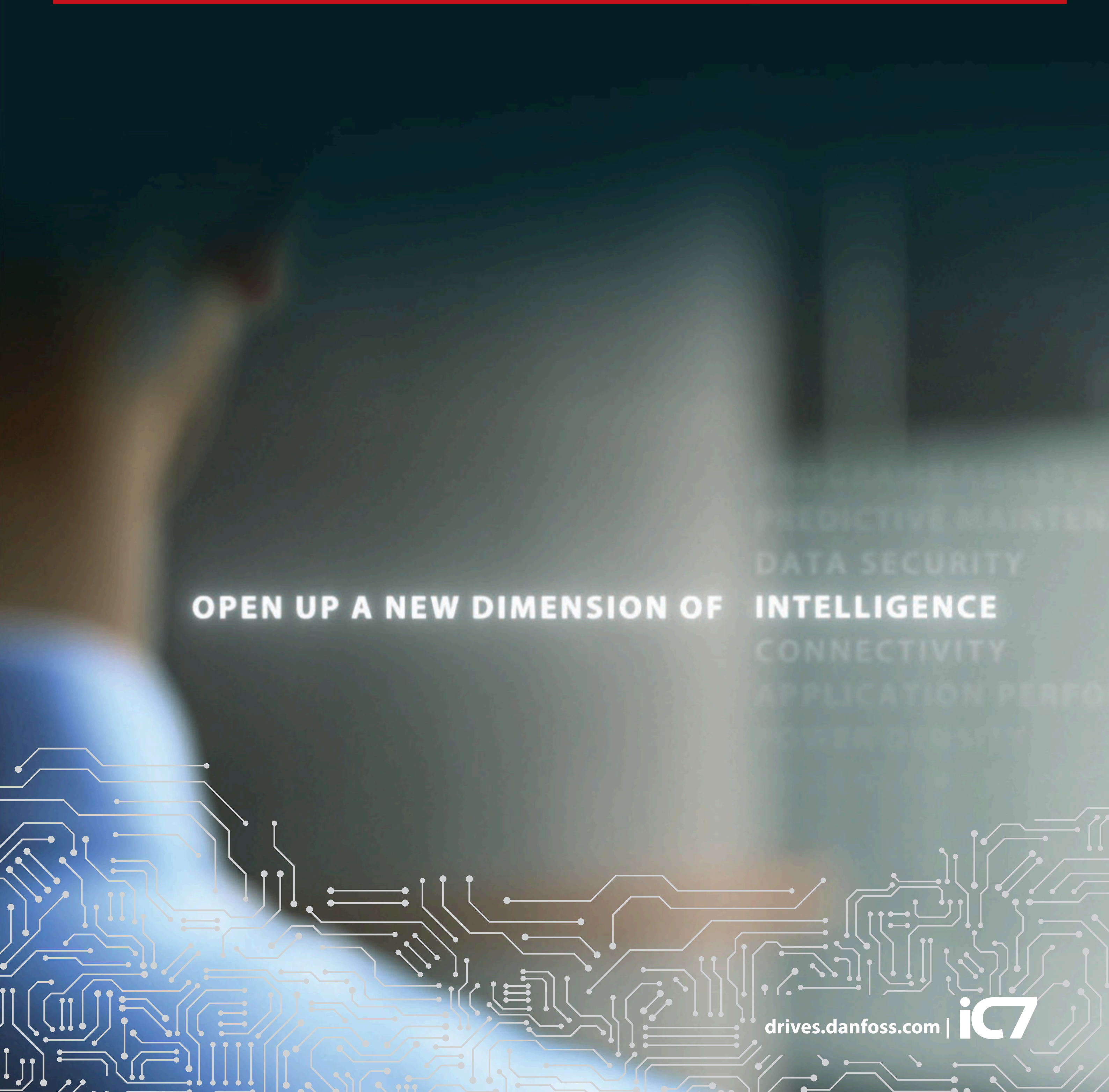
ENGINEERING TOMORROW

Application Guide

Simulation with Virtual iC7 Industry Application

MyDrive® Virtual



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Contents

1 Introduction

1.1 Purpose of the Guide

This application guide provides information on using simulation models to assess the performance of iC7 drives in an application and is intended for qualified personnel such as automation engineers and system designers who have experience in designing application systems. The intended audience of this guide is expected to be familiar with simulation tools and simulation models based on the FMI standard. The simulation tool shown in the examples in this guide is Simulink.

Instructions for using the different simulation tools are not in the scope of this guide. Refer to the documentation of the simulation tool in use for the instructions.

1.2 Version History

This guide is regularly reviewed and updated. All suggestions for improvement are welcome.

The original language of this guide is English.

Table 1: Version History

Version	Remarks
AB436544831461, version 0301	The information in this version is based on application software version 4.0.7 and firmware version 5.0.8.
AB436544831461, version 0201	The information in this version is based on application software version 3.2.4 and firmware version 4.0.7.
AB436544831461, version 0101	First version. The information in this guide is based on application software version 2.1.8 and firmware version 2.2.1.

2 Overview of MyDrive® Virtual

2.1 Simulation Models for Motor Applications

Danfoss offers different MyDrive® Virtual models depending on the application software and simulation use case.

4 different model scopes are available for motor control applications:

- Application model
- Drive model
- Drive-train model
- Drive system model

The number of parts included in the model scopes vary and the choice of the model depends on the simulation use case.

Table 2: Elements of Simulation Model Scopes

Simulation model	Application software	Control firmware	Converter model	Machine models	Load models
Application	x	–	–	–	–
Drive	x	x	x	–	–
Drive-train	x	x	x	x	–
Drive system	x	x	x	x	x

Application model

The application model contains the complete application software. A basic plant model is added to cover the basic functionality of the drive, such as starting and stopping the drive and configuring ramp behavior. The parameter menu of the application is also available as part of the application software. The drive can be controlled through I/O and fieldbus.

Drive model

The drive model simulates the complete iC7 drive containing application software, firmware, and a model of the drive hardware. As the drive model contains the complete drive software, full functionality is available, including the full drive parameter menu which can be accessed in the FMU parameter menu.

The ***DriveSize*** parameter menu can be used to select the drive size from a list that is modeled in the drive hardware.

Drive-train model

The drive-train model contains the same assets as the drive model and an additional motor model. Certain IM and PM motors can be selected from the ***Motor*** menu to be modeled in the motor hardware plant part. A load model must be connected externally, and external motor speed has to be fed back to the drive-train model.

The drive-train model is recommended if the load behavior of the application is known or exists as a model to simulate drive performance under these conditions.

Drive system model

The drive system model contains the complete drive system: a drive-train model and a model of the motor load.

3 Parameters

3.1 Parameter Overview

Accessing and configuring the parameters depend on the simulation tool that is used to run a MyDrive® Virtual model. The simulation tool used in the examples in this guide is Simulink. Some features may not be available in other simulation tools.

Each MyDrive® Virtual model can be parameterized.

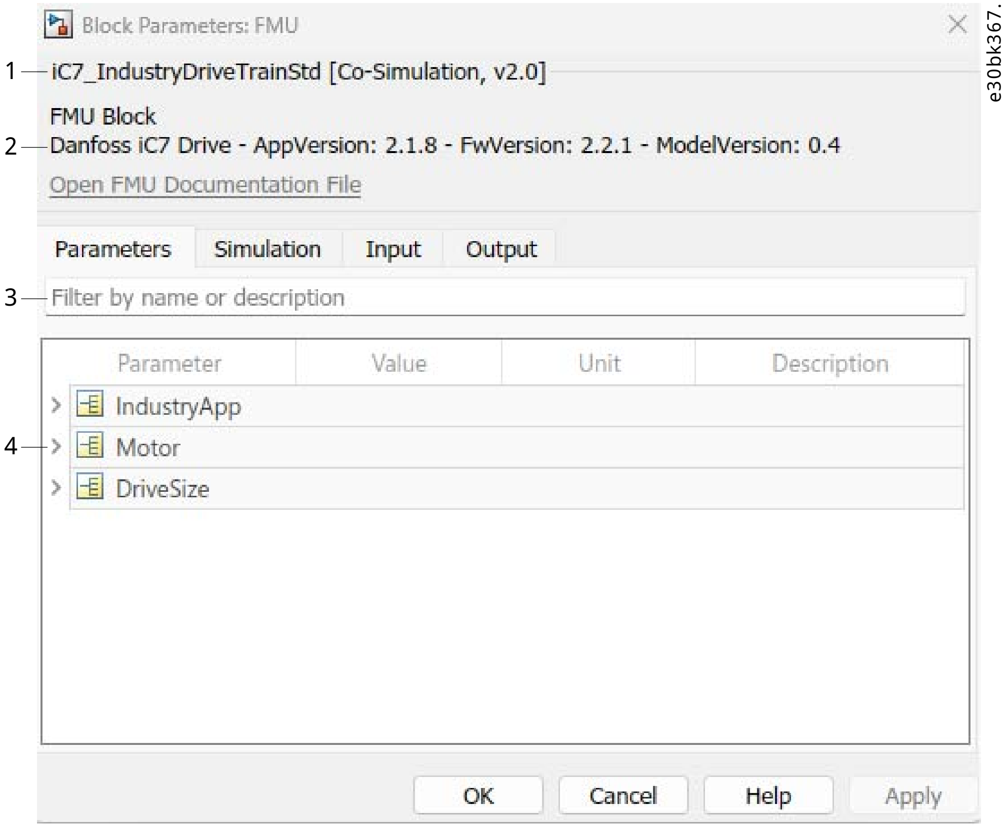


Figure 1: Parameter Menu in Simulink

1	Name of the simulation model	**2**	Software versions included in the simulation model
3	Parameter search The parameter search is not available in all simulation tools.	**4**	Available parameter menus

NOTICE

In Simulink, changing an existing parameter is allowed during the simulation. The value changes immediately.

- Consider if the change during simulation makes sense. For example, changing the motor type during runtime is not a valid use case for simulation.

3.2 Parameter Menus

The parameter menu is split into 2 parts:

- Drive parameter menu

- Hardware configuration menu

The drive parameter menu is used for configuring the drive. The structure of the menu reflects the menu of the iC7 drive, which the simulation model is based on. In this example, the simulation model is for the Industry application software package.

The hardware configuration menu is used for selecting a motor and a specific drive size variant for simulation. The structure and content of the hardware configuration menu depend on the available simulation model and are different for motor and grid applications.

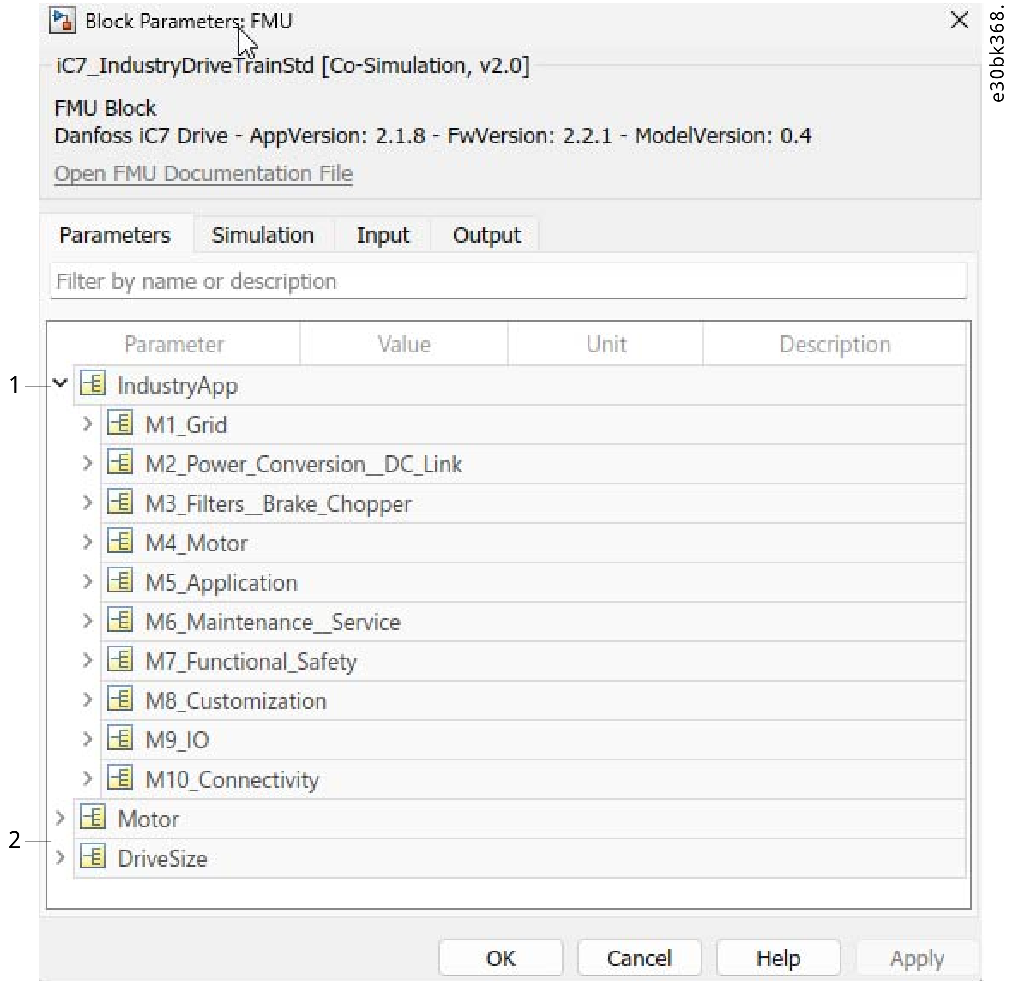


Figure 2: Parameter Main Menus in Simulink

1	Drive parameter configuration menu	**2**	Hardware configuration menu

3.3 Drive Parameter Configuration Menu

Drive parameters included in the application software can be configured. In this example, the default value of parameter ***Motor Control Principle*** is changed from U/f control to VVC+ control by changing the selection from [0] to [1]. The parameter menu includes a help text which provides more information about the purpose of the parameter and what are the available selections for the parameter.

> **IMPORTANT:** Status parameters are not included in the parameter menu.
>
> Because of restrictions in the FMI standard, it is not possible to write back parameter values from the simulation model to the parameter menu. Therefore, readout parameters are not included in the parameter menu, but are removed.

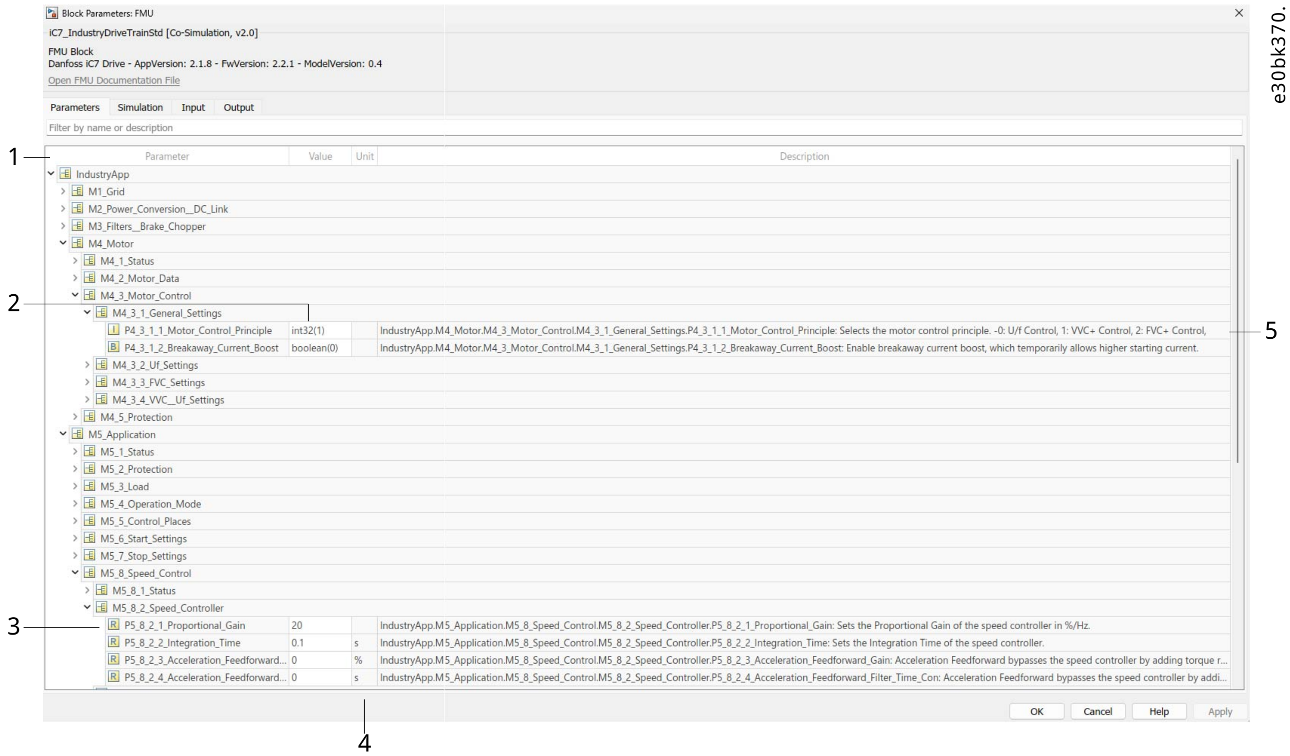


Figure 3: Example of the Drive Parameter Menu in Simulink

1	Title bar In Simulink, it is possible to sort the parameters by clicking the *Parameter* text in the title bar.	**2**	Parameter value
3	Parameter index number	**4**	Unit of parameter value
5	Available selections for parameter value		

For detailed information about parameters, see the relevant application guide.

3.4 Hardware Configuration Menu

In this example, a motor is configured using the hardware configuration parameter menu and the motor plant simulation model.

The Motor Configuration menu can be divided into 2 main groups:

- Customizable motor configurations
- Preconfigured motor configuration setups

The customizable motor configurations support induction and synchronous motors. The customizable configurations are M0 and M1 in Figure 4. Preconfigured motor setups are loaded with the dedicated motor data. In this example, the preconfigured motor data is the OGD motor, which is indicated as M2 in Figure 4.

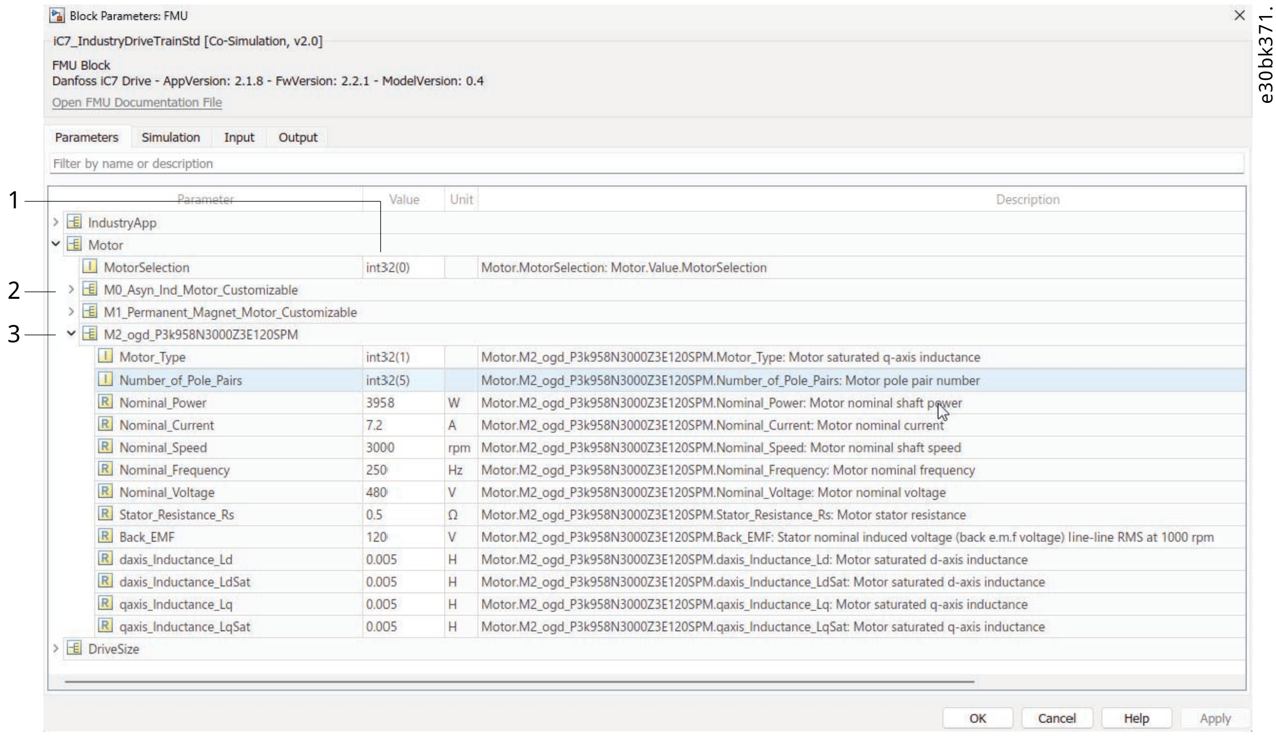


Figure 4: Example of the Hardware Configuration Parameter Menu in Simulink

1	Motor selection value	**2**	Parameter for induction motor configuration
3	Preconfigured OGD motor		

The complete motor setup is visible in the parameters under ***M2_ogd_P3k958N3000Z3E120SPM***. The values come from a motor database and are used to configure the motor plant model inside the simulation model. As with drive parameters, changing the values is allowed, for example to simulate temperature changes of the motor by changing the value of parameter ***Stator Resistance Rs***.

3.5 DriveSize Menu

The drive variant for the simulation is selected in the ***DriveSize*** menu. The number of the drive size is included in the name as a prefix and in the value.

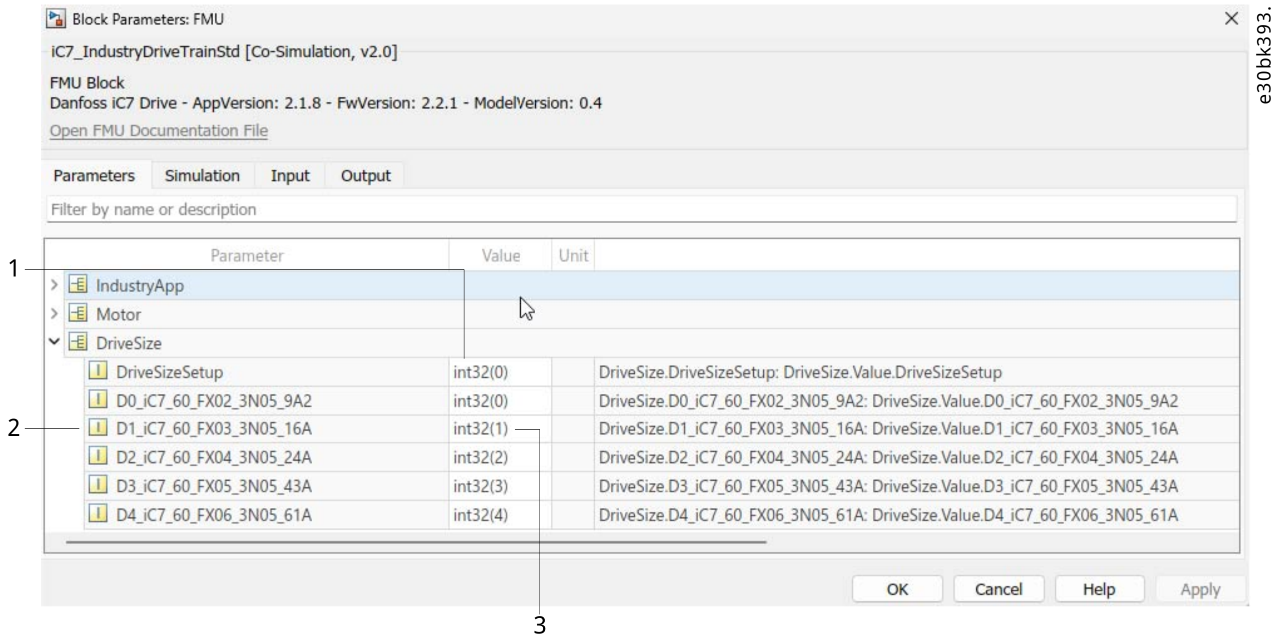


Figure 5: Example of the DriveSize Menu in Simulink

1	Value of the parameter	**2**	Current rating of the drive in the parameter name
3	Current rating of the drive in the parameter value		

For more information on the current ratings of drives, refer to the drive-specific design guides.

4 I/O Interface

4.1 Overview

Each FMU model comes with a collection of inputs and outputs, which fulfill the typical needs when performing simulations. Danfoss has defined a standard I/O interface for each model.

The inputs and outputs are based on the FMI standard and can be 1 of the following data types:

- Integer: 32-bit signed integer, int32
- Real: 64-bit floating point, double
- Boolean: 1-bit boolean, bool

NOTICE

Depending on the simulation tool, using incorrect data types may cause errors.

- Make sure that signals of the correct data types are handed over to MyDrive® Virtual.

The interface descriptions in this guide reflect application software version 4.0.7 and firmware version 5.0.8. For more information about the control and functionality of Industry application software, refer to *iC7 Series Industry Application Guide*.

4.2 Events

Models containing control firmware also simulate event behaviors. Output ***Exception Status*** indicates the occurrence of events during simulation. Exception statuses and event levels are explained in Table 3.

Table 3: Descriptions of Exception Status Values

Exception status value	Event level
1	None
2	Info
3	Warning
4	Fault

The Events.log file created by the MyDrive®Virtual FMU model includes detailed information about events. The log file is stored in the work folder of the simulation tool, and contains the exact timestamp when the event occurred during the simulation, the event code, event level, and resulting actions. For more information on the occurrences, see the *iC7 Series Industry Application Guide*.

```
At simulation time: 0.0000200s -> Occurrence[5301] set to WARNING with Inverter action: NONE and BrakeAction: NONE (03/01/24);
At simulation time: 0.0050200s -> Occurrence[5301] set to REMOVED with Inverter action: NONE and BrakeAction: NONE (03/01/24);
At simulation time: 0.8000200s -> Occurrence[5171] set to INFO with Inverter action: NONE and BrakeAction: NONE (03/01/24);
At simulation time: 3.8000200s -> Occurrence[5291] set to WARNING with Inverter action: NONE and BrakeAction: NONE (03/01/24);
At simulation time: 6.1000200s -> Occurrence[5291] set to REMOVED with Inverter action: NONE and BrakeAction: NONE (03/01/24);
At simulation time: 6.9000200s -> Occurrence[5172] set to INFO with Inverter action: NONE and BrakeAction: NONE (03/01/24);
At simulation time: 7.2652000s -> Occurrence[4178] set to FAULT with Inverter action: COAST and BrakeAction: NONE (03/01/24);
At simulation time: 7.2804000s -> Occurrence[4164] set to WARNING with Inverter action: NONE and BrakeAction: NONE (03/01/24);
At simulation time: 10.5050200s -> Occurrence[4178] set to REMOVED with Inverter action: NONE and BrakeAction: NONE (03/01/24);
At simulation time: 10.5050200s -> RESET signal detected (03/01/24);
At simulation time: 12.2504000s -> Occurrence[4164] set to REMOVED with Inverter action: NONE and BrakeAction: NONE (03/01/24);
At simulation time: 27.0264000s -> Occurrence[4178] set to FAULT with Inverter action: COAST and BrakeAction: NONE (03/01/24);
```

e30bl567.10

Figure 6: Example of an Events.log File

4.3 Industry Application Std Model

Table 4: Industry Application Std Model Inputs

Name	Type	Description
FbCtrlWord	Integer	Fieldbus control word
FbSpeedRef	Integer	Fieldbus speed reference
DigIn10113	Boolean	Digital input 10113
DigIn10114	Boolean	Digital input 10114
DigIn10115	Boolean	Digital input 10115
DigIn10116	Boolean	Digital input 10116
DigIn10117	Boolean	Digital input 10117
DigIn10118	Boolean	Digital input 10118
AnaIn10133	Real	Analog input 10133
AnaIn10134	Real	Analog input 10134

Table 5: Industry Application Std Model Outputs

Name	Type	Description
FbStatusWord	Integer	Fieldbus status word
FbMainActualValue	Integer	Fieldbus main actual value
AppSpecStatusWord	Integer	Application-specific status word
MotorCtrlStatusWord	Integer	Motor control status word
DigOut10115	Boolean	Digital output 10115
DigOut10116	Boolean	Digital output 10116
AnaOut10131	Real	Analog output 10131
FreqRef	Real	Frequency reference
FreqActual	Real	Frequency actual output

4.4 Industry Drive Std Model

Table 6: Industry Drive Std Model inputs

Name	Type	Description
FbCtrlWord	Integer	Fieldbus control word
FbSpeedRef	Integer	Fieldbus speed reference
FbTorqueRef	Integer	Fieldbus torque reference
DigIn10113	Boolean	Digital input 10113
DigIn10114	Boolean	Digital input 10114

Table 6: Industry Drive Std Model inputs (continued)

Name	Type	Description
DigIn10115	Boolean	Digital input 10115
DigIn10116	Boolean	Digital input 10116
DigIn10117	Boolean	Digital input 10117
DigIn10118	Boolean	Digital input 10118
AnaIn10133	Real	Analog input 10133
AnaIn10134	Real	Analog input 10134
GridVoltage	Real	Grid voltage LL RMS
MotorEuvw	Real	Motor voltage phases U, V, and W
MotorIsuvw	Real	Motor stator current phases U, V, and W

Table 7: Industry Drive Std Model Outputs

Name	Type	Description
FbStatusWord	Integer	Fieldbus status word
FbMainActualValue	Integer	Fieldbus main actual value
AppSpecStatusWord	Integer	Application specific status word
MotorCtrlStatusWord	Integer	Motor control status word
MotorCtrlReadyStatusWord	Integer	Motor control ready status word
MotorCtrlRegulatorStatusWord	Integer	Motor control regulator status word
DigOut10115	Boolean	Digital output 10115
DigOut10116	Boolean	Digital output 10116
AnaOut10131	Real	Analog output 10131
FreqRef	Real	Frequency reference
FreqActual	Real	Actual frequency output
DcLinkVoltage	Real	DC-link voltage
MotorSpeed	Real	Motor speed
MotorTorque	Real	Motor torque
MotorTorquePct	Real	Motor torque in percent of nominal torque
ConverterUuvw	Real	Converter output voltage phase U, V, and W
OutputCurrent	Real	Output current
OutputCurrentPct	Real	Output current in percent of nominal current
OutputVoltage	Real	Output voltage

Table 7: Industry Drive Std Model Outputs (continued)

Name	Type	Description
OutputVoltagePct	Real	Output voltage in percent of nominal voltage
ExceptionStatus	Integer	Exception status: 1 None 2 Info 3 Warning 4 Fault

4.5 Industry Drive Train Std Model

Table 8: Industry Drive Train Std Model Inputs

Name	Type	Description
FbCtrlWord	Integer	Fieldbus control word
FbSpeedRef	Integer	Fieldbus speed reference
FbTorqueRef	Integer	Fieldbus torque reference
DigIn10113	Boolean	Digital input 10113
DigIn10114	Boolean	Digital input 10114
DigIn10115	Boolean	Digital input 10115
DigIn10116	Boolean	Digital input 10116
DigIn10117	Boolean	Digital input 10117
DigIn10118	Boolean	Digital input 10118
AnaIn10133	Real	Analog input 10133
AnaIn10134	Real	Analog input 10134
GridVoltage	Real	Grid Voltage LL RMS
WmExtern	Real	Omega motor from external load

Table 9: Industry Drive Train Std Model Outputs

Name	Type	Description
FbStatusWord	Integer	Fieldbus status word
FbMainActualValue	Integer	Fieldbus main actual value
AppSpecStatusWord	Integer	Application-specific status word
MotorCtrlStatusWord	Integer	Motor control status word
MotorCtrlReadyStatusWord	Integer	Motor control ready status word
MotorCtrlRegulatorStatusWord	Integer	Motor control regulator status word
DigOut10115	Boolean	Digital output 10115

Table 9: Industry Drive Train Std Model Outputs (continued)

Name	Type	Description
DigOut10116	Boolean	Digital output 10116
AnaOut10131	Real	Analog output 10131
FreqRef	Real	Frequency reference
FreqActual	Real	Actual frequency output
DcLinkVoltage	Real	DC-link voltage
MotorSpeed	Real	Motor speed
MotorTorque	Real	Motor torque
MotorTorquePct	Real	Motor torque in percent of nominal torque
MotorTm	Real	Motor torque towards load model
OutputCurrent	Real	Output current
OutputCurrentPct	Real	Output current in percent of nominal torque
MotorIsuvw[3]	Real	Motor current phase U, V, and W
OutputVoltage	Real	Output voltage in percent of nominal torque
OutputVoltagePct	Real	Output voltage in percent of nominal voltage
MotorUsuvw[3]	Real	Motor voltage phases U, V, and W
ExceptionStatus	Integer	Exception status: 1 None 2 Info 3 Warning 4 Fault

4.6 Industry System Std Model

Table 10: Industry System Std Model Inputs

Name	Type	Description
FbCtrlWord	Integer	Fieldbus control word
FbSpeedRef	Integer	Fieldbus speed reference
FbTorqueRef	Integer	Fieldbus torque reference
DigIn10113	Boolean	Digital input 10113
DigIn10114	Boolean	Digital input 10114
DigIn10115	Boolean	Digital input 10115
DigIn10116	Boolean	Digital input 10116
DigIn10117	Boolean	Digital input 10117
DigIn10118	Boolean	Digital input 10118

Table 10: Industry System Std Model Inputs (continued)

Name	Type	Description
AnaIn10133	Real	Analog input 10133
AnaIn10134	Real	Analog input 10134
GridVoltage	Real	Grid voltage LL RMS
LoadReferenceTorque	Real	Load motor torque reference in Newton meters
LoadInertiaFactor	Real	The inertia factor sets the plant moment of inertia that is connected to the motor shaft.
LoadFriction	Real	Friction constant sets the friction load that linearly follows the motor shaft speed. Friction constant at 100 corresponds to 50 Nm load at nominal speed.
QuadraticLoadConst	Real	A quadratic constant sets the load that follows the squared motor shaft speed. A quadratic constant set to 100 corresponds to a 50 Nm load at nominal speed.
MechBrakeSignal	Real	Mechanical brake enable signal
MotorInertia	Real	Motor inertia

Table 11: Industry System Std Model Outputs

Name	Type	Description
FbStatusWord	Integer	Fieldbus status word
FbMainActualValue	Integer	Fieldbus main actual value
AppSpecStatusWord	Integer	Application specific status word
MotorCtrlStatusWord	Integer	Motor control status word
MotorCtrlReadyStatusWord	Integer	Motor control ready status word
MotorCtrlRegulatorStatusWord	Integer	Motor control regulator status word
DigOut10115	Boolean	Digital output 10115
DigOut10116	Boolean	Digital output 10116
AnaOut10131	Real	Analog output 10131
FreqRef	Real	Frequency reference
FreqActual	Real	Actual frequency output
DcLinkVoltage	Real	DC-link voltage
MotorSpeed	Real	Motor speed
MotorTorque	Real	Motor torque
MotorTorquePct	Real	Motor torque in percent of nominal torque
OutputCurrent	Real	Output current
OutputCurrentPct	Real	Output current in percent of nominal current

Table 11: Industry System Std Model Outputs (continued)

Name	Type	Description
MotorIsuvw[3]	Real	Motor current phase U, V, and W
OutputVoltage	Real	Output voltage
OutputVoltagePct	Real	Output voltage in percent of nominal voltage
MotorUsuvw[3]	Real	Motor voltage phases U, V, and W
ExceptionStatus	Integer	Exception status: 1 None 2 Info 3 Warning 4 Fault

5 Application Notes

5.1 I/O Preset Reference Control with High Inertia and Fan Load

5.1.1 Configuring I/O Preset Reference Control with High Inertia and Fan Load

The speed preset-reference configuration example shows how to use the digital I/O to select different preset references and configure the start of DC-motor current injection for smooth speed ramp-up.

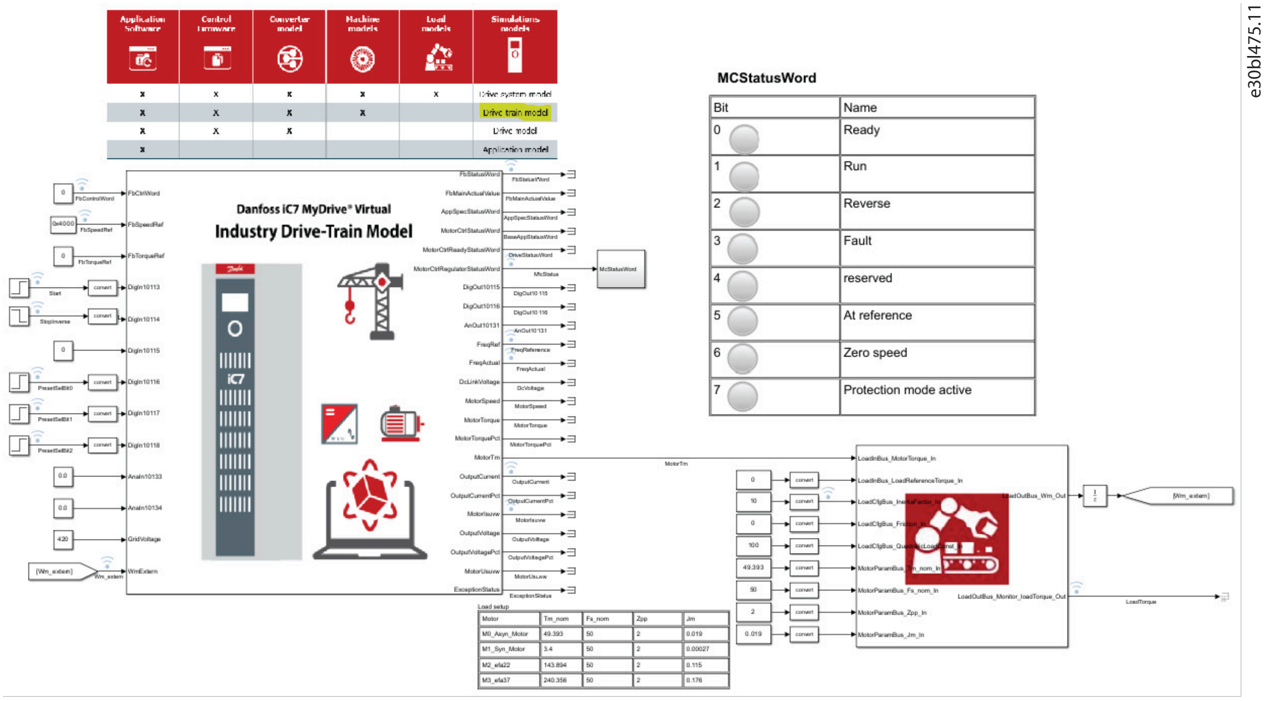


Figure 7: Industry Drive-Train Model and I/O Preset Reference Control Configuration

> **IMPORTANT:** The menu index numbers and names of parameters are based on the currently available software. Refer to the latest version of the application guide for the most recent information on parameters.

The basic setup of the drive simulation consists of the following configuration steps:

1. Actual motor configuration
2. Motor load configuration
3. Current rating selection
4. Drive input configuration
5. Drive parameter configuration
   a. Drive motor data
   b. Motor control principle
   c. Start settings
   d. Control places
   e. I/O control
   f. Speed reference

g. Speed ramps

5.1.2 Model Input Configuration

In this example, the inputs are used as follows:

- Digital input 10113 is used for starting forward after 0.5 s.
- Digital input 10114 is used for Stop after 10 s.
- Digital input 10115 is used for reversing.
- Digital input 10116 is used for preset-reference bit 0 that goes high after 3 s.
- Digital input 10117 is used for preset-reference bit 1 that goes high after 5 s.
- Digital input 10118 is used for preset-reference bit 2 that goes high after 8 s.
- Grid supply voltage is set to 420 V line-line RMS.

Table 12: Model Input Configuration

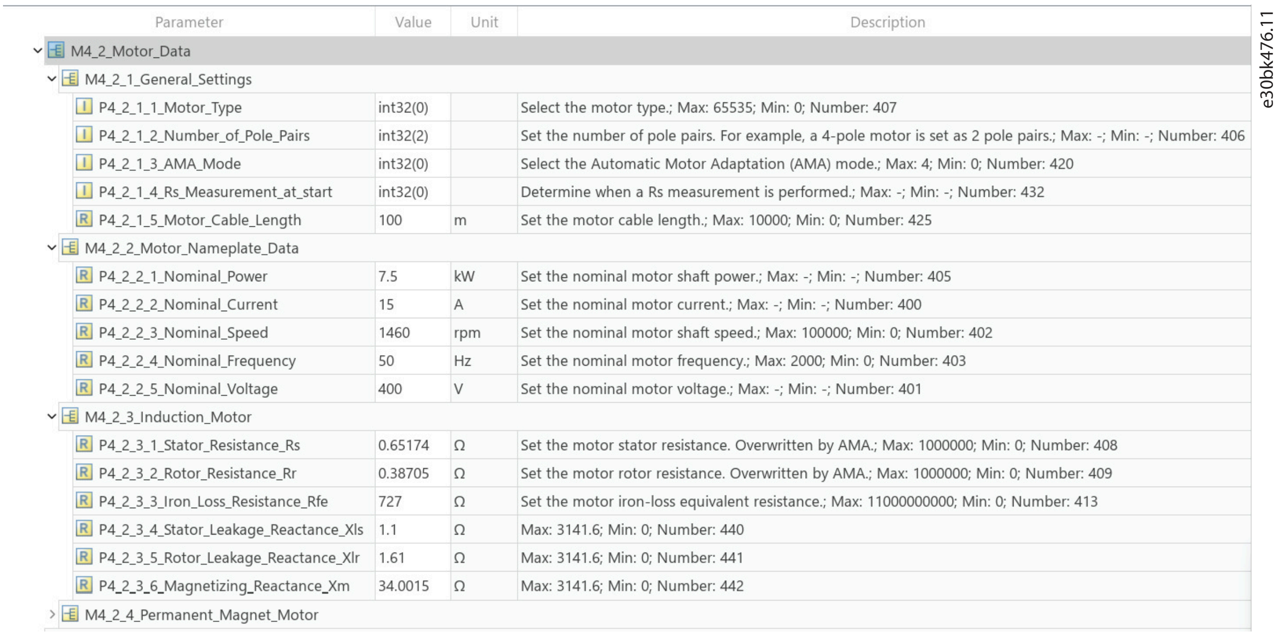
Name	Initial value	Final value	Step time [s]	Description
FbControlWord	0	0	0	Fieldbus control word (Not used for this example.)
FbSpeedRef	0x3000	0x3000	0	Fieldbus reference (Not used for this example.)
DigIn10113	0	1	0.5	Digital input 10113, used for Start forward.
DigIn10114	1	0	10	Digital input 10114, used for Stop inverse.
DigIn10115	0	0	0	Digital input 10115, used for reversing.
DigIn10116	0	1	3	Digital input 10116, used for preset-reference bit 0.
DigIn10117	0	1	5	Digital input 10117, used for preset-reference bit 1.
DigIn10118	0	1	8	Digital input 10118, used for preset-reference bit 2.
AnaIn10133	0	0	0	Analog input 10133
AnaIn10134	0	0	0	Analog input 10134
GridVoltage	420	420	0	Line-Line RMS grid voltage
WmExtern	–	–	–	Feedback speed from load in rad./s.

5.1.3 Motor Selection

In this example, a customizable 7.5 kW, 4-pole, 400 V induction motor is configured for the simulation. Parameters must be configured in menu index ***4 Motor***.

Table 13: Motor Type Selection

Name	Value	Description
MotorSelection	Int32(0)	Select the motor types available in the model.



Parameter	Value	Unit	Description
M4_2_Motor_Data			
M4_2_1_General_Settings			
P4_2_1_1_Motor_Type	int32(0)		Select the motor type.; Max: 65535; Min: 0; Number: 407
P4_2_1_2_Number_of_Pole_Pairs	int32(2)		Set the number of pole pairs. For example, a 4-pole motor is set as 2 pole pairs.; Max: -; Min: -; Number: 406
P4_2_1_3_AMA_Mode	int32(0)		Select the Automatic Motor Adaptation (AMA) mode.; Max: 4; Min: 0; Number: 420
P4_2_1_4_Rs_Measurement_at_start	int32(0)		Determine when a Rs measurement is performed.; Max: -; Min: -; Number: 432
P4_2_1_5_Motor_Cable_Length	100	m	Set the motor cable length.; Max: 10000; Min: 0; Number: 425
M4_2_2_Motor_Nameplate_Data			
P4_2_2_1_Nominal_Power	7.5	kW	Set the nominal motor shaft power.; Max: -; Min: -; Number: 405
P4_2_2_2_Nominal_Current	15	A	Set the nominal motor current.; Max: -; Min: -; Number: 400
P4_2_2_3_Nominal_Speed	1460	rpm	Set the nominal motor shaft speed.; Max: 100000; Min: 0; Number: 402
P4_2_2_4_Nominal_Frequency	50	Hz	Set the nominal motor frequency.; Max: 2000; Min: 0; Number: 403
P4_2_2_5_Nominal_Voltage	400	V	Set the nominal motor voltage.; Max: -; Min: -; Number: 401
M4_2_3_Induction_Motor			
P4_2_3_1_Stator_Resistance_Rs	0.65174	Ω	Set the motor stator resistance. Overwritten by AMA.; Max: 1000000; Min: 0; Number: 408
P4_2_3_2_Rotor_Resistance_Rr	0.38705	Ω	Set the motor rotor resistance. Overwritten by AMA.; Max: 1000000; Min: 0; Number: 409
P4_2_3_3_Iron_Loss_Resistance_Rfe	727	Ω	Set the motor iron-loss equivalent resistance.; Max: 11000000000; Min: 0; Number: 413
P4_2_3_4_Stator_Leakage_Reactance_Xls	1.1	Ω	Max: 3141.6; Min: 0; Number: 440
P4_2_3_5_Rotor_Leakage_Reactance_Xlr	1.61	Ω	Max: 3141.6; Min: 0; Number: 441
P4_2_3_6_Magnetizing_Reactance_Xm	34.0015	Ω	Max: 3141.6; Min: 0; Number: 442
M4_2_4_Permanent_Magnet_Motor			

Figure 8: Motor Type Selection in Simulink

Table 14: Motor Type Selection

Name	Value	Description
MotorSelection	Int32(0)	Select the motor types available in the model.

Table 15: Motor Data

Name	Value	Description
Motor_Type	Int32(0)	0: Induction motor 1: Permanent magnet motor
Number_of_Pole_Pairs	Int32(2)	Motor pole pair number
Nominal_Power	7500	Motor nominal shaft power
Nominal_Current	14.6	Motor nominal current
Nominal_Speed	1450	Motor nominal shaft speed
Nominal_Frequency	50	Motor nominal frequency
Nominal_Voltage	400	Motor nominal voltage
Stator_Resistance_Rs	0.7531	Motor stator resistance
Rotor_Resistance_Rr	0.4678	Motor rotor resistance
Iron_Loss_Resistance_Rfe	762.4	Motor iron loss equivalent resistance
Stator_Leakage_Lls	0.0044	Stator leakage inductance
Rotor_Leakage_Llr	0.0044	Rotor leakage inductance
Magnetizing_Lm	0.1312	Magnetizing inductance

5.1.4 Drive Selection

In this example, an iC7-Automation frequency converter (iC7 FX03-3N05-16A) is selected to run the 7.5 kW motor. For details on drive variants, refer to the drive-specific design guide.

Table 16: Drive Selection

Name	Value	Description
DriveSizeSetup	Int32(9)	Select the drive variant available in the model.

Parameter	Value	Unit	Description
Industry			
Motor			
DriveSize			
DriveSizeSelection	int32(7)		DriveSize.Value.DriveSizeSelection
D0_iC7_60_FX02_3N05_1A3	int32(0)		DriveSize.Value.D0_iC7_60_FX02_3N05_1A3
D1_iC7_60_FX02_3N05_1A8	int32(1)		DriveSize.Value.D1_iC7_60_FX02_3N05_1A8
D2_iC7_60_FX02_3N05_2A4	int32(2)		DriveSize.Value.D2_iC7_60_FX02_3N05_2A4
D3_iC7_60_FX02_3N05_3A0	int32(3)		DriveSize.Value.D3_iC7_60_FX02_3N05_3A0
D4_iC7_60_FX02_3N05_4A0	int32(4)		DriveSize.Value.D4_iC7_60_FX02_3N05_4A0
D5_iC7_60_FX02_3N05_5A6	int32(5)		DriveSize.Value.D5_iC7_60_FX02_3N05_5A6
D6_iC7_60_FX02_3N05_7A2	int32(6)		DriveSize.Value.D6_iC7_60_FX02_3N05_7A2
D7_iC7_60_FX02_3N05_9A2	int32(7)		DriveSize.Value.D7_iC7_60_FX02_3N05_9A2
D8_iC7_60_FX02_3N05_12A5	int32(8)		DriveSize.Value.D8_iC7_60_FX02_3N05_12A5
D9_iC7_60_FX03_3N05_16A	int32(9)		DriveSize.Value.D9_iC7_60_FX03_3N05_16A
D10_iC7_60_FX04_3N05_24A	int32(10)		DriveSize.Value.D10_iC7_60_FX04_3N05_24A
D11_iC7_60_FX04_3N05_31A	int32(11)		DriveSize.Value.D11_iC7_60_FX04_3N05_31A
D12_iC7_60_FX05_3N05_38A	int32(12)		DriveSize.Value.D12_iC7_60_FX05_3N05_38A
D13_iC7_60_FX05_3N05_43A	int32(13)		DriveSize.Value.D13_iC7_60_FX05_3N05_43A
D14_iC7_60_FX06_3N05_61A	int32(14)		DriveSize.Value.D14_iC7_60_FX06_3N05_61A
D15_iC7_60_FA07_3N05_90A	int32(15)		DriveSize.Value.D15_iC7_60_FA07_3N05_90A

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Figure 9: Drive Size Selection in Simulink

5.1.5 Load Configuration

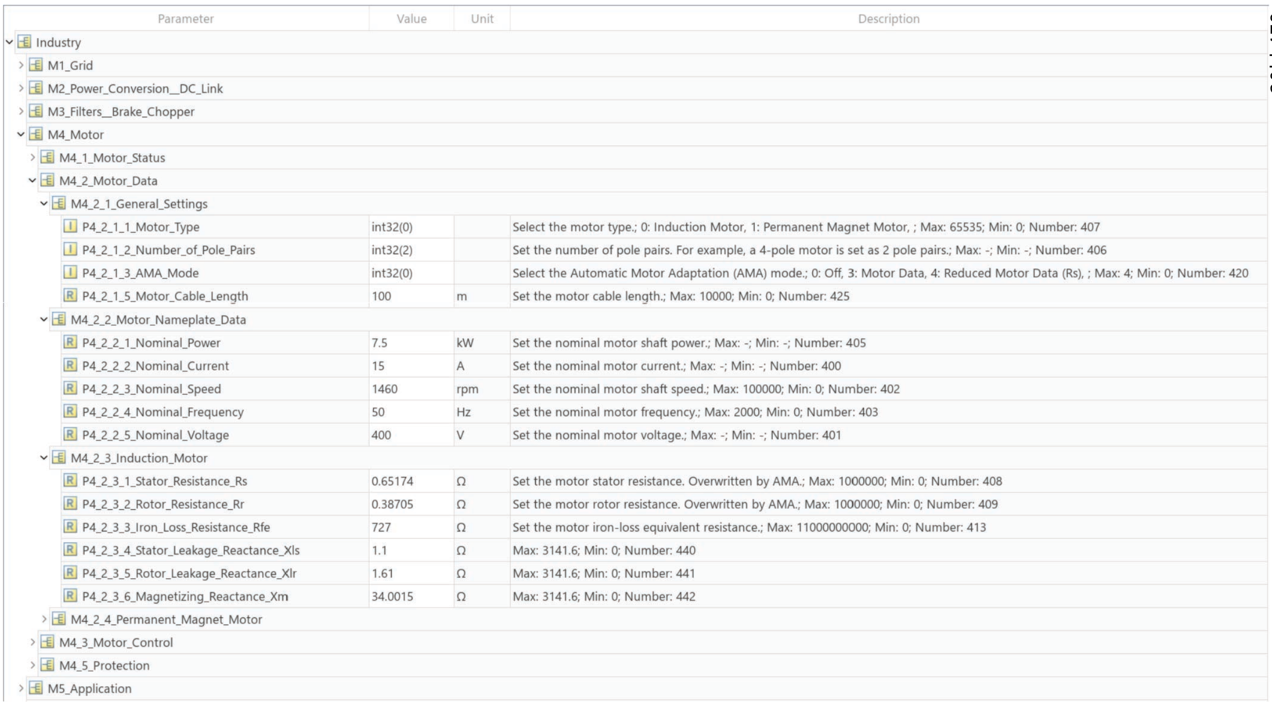
In this example, the load is configured as a high-inertia load system (10 x motor inertia) and a fan torque characteristic, with quadratic torque as function of speed. Nominal motor torque is configured at nominal motor speed.

5.1.6 Drive Parameter Configuration

5.1.6.1 Drive Motor Data

Table 17: Drive Motor Data

Index	Parameter name	Setting	Description
4.2.1.1	Motor Type	Int32(0)	0: Induction motor 1: Permanent magnet motor
4.2.1.2	Number of Pole Pairs	Int32(2)	Motor pole pair number
4.2.2.1	Nominal Power	7500	Motor nominal shaft power
4.2.2.2	Nominal Current	14.6	Motor nominal current
4.2.2.3	Nominal Speed	1450	Motor nominal shaft speed
4.2.2.4	Nominal Frequency	50	Motor nominal frequency
4.2.2.5	Nominal Voltage	400	Motor nominal voltage
4.2.3.1	Motor Stator Resistance	0.7531	Motor stator resistance
4.2.3.2	Rotor Resistance	0.4678	Motor rotor resistance
4.2.3.3	Iron Loss Resistance	762.4	Motor iron loss equivalent resistance
4.2.3.4	Stator Leakage Reactance	1.3823	2*pi*50 Hz*0.0044Henry
4.2.3.6	Rotor Leakage reactance	1.3823	2*pi*50 Hz*0.0044Henry
4.2.3.6	Magnetizing Reactance	41.218	2*pi*50 Hz*0.1312Henry



Parameter	Value	Unit	Description
Industry			
M1_Grid			
M2_Power_Conversion__DC_Link			
M3_Filters__Brake_Chopper			
M4_Motor			
M4_1_Motor_Status			
M4_2_Motor_Data			
M4_2_1_General_Settings			
P4_2_1_1_Motor_Type	int32(0)		Select the motor type.; 0: Induction Motor, 1: Permanent Magnet Motor, ; Max: 65535; Min: 0; Number: 407
P4_2_1_2_Number_of_Pole_Pairs	int32(2)		Set the number of pole pairs. For example, a 4-pole motor is set as 2 pole pairs.; Max: -; Min: -; Number: 406
P4_2_1_3_AMA_Mode	int32(0)		Select the Automatic Motor Adaptation (AMA) mode.; 0: Off, 3: Motor Data, 4: Reduced Motor Data (Rs), ; Max: 4; Min: 0; Number: 420
P4_2_1_5_Motor_Cable_Length	100	m	Set the motor cable length.; Max: 10000; Min: 0; Number: 425
M4_2_2_Motor_Nameplate_Data			
P4_2_2_1_Nominal_Power	7.5	kW	Set the nominal motor shaft power.; Max: -; Min: -; Number: 405
P4_2_2_2_Nominal_Current	15	A	Set the nominal motor current.; Max: -; Min: -; Number: 400
P4_2_2_3_Nominal_Speed	1460	rpm	Set the nominal motor shaft speed.; Max: 100000; Min: 0; Number: 402
P4_2_2_4_Nominal_Frequency	50	Hz	Set the nominal motor frequency.; Max: 2000; Min: 0; Number: 403
P4_2_2_5_Nominal_Voltage	400	V	Set the nominal motor voltage.; Max: -; Min: -; Number: 401
M4_2_3_Induction_Motor			
P4_2_3_1_Stator_Resistance_Rs	0.65174	Ω	Set the motor stator resistance. Overwritten by AMA.; Max: 1000000; Min: 0; Number: 408
P4_2_3_2_Rotor_Resistance_Rr	0.38705	Ω	Set the motor rotor resistance. Overwritten by AMA.; Max: 1000000; Min: 0; Number: 409
P4_2_3_3_Iron_Loss_Resistance_Rfe	727	Ω	Set the motor iron-loss equivalent resistance.; Max: 11000000000; Min: 0; Number: 413
P4_2_3_4_Stator_Leakage_Reactance_Xls	1.1	Ω	Max: 3141.6; Min: 0; Number: 440
P4_2_3_5_Rotor_Leakage_Reactance_Xlr	1.61	Ω	Max: 3141.6; Min: 0; Number: 441
P4_2_3_6_Magnetizing_Reactance_Xm	34.0015	Ω	Max: 3141.6; Min: 0; Number: 442
M4_2_4_Permanent_Magnet_Motor			
M4_3_Motor_Control			
M4_5_Protection			
M5_Application			

e30bk478.

Figure 10: Drive Motor Data in Simulink

5.1.6.2 Motor Control Principle

In this example, FVC+ is selected as the motor control principle.

Table 18: Motor Control Principle Parameter

Index	Parameter name	Setting	Description
4.3.1.1	Motor Control Principle	int32(2)	Selects the motor control principle. • 0: U/f Control • 1: VVC+ Control • 2: FVC+ Control

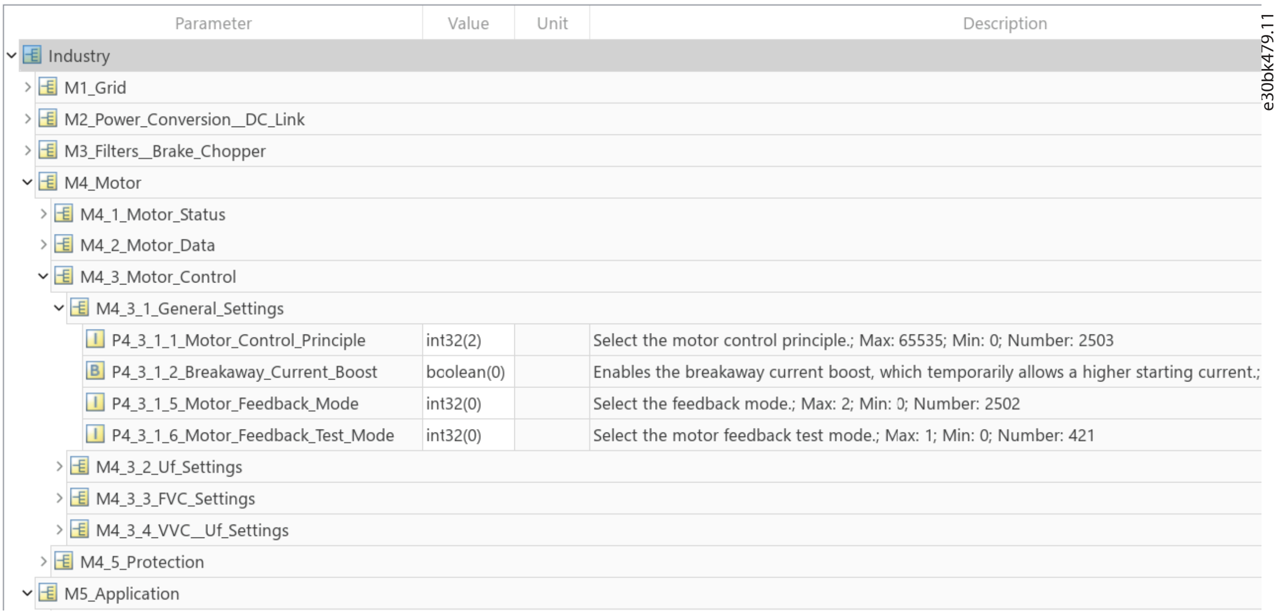


Figure 11: Motor Control Principle in Simulink

5.1.6.3 Start Settings

In this example, 60% of nominal motor current is injected for 0.5 s with a current rise time of 0.1 s.

Table 19: Start Setting Parameters

Index	Parameter name	Setting	Description
5.6.2.1	DC Start Time	0.5	Set the DC current injection time in stop state before running.
5.6.2.2	DC Start Rise Time	0.1	Set the time to ramp the current from zero to the specified injection level.
5.6.2.3	DC Start Current	60	Set the stator DC current in percent of motor nominal current. This current is injected in the stop state before running.

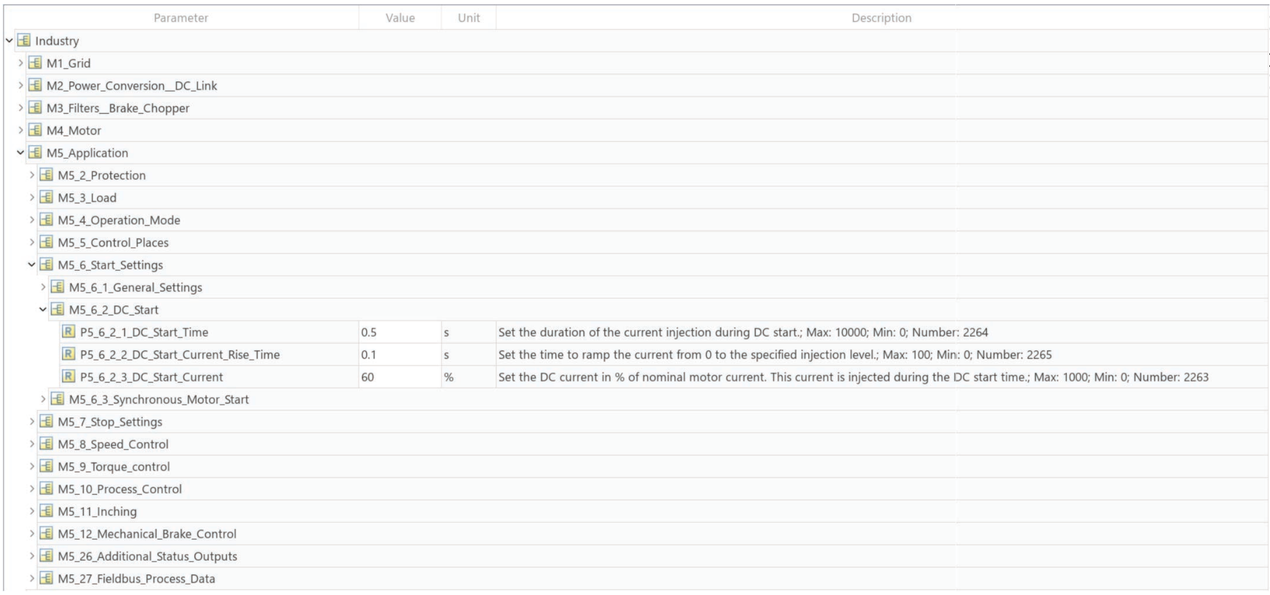


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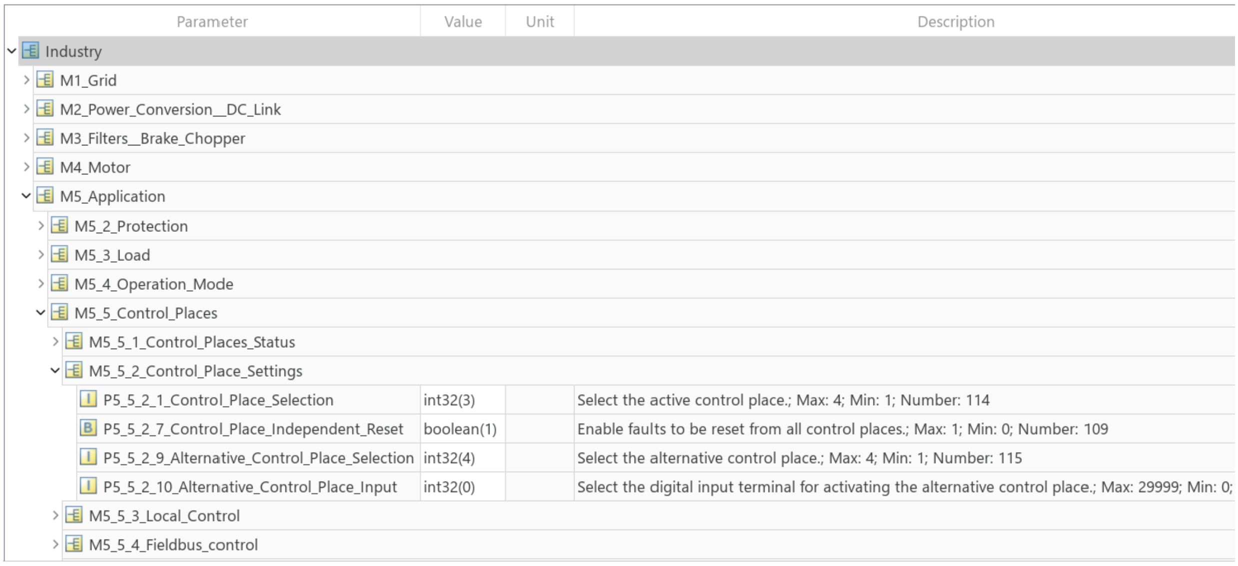
Figure 12: Start Settings in Simulink

5.1.6.4 Control Places

In this example, I/O control is selected.

Table 20: Control Place Parameter

Index	Parameter name	Setting	Description
5.5.2.1	Control Place Selection	int32(3)	Select active control place. • 0: PC Control • 1: Local Control • 2: Fieldbus Control • 3: I/O Control • 4: Advanced Control



Parameter	Value	Unit	Description
Industry			
M1_Grid			
M2_Power_Conversion__DC_Link			
M3_Filters__Brake_Chopper			
M4_Motor			
M5_Application			
M5_2_Protection			
M5_3_Load			
M5_4_Operation_Mode			
M5_5_Control_Places			
M5_5_1_Control_Places_Status			
M5_5_2_Control_Place_Settings			
P5_5_2_1_Control_Place_Selection	int32(3)		Select the active control place.; Max: 4; Min: 1; Number: 114
P5_5_2_7_Control_Place_Independent_Reset	boolean(1)		Enable faults to be reset from all control places.; Max: 1; Min: 0; Number: 109
P5_5_2_9_Alternative_Control_Place_Selection	int32(4)		Select the alternative control place.; Max: 4; Min: 1; Number: 115
P5_5_2_10_Alternative_Control_Place_Input	int32(0)		Select the digital input terminal for activating the alternative control place.; Max: 29999; Min: 0;
M5_5_3_Local_Control			
M5_5_4_Fieldbus_control			

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Figure 13: Control Place Selection in Simulink

5.1.6.5 I/O Control

In this example:

- Digital input 10113 is set to control the Start forward.
- Digital input 10114 is set to control Stop inverse.
- Digital input 10115 is set to control Reversing.
- Reset is set to zero.

Table 21: I/O Control Parameters

Index	Parameter name	Setting	Description
5.5.5.1.1	Start Input	Int32(10113)	Set the digital input for starting.
5.5.5.1.3	Stop Inverse Input	Int32(10114)	Set the digital input for stopping.
5.5.5.1.5	Reversing Input	Int32(10115)	Set the digital input for inverting the reference signal. It does not provide a start signal.
5.5.5.1.6	Reset Input	Int32(0)	Set the digital input for resetting faults.

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Figure 14: I/O Control Selection in Simulink

5.1.6.6 Speed Reference

In this example:

- Preset references 1, 2, 4, and 8 are used for controlling the speed reference.
- Preset reference bit 0 is connected to digital input 10116.
- Preset reference bit 1 is connected to digital input 10117.
- Preset reference bit 2 is connected to digital input 10118.

Table 22: Speed Reference Parameters

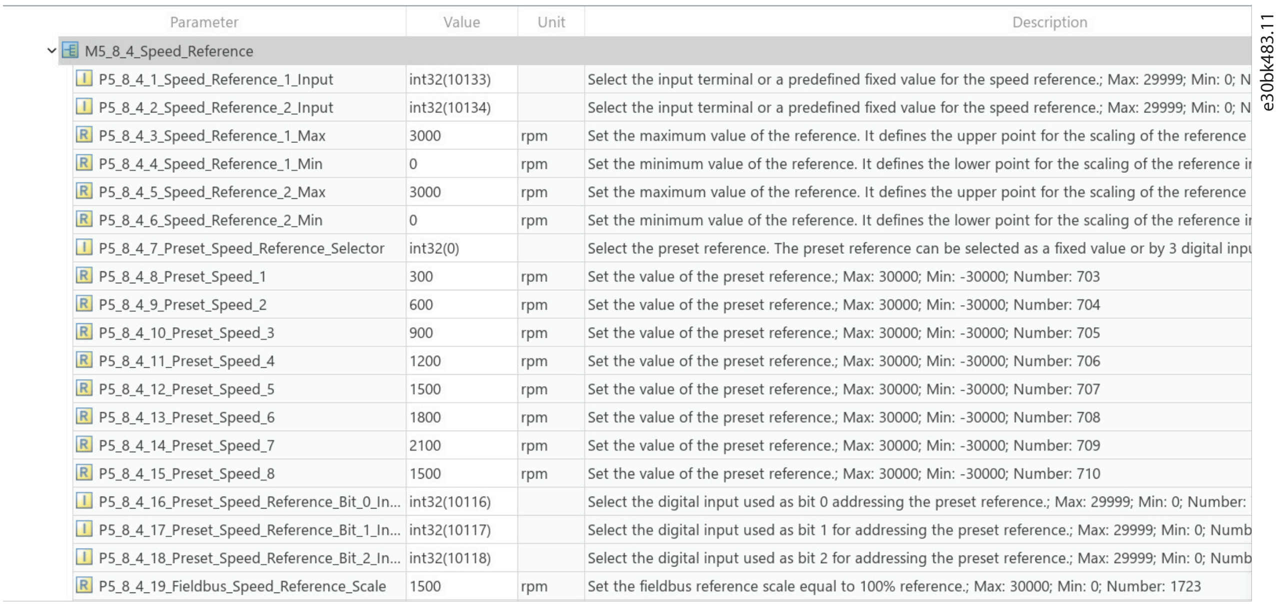
Index	Parameter name	Setting	Description
5.5.5.2.1	IO Speed Reference[1,1]	5	Select the speed reference sources for when the drive operates in I/O control. Define multiple entries for combining several sources into 1 reference value. • 0: None • 2: Fieldbus Reference • 3: Analog Input Reference 1 • 4: Analog Input Reference 2 • 5: Preset Reference • 8: Process Ctrl. Reference
5.8.4.7	Preset Speed Selector	0	Set the number of the preset reference to be used. • 0: Bit Selection • 1: Preset 1 • 2: Preset 2 • 3: Preset 3 • 4: Preset 4 • 5: Preset 5 • 6: Preset 6 • 7: Preset 7 • 8: Preset 8
5.8.4.8	Preset Speed 1	300	Set the value of the preset reference 1.
5.8.4.9	Preset Speed 2	600	Set the value of the preset reference 2.

Table 22: Speed Reference Parameters (continued)

Index	Parameter name	Setting	Description
5.8.4.11	Preset Speed 4	1200	Set the value of the preset reference 4.
5.8.4.15	Preset Speed 8	1500	Set the value of the preset reference 8.
5.8.4.16	Preset Speed Bit 0 Input	10116	Set the digital input to be used as bit 0 for addressing the preset reference.
5.8.4.17	Preset Speed Bit 1 Input	10117	Set the digital input to be used as bit 1 for addressing the preset reference.
5.8.4.18	Preset Speed Bit 2 Input	10118	Set the digital input to be used as bit 2 for addressing the preset reference.

Table 23: Truth Table for Preset Reference Number

Preset speed bit 0	Preset speed bit 1	Preset speed bit 2	Preset speed nr.
0	0	0	1
1	0	0	2
0	1	0	3
1	1	0	4
0	0	1	5
1	0	1	6
0	1	1	7
1	1	1	8



Parameter	Value	Unit	Description
M5_8_4_Speed_Reference			
P5_8_4_1_Speed_Reference_1_Input	int32(10133)		Select the input terminal or a predefined fixed value for the speed reference.; Max: 29999; Min: 0; N
P5_8_4_2_Speed_Reference_2_Input	int32(10134)		Select the input terminal or a predefined fixed value for the speed reference.; Max: 29999; Min: 0; N
P5_8_4_3_Speed_Reference_1_Max	3000	rpm	Set the maximum value of the reference. It defines the upper point for the scaling of the reference
P5_8_4_4_Speed_Reference_1_Min	0	rpm	Set the minimum value of the reference. It defines the lower point for the scaling of the reference i
P5_8_4_5_Speed_Reference_2_Max	3000	rpm	Set the maximum value of the reference. It defines the upper point for the scaling of the reference
P5_8_4_6_Speed_Reference_2_Min	0	rpm	Set the minimum value of the reference. It defines the lower point for the scaling of the reference i
P5_8_4_7_Preset_Speed_Reference_Selector	int32(0)		Select the preset reference. The preset reference can be selected as a fixed value or by 3 digital inpu
P5_8_4_8_Preset_Speed_1	300	rpm	Set the value of the preset reference.; Max: 30000; Min: -30000; Number: 703
P5_8_4_9_Preset_Speed_2	600	rpm	Set the value of the preset reference.; Max: 30000; Min: -30000; Number: 704
P5_8_4_10_Preset_Speed_3	900	rpm	Set the value of the preset reference.; Max: 30000; Min: -30000; Number: 705
P5_8_4_11_Preset_Speed_4	1200	rpm	Set the value of the preset reference.; Max: 30000; Min: -30000; Number: 706
P5_8_4_12_Preset_Speed_5	1500	rpm	Set the value of the preset reference.; Max: 30000; Min: -30000; Number: 707
P5_8_4_13_Preset_Speed_6	1800	rpm	Set the value of the preset reference.; Max: 30000; Min: -30000; Number: 708
P5_8_4_14_Preset_Speed_7	2100	rpm	Set the value of the preset reference.; Max: 30000; Min: -30000; Number: 709
P5_8_4_15_Preset_Speed_8	1500	rpm	Set the value of the preset reference.; Max: 30000; Min: -30000; Number: 710
P5_8_4_16_Preset_Speed_Reference_Bit_0_In...	int32(10116)		Select the digital input used as bit 0 addressing the preset reference.; Max: 29999; Min: 0; Number:
P5_8_4_17_Preset_Speed_Reference_Bit_1_In...	int32(10117)		Select the digital input used as bit 1 for addressing the preset reference.; Max: 29999; Min: 0; Numb
P5_8_4_18_Preset_Speed_Reference_Bit_2_In...	int32(10118)		Select the digital input used as bit 2 for addressing the preset reference.; Max: 29999; Min: 0; Numb
P5_8_4_19_Fieldbus_Speed_Reference_Scale	1500	rpm	Set the fieldbus reference scale equal to 100% reference.; Max: 30000; Min: 0; Number: 1723

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Figure 15: Speed Reference Settings in Simulink

5.1.6.7 Speed Ramps

In this example, ramp 1 is configured to 5 s ramp-up time and 5 s ramp-down time.

Table 24: Speed Ramp Parameters

Index	Parameter name	Setting	Description
5.8.6.2.2	Ramp 1 Accel. Time	5	Acceleration time from 0 to nominal speed.
5.8.6.2.3	Ramp 1 Decel. Time	5	Deceleration time from nominal speed to 0

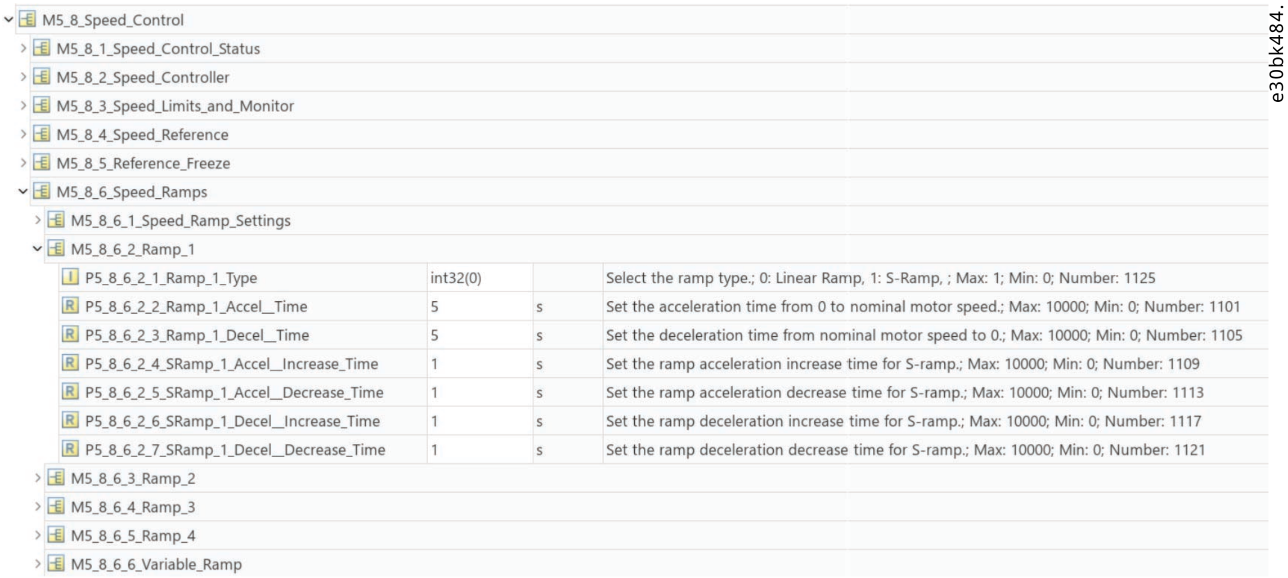

Figure 16: Speed Ramp Settings in Simulink

5.1.7 Simulation Results

After completing the simulation configuration, the results are shown as graphs.

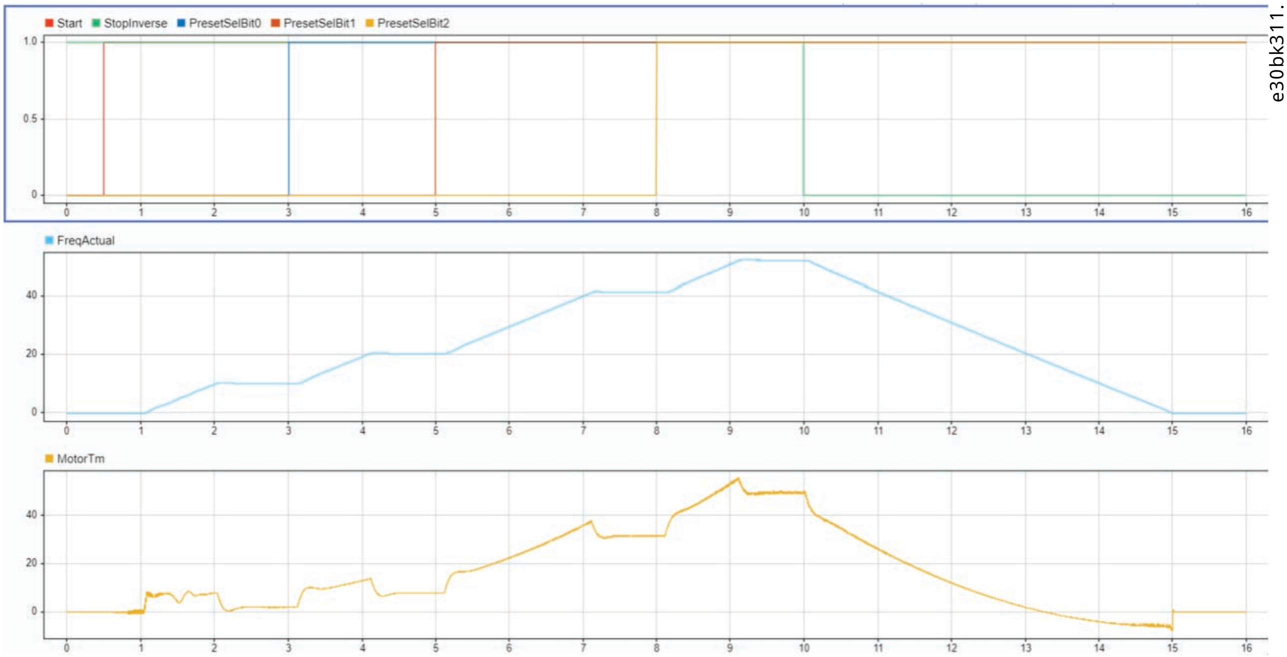

Figure 17: Example of Simulation Results Configuring I/O Control with Industry Application

5.2 iC Speed Profile

5.2.1 Configuring iC Speed Profile

The iC Speed Profile configuration example shows how the Industry Drive-Train Std model can be controlled using the fieldbus profile iC Speed Profile.

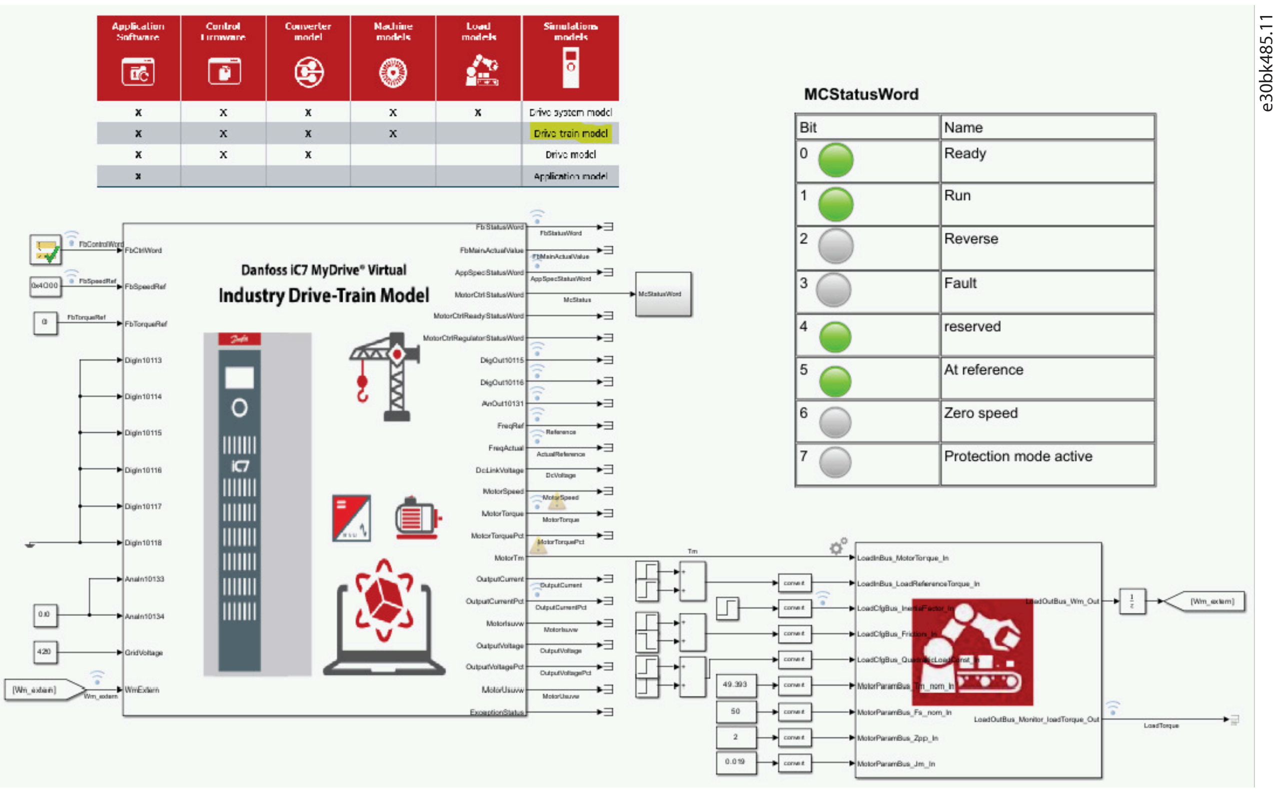

Figure 18: Industry Drive-Train Model and iC Speed Profile Configuration

IMPORTANT: The menu index numbers and names of parameters are based on the currently available software. Refer to the latest version of the application guide for the most recent information on parameters.

5.2.2 I/O Connections

In this example, ***FbControlWord*** and ***FbReference*** inputs are used to control the drive. ***FreqLimitPos*** and ***FreqLimitNeg*** are set to 60 Hz and -60 Hz, and ***GridVoltage*** to 420 V. ***WM_Extern*** gets the feedback from the load model. Other inputs are not used and are set to 0 or false.

Output ***MotorTm*** is used to hand over torque to the load model. ***FbStatusWord*** and ***FreqActual*** are tracked as well as all other outputs of interest.

5.2.3 Parameter Setup

In this example, fieldbus is selected for the control place. The relevant parameter settings can be combined with other control settings, using different drive variants.

Table 25: Control Place Parameters

Index	Parameter name	Setting	Description
5.5.2.1	Control Place Selection	int32(2)	Select active control place. • 0: PC Control • 1: Local Control • 2: Fieldbus Control • 3: I/O Control • 4: Advanced Control
5.5.4.1.1	FB Speed Reference	int32(2)	Select the speed reference sources for when the drive operates in fieldbus control. Define multiple entries for combining several sources into 1 reference value. • 0: None • 2: Fieldbus Reference • 3: Analog Input Reference 1 • 4: Analog Input Reference 2 • 5: Preset Reference • 8: Process Ctrl. Reference
5.8.4.19	Fieldbus Speed Reference 100 Scale	1500 RPM	Set the fieldbus reference scale equal to 100% reference.
10.3.1.2	Fieldbus Profile	int32(101)	Select the fieldbus profile – CtrlWord/StatusWord interpretation. • 101: Danfoss Speed Profile • 201: PROFIdrive Application Class 1

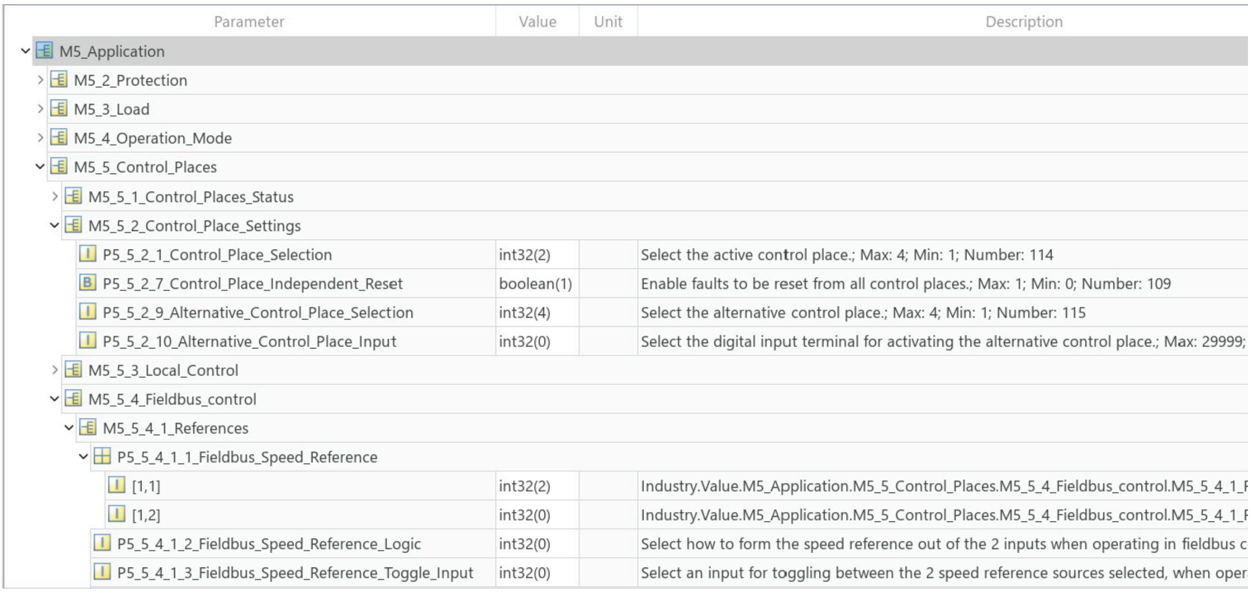

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Figure 19: Control Place Selection for Fieldbus Control in Simulink

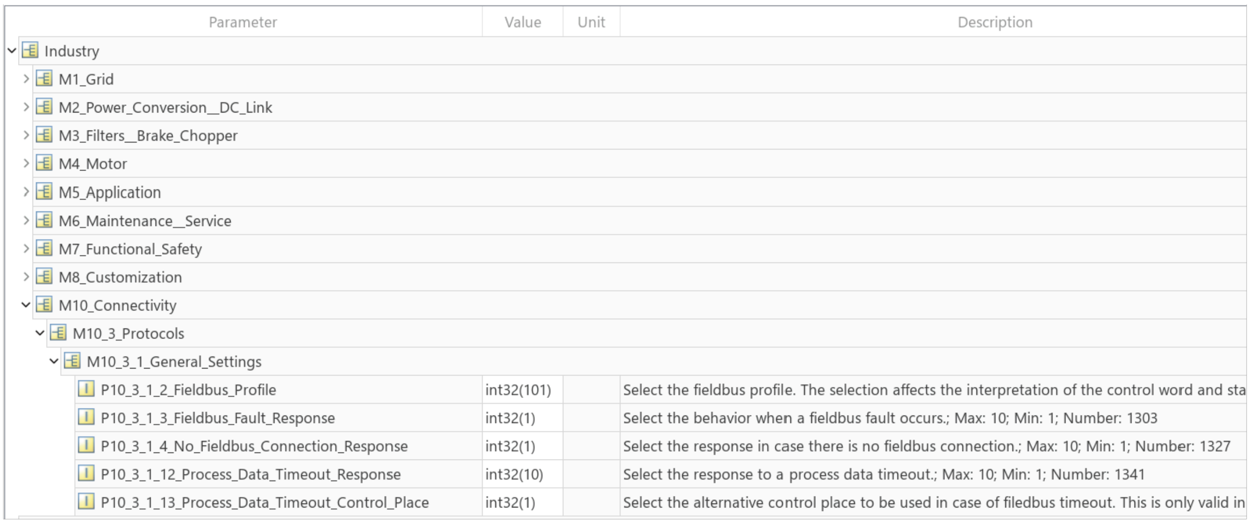

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Figure 20: Settings for Fieldbus Control in Simulink

5.2.4 Fieldbus Control Word

In this example:

- A startup sequence is configured to start up the drive.
- Bit 8 is configured to activate the jog function.
- Quick stop bit 4 is configured to stop the drive.

Table 26: Control Word Bits

Time	Step	Bit	Value
0 s	Init	FbControlWord – all	0
0.5 s	Fieldbus Activate	10 – Data valid	1

Table 26: Control Word Bits (continued)

Time	Step	Bit	Value
1 s	Remove Stop	3 – No coast	1
		4 – No quick stop	1
		5 – No hold	1
1.5 s	Start	6 – Start	1
11.5 s	Activate Jog	8 – Jog	1
21.5 s	Deactivate Jog	8 – Jog	0
26.5 s	Quick Stop	4 – No quick stop	0

The functions of all bits in the iC Speed Profile control word are explained in 5.2.5 Control Word (CTW).

5.2.5 Control Word (CTW)

Table 27: iC Speed Profile Control Word Bits

Bit number	Name	Description
0+1	Preset reference selector	00: Preset reference 1 01: Preset reference 2 10: Preset reference 3 11: Preset reference 4
2	Reserved	Reserved for future use. Any control words sent to the device should keep this bit at 0 to ensure compatibility with future extensions of the control word.
3	No coast/Coast	1: No function. 0: Causes the drive to immediately coast the motor.
4	No quick stop/Quick Stop	1: No function. 0: Quick stops the drive and ramps down the motor speed to stop as defined with the quick stop ramp parameter.
5	No hold/Hold output frequency	1: No function. 0: Hold the present output frequency (in Hz).
6	Start/No start	1: If the other starting conditions are fulfilled, this selection allows the drive to start the motor. 0: Stops the drive and ramps down the motor speed as defined with the ramp down parameter.
7	Fault acknowledge	0 ⇒ 1: Acknowledge faults. Acknowledge is edge-triggered, when the logic is changed from 0 to 1. Faults can only be acknowledged is the triggering condition has been removed and any required acknowledgment has been done. 0: No function.

Table 27: iC Speed Profile Control Word Bits (continued)

Bit number	Name	Description
8	Jog/No jog	1: Sets the output frequency to the jog speed defined with the jog speed parameter. 0: No function.
9	Ramp select	1: Ramp 2 is active. 0: Ramp 1 is active.
10	Data valid	1: Use process data (control by PLC). 0: Ignore the current process data. This is linked to the submodule where the CTW is present. If signals are to be covered, the CTW/STW profile (for example, the iC Speed Profile) must be part of the signals list. Use the previously processed data when the data valid bit was true (no control by PLC).
11	Reserved	Reserved for future use.
12	User defined	These bits are reserved for application-specific advanced control. For more information, refer to the *Parameter Descriptions* chapter in the application guide.
13	User defined	
14	User defined	
15	User defined	

5.2.6 FbReference

The ***FbReference*** signal is a 32-bit signal. Hex value 0x4000 represents 100% of the reference scale, which is defined in the parameters. In this example, it is set to 50 Hz.

5.2.7 Load Configuration

The general load model is configured for motor M0 (default). Load step of 12.3 Nm is applied when the drive is running at ***FreqRef***.

5.2.8 Fieldbus Status Word

The functions of all bits in the iC Speed Profile status word are explained in 5.2.9 Status Word (STW) in iC Speed Profile.

5.2.9 Status Word (STW) in iC Speed Profile

Table 28: iC Speed Profile Status Word Bits

Bit number	Name	Description
0	Control ready	1 = The device controls are ready and react to process data. 0 = The device controls are not ready and do not react to process data.
1	Frequency converter ready	1 = The frequency converter is ready for operation. 0 = The frequency converter is not ready for operation. This status does not involve faults and warnings as they are indicated in their respective bits elsewhere.

Table 28: iC Speed Profile Status Word Bits (continued)

Bit number	Name	Description
2	Coast	1 = There are no active coast signals, and the motor can start when a start signal is given. 0 = The frequency converter has an active coast signal and has released the motor.
3	Fault	1 = A fault has occurred, and an acknowledge signal is required to re-establish operation. 0 = There are no faults.
4	Reserved	Reserved.
5	Reserved	Reserved.
6	Reserved	Reserved.
7	Warning	1 = A warning is active. 0 = There are no warnings.
8	Speed=reference	1 = The current motor speed matches the current speed reference within a given tolerance. The tolerance is product specific. 0 = The motor runs, but the current speed is different from the current speed reference, for example while the speed ramps up or down during start or stop.
9	Bus control/Local operation	1 = The device is controlled and reacting to I/O and process data. 0 = The device does not react on commands from the fieldbus, for 1 of the following reasons: • CTW bit 10 = 0. • HMI is in local mode. • MyDrive® Insight has taken control. • Control places do not include fieldbus.
10	Frequency limit	1 = The output frequency is within the defined motor limits. 0 = The output frequency has exceeded the defined motor limits. The speed limits are set with the parameters: • ***P 5.8.3.1 Positive Speed Limit*** • ***P 5.8.3.2 Negative Speed Limit*** • ***P 5.8.3.3 Minimum Speed Limit***
11	Operation	1 = The process is running, and the motor can be running or start at any time. 0 = There are no active start requests, and the process does not run. The motor is coasted and is not started.
12	Reserved	Reserved.
13	Reserved	Reserved.
14	User defined	These bits are reserved for application-specific advanced control. For more information, refer to the Parameter Descriptions chapter in the application guide.
15	User defined	

5.2.10 Simulation Results

After completing the simulation configuration, the results are shown as graphs.

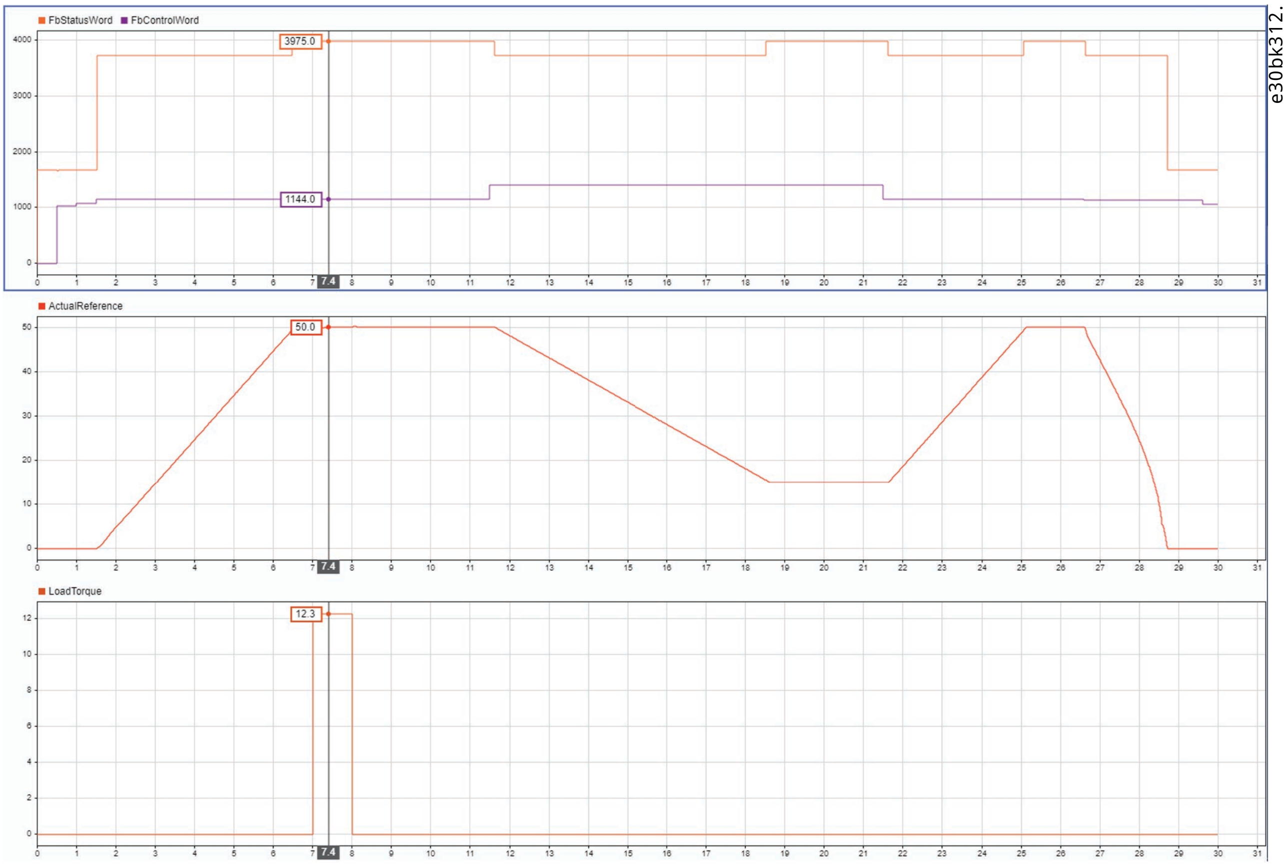

Figure 21: Example of Simulation Results for Configuring iC Speed Profile with Industry Application

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