EZmotion

User Guide

PRS and SRS R2 Series
Motor Driver Modules

Table of Contents

Overview

Applicable Products

Table 1 lists the products for which this user guide is applicable.

Table 1: Applicable Products

Item	Applicable Part Number
1	MMP760400-75-R2-1
2	MMP760200-75-R2-1
3	MMP760100-75-R2-1
4	MMS760400-48-R2-1
5	MMS760200-48-R2-1
6	MMP740100-55-R2-1
7	MMP740050-55-R2-1
8	MMS740100-24-R2-1
9	MMS740050-24-R2-1

Section 1. Product Information

1.1 Introduction

The PRS series of motor driver modules are fully integrated servo motor controllers with a very small size, which provide field-oriented control (FOC) for permanent magnet synchronous motors (PMSMs). They integrate an accurate angle sensor, communication interface, advanced motion controller, power inverter, and multi-function external input/outputs (I/Os) into a single package to provide a complete solution (see Figure 1). These motor driver modules simplify the development process for motor control systems.

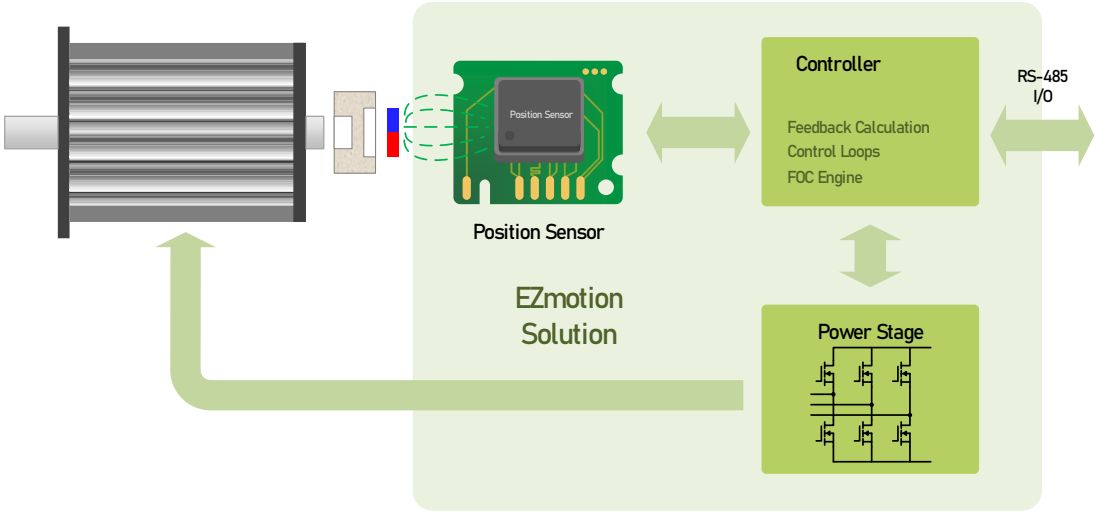


Figure 1: Motor Control Block Diagram

The SRS series of all-in-one smart motors are integrated servo motors with a compact size, providing a total solution for servo control applications. They integrate a servo motor, motor driver module, and I/O interface to provide a complete smart motor solution.

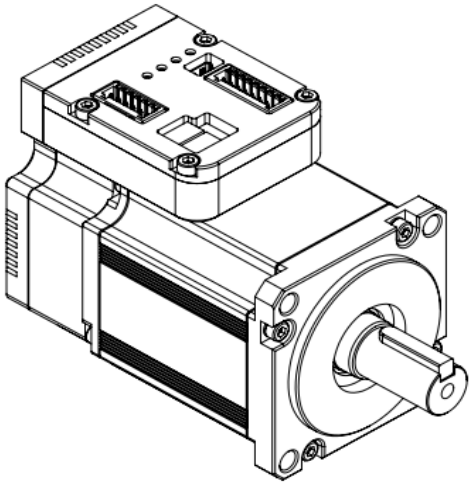


Figure 2: SRS Series All-in-One Smart Motor

The motor can operate in speed, velocity, or torque control modes. The motor is controlled through either an RS-485 interface with Modbus protocol, or with simple I/O signals. Configurable parameters can be set using a simple PC-based program, which interfaces with the motor through a USB debugging interface. Once the parameters have been optimized, they can be saved to module's non-volatile memory (NVM).

To use the PRS series motor driver module with a servo motor, integrate the module and the motor with a magnet at the motor shaft. Connect to the module a USB debugging interface or external pulse inputs, then use the MotionLAB GUI software to tune and set the control parameters.

For the hardware specifications, refer to the corresponding datasheets on the EZmotion website.

1.2 Features

- Embedded Angular Sensor
- Field-Oriented Control (FOC)
- RS-485 Interface with Modbus Protocol
- Supports CiA DSP402 Profile Position (PP), Profile Velocity (PV), Profile Torque (PT), and Homing Modes
- Motor and System Parameter Identification and Loop Parameter Auto-Tuning
- AccuFilter for Low Noise and Vibration
- Advanced Motion Controller Enables Smooth Changes between Different Operation Modes
- Two Separate Notch Filters for Elastic Load Optimization
- External I/O Interface Supports PUL/DIR, PWM/DIR, or A/B Signal Inputs
- General-Purpose I/O for Logic Signal Inputs or Outputs
- DC Voltage Detection and Limit Function
- Brake Control Logic
- Temperature-Sensing
- Rich Protection Functions
- Power, Alarm, and Communication Status Indication

Section 2. Communication

The PRS and SRS series product use the Modbus RTU protocol over the RS-485 interface to exchange messages between the motion controller and the motors. A master-slave system has one node (the master node) that issues explicit commands to one of the slave nodes, and does not communicate with the other slaves. The slave nodes never communicate with each other.

In the module, control parameters are stored as discontinuous holding registers. They can be accessed using the Modbus function codes 0x03 (read holding registers), 0x06 (write single register), and 0x10 (write multiple registers).

2.1 Communication Protocol

The data frame format contains an address field, a function code, data, and a cyclic redundancy check (CRC) (see Figure 3). For each byte in the data frame, the data format is 8 data bits, 1 stop bit, and 1 even polarity check bit.

Figure 3: Modbus RTU Data Frame

Modbus allows 256 different addresses. Address 0 is the broadcast address; all slave nodes recognize the broadcast address. Addresses 1~247 are valid individual addresses, and addresses 248~255 are reserved.

An exception response is sent if a communication error is detected. Figure 4 shows the exception data frame format.

Figure 4: Modbus Exception Data Frame

For the supported function codes, the data field is defined in the following sections.

2.1.1 Reading Holding Registers (0x03)

This function code is used to read the contents of the holding registers in a slave device.

8-bit parameters occupy the lower byte of the 16-bit holding register, with the upper byte set to 0. 16-bit parameters occupy a single 16-bit holding register. 32-bit parameters occupy 2 continuous holding registers. The data format for the request, response, and error frames are shown below.

Request

Slave Address	Function Code	Register Address		Quantity of Registers		CRC
1 byte	0x03	High byte	Low byte	High byte	Low byte	2 bytes

Response

Slave Address	Function Code	Number of Bytes Returned	Register Value 1		……	CRC
1 byte	0x03	1 byte	High byte	Low byte	……	2 bytes

Error

Slave Address	Error Code	Exception Code	CRC
1 byte	0x80 + 0x03	0x01 or 0x02 or 0x03 or 0x04	2 bytes

Table 2: Read Actual Velocity (0x66C0) Using Slave Address 0x01

Request		Response	
Field Name	Data (Hex)	Field Name	Data (Hex)
Address	0x01	Address	0x01
Function Code	0x03	Function Code	0x03

Starting Address (High)	0x66	Byte Count	0x04
Starting Address (Low)	0xC0	Register Value (High)	0x08
Quantity of Registers (High)	0x00	Register Value (Low)	0x73
Quantity of Registers (Low)	0x02	Register Value (High)	0x00
CRC (Low)	0xDA	Register Value (Low)	0x00
CRC (High)	0xBF	CRC (Low)	0x09
-	-	CRC (High)	0x88

2.1.2 Write Single Register (0x06)

This function code is used to write a single holding register in a slave device. This function can be used to write 8-bit and 16-bit control parameters, as they both occupy 1 holding register.

Request

Slave Address	Function Code	Register Address		Value to Write		CRC
1 byte	0x06	High Byte	Low byte	High Byte	Low Byte	2 bytes

Response

Slave Address	Function Code	Register Address		Written Value		CRC
1 byte	0x06	High Byte	Low Byte	High Byte	Low Byte	2 bytes

Error

Slave Address	Error Code	Exception Code	CRC
1 byte	0x80 + 0x06	0x01 or 0x02 or 0x03 or 0x04	2 bytes

Table 3: Write Control Word (0x6400) Using Slave Address 0x01

Request		Response	
Field Name	**Data (Hex)**	**Field Name**	**Data (Hex)**
Address	0x01	Address	0x01
Function Code	0x06	Function Code	0x06
Starting Address (High)	0x64	Starting Address (High)	0x64
Starting Address (Low)	0x00	Starting Address (Low)	0x00
Value to Write (High)	0x00	Register value (High)	0x00
Value to Write (Low)	0x06	Register value (Low)	0x06
CRC (Low)	0x16	CRC (Low)	0x16
CRC (High)	0xF8	CRC (High)	0xF8

2.1.3 Write Multiple Registers (0x10)

This function code is used to write a block of continuous registers in a slave device. This function can be used to write 32 bits control parameters with register length 2.

Request

Slave Address	Function Code	Start Register Address	Register Number	Byte Count	Register Value 1	……	CRC
1 byte	0x10	2 bytes	2 bytes	1 byte	2 bytes	……	2 bytes

Response

Slave Address	Function Code	Start Register Address		Register Number		CRC
1 byte	0x10	High byte	Low byte	High byte	Low byte	2 bytes

Error

Slave Address	Error Code	Exception Code
1 byte	0x80 + 0x10	0x01 or 0x02 or 0x03 or 0x04

Table 4: Write Target Velocity (0x6FF0) Using Slave Address 0x01

Request		Response	
Field Name	**Data (Hex)**	**Field Name**	**Data (Hex)**
Address	0x01	Address	0x01
Function Code	0x10	Function Code	0x10
Starting Address (High)	0x6F	Starting Address (High)	0x6F
Starting Address (Low)	0xF0	Starting Address (Low)	0xF0
Register Number (High)	0x00	Register Number (High)	0x00
Register Number (Low)	0x02	Register Number (Low)	0x02
bytes to Write	0x04	CRC (Low)	0x5C
Value to Write (High)	0x00	CRC (High)	0xEF
Value to Write (Low)	0x01	-	-
Value to Write (High)	0x00	-	-
Value to Write (Low)	0x00	-	-
CRC (Low)	0x44	-	-
CRC (High)	0xD9	-	-

2.2 Related Registers

Address	Description	Access	Data Type	Unit	Range	Default
3050h	Modbus address	R/W	UINT8	-	1 to 247	0x01
3060h	Modbus baud rate	R/W	UINT16	100bps	-	0x0480
3070h	Modbus parity	R/W	UINT8	-	0 to 2	2

Section 3. Operational Mode

3.1 State Machine

3.1.1 Function Description

The module uses a finite state machine to manage the motor controller's state transitions. The state is changed according to the current state, control word or local signals, and fault signals. Figure 5 shows the finite state automation diagram.

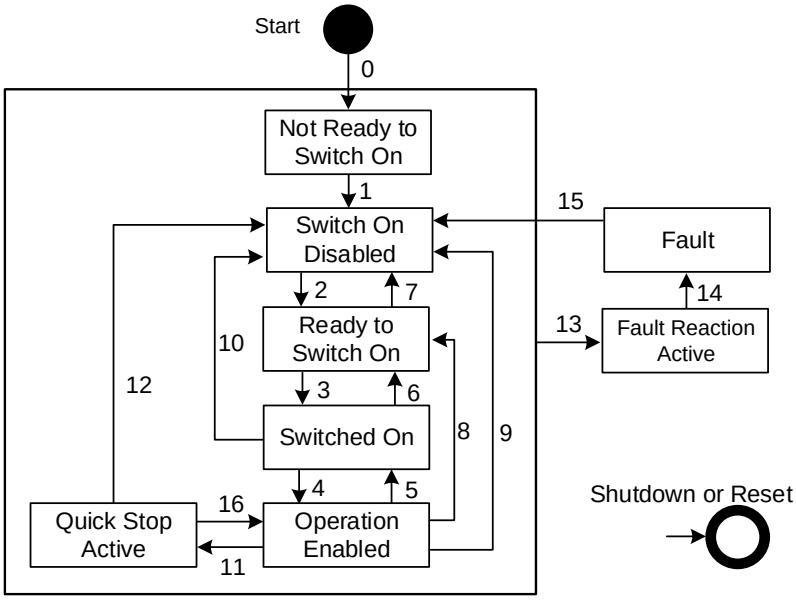


Figure 5: Finite State Automation

Table 5 lists the transition event and actions.

Table 5: Transition Events and Actions

Transition	Event(s)	Action(s)
0	Automatic transition after power-on or reset	Perform self-initialization and self-test.
1	Automatic transition	Communication is activated.
2	Shutdown command	None.
3	Switch-on command	Power stage switches on.
4	Enable operation command	Drive function is enabled.
5	Disable operation command	Drive function is disabled.
6	Shutdown command	Motor is free to rotate.
7	Quick stop command	None.
8	Shutdown command	Motor is free to rotate.
9	Disable voltage command	Motor is free to rotate.
10	Disable voltage command or quick stop command	Motor is free to rotate.
11	Quick stop command	The quick stop function has started.
12	Disable voltage command or quick stop finished	Power stage switches off.
13	Fault signal	Fault reaction function is executed.
14	Automation transition	Drive function is disabled.
15	Fault reset command	Leave fault status (if no fault exists).
16	Enable operation command	Drive function is enabled.

Table 10 lists the relationship between certain transition events and “Control word”, where “0” means that data for this bit is set to 0, “1” means the data for this bit is set to 1, and “x” means that the value can be 0 or 1.

Table 6: Command Coding

Command	“Control Word” Bits					Transitions
	Bit[7]	Bit[3]	Bit[2]	Bit[1]	Bit[0]	
Shutdown	0	x	1	1	0	2, 6, 8
Switch on	0	0	1	1	1	3
Switch on + enable operation	0	1	1	1	1	3 + 4 (1)
Disable voltage	0	x	x	0	x	7, 9, 10, 12
Quick stop	0	x	0	1	x	7, 10, 11
Disable operation	0	0	1	1	1	5
Enable operation	0	1	1	1	1	4, 16
Fault reset	↑	x	x	x	x	15

Note:

1) The automatic transition to the enable operation state is made after executing the switch on state.

After start-up, the state transition to switch on is disabled (see Figure 5 on page 14). Writing 0x0006 to “Control word” (the shutdown command) causes the state to advance to the ready to switch on state. Then, writing 0x000F to “Control word” (the “Switch on” and “Enable operation” command) causes the state to advance to the enable operation state, and the motor operates according to the set operation mode. If the motor is in a fault state and there are no additional errors, then a rising edge on “Control word”, bit[7] returns the system to the switch on disabled state.

3.1.2 Related Registers

Address	Description	Access	Data Type	Unit	Range	Default
6040h	Control word	R/W	UINT16	-	UINT16	0
6041h	Status word	RO	UINT16	-	UINT16	-

3.2 Profile Position (PP) Mode

3.2.1 Function Description

Profile position (PP) mode accepts the user’s target position command and profile parameters. The trajectory generator automatically generates a position curve according to the profile parameters. The profile velocity, profile acceleration, and profile deceleration can be changed before a new set point is updated. Figure 6 shows the overall structure for this mode.

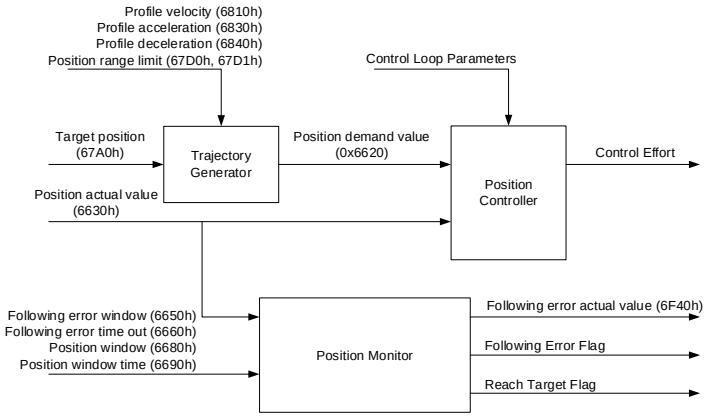


Figure 6: Profile Position Mode Block Diagram

The module uses a trapezoidal profile, with a constant acceleration and deceleration between two set points (See Figure 7).

If the profile velocity (set via 6081h) has not been reached and there is enough distance left for the motor to decrease the velocity and stop, the motor increases the velocity using the profile acceleration object (set via 6083h). When the velocity reaches the profile velocity, the motor limits the velocity at that value. When the trajectory generator block detects that the remaining distance is not sufficient for the motor to decrease the velocity using the profile deceleration (set via 6084h), the motor velocity decreases, so that the velocity is zero once the target position is reached.

If a new position command is issued while the motor speed is decreasing, the trajectory generator increases the motor speed again to ensure that the motor reaches the target position as soon as possible.

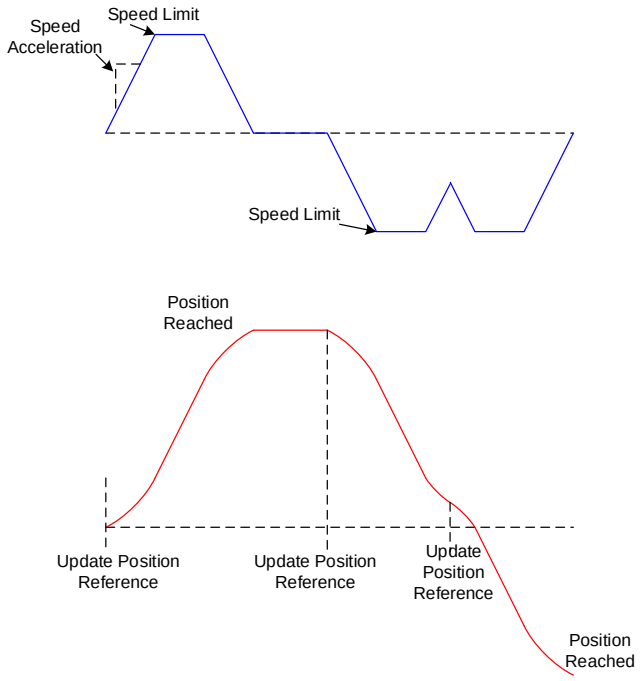


Figure 7: Profile Position Trajectory Generator

3.2.2 Related Registers

Address	Description	Access	Data Type	Unit	Range	Default
0x6400	Control word	R/W	UINT16	-	UINT16	0
0x6410	Status word	R/W	UINT16	-	UINT16	-
0x6600	Operation modes	R/W	INT8	-	-4 to +6	0
0x6610	Operation modes display	RO	INT8	-	-4 to +6	0
0x6620	Position demand value	RO	INT32	INC	INT32	0
0x6630	Position actual value internal	RO	INT32	INC	INT32	0
0x6650	Following error window	R/W	UINT32	INC	UINT32	182
0x6660	Following error time out	R/W	UINT16	ms	UINT16	10
0x6670	Position window	R/W	UINT32	INC	UINT32	182
0x6680	Position window time	R/W	UINT16	ms	UINT16	10
0x67A0	Target position	R/W	INT32	INC	INT32	0
0x67D0	Min software position limit	R/W	INT32	INC	INT32	-2^{31}
0x67D1	Max software position limit	R/W	INT32	INC	INT32	$2^{32} - 1$
0x6810	Profile velocity	R/W	UINT32	INC/s	UINT32	655360
0x6830	Profile acceleration	R/W	UINT32	INC/s^2	UINT32	3276800
0x6840	Profile deceleration	R/W	UINT32	INC/s^2	UINT32	3276800
0x6860	Motion profile type	R/W	INT16	-	0	0

0x6F40	Following error actual value	RO	INT32	INC	INT32	0

3.2.3 Use of “Control Word” and “Status Word”

Address	Description	Access	Data Type	Unit	Range	Default
6400h	Control word	R/W	UINT16	-	UINT16	0
Bits	**Name**	**Description**				
15:9	Reserved	Unused.				
8	Halt	Enable halt.				
7	Fault reset	Change from 0 to 1 to reset the internal fault status.				
6	Absolute/relative mode	0: Absolute position mode 1: Relative position mode				
5	Reserved	Unused				
4	New set point	The rising edge of this bit updates the new target position and profile parameters.				
3	Enable operation	Enter operation mode.				
2	Quick stop	Enter quick stop mode.				
1	Enable voltage	No effect; DC power is always enabled.				
0	Switch on	Enable power stage switch.				

Address	Description	Access	Data Type	Unit	Range	Default
6040h	Status word	RO	UINT16	-	UINT16	-
Bits	**Name**	**Description**				
15:14	Reserved	Unused.				
13	Set point acknowledge	1: A new set point is allowed 0: The previous set point still in process				
12	Following error	1: The position following error is too large 0: The position following error is within the set range				
11	Internal limit active	If position limit is reached, this is set.				
10	Target reached	0: Target not reached (if Halt equals 0); axis deceleration (if Halt equals 1) 1: Target reached (if Halt equals 0); velocity axis is 0 (if Halt equals 1)				
9	Remote	If set, parameters may be modified by communication. This bit is always 1.				
8	Reserved	Reserved.				
7	Warning	0: No warning 1: Warning				
6	Switch on disabled	Sets the switch on disabled state.				
5	Quick stop	1: Quick stop is able to perform 0: Quick stop is performing (or is unable to perform)				
4	Voltage enabled	Always set to 1. A high voltage is applied to the drive.				
3	Fault	If a fault occurs, this bit is set.				
2	Operation enabled	Operation enabled mode is entered.				
1	Switch on	The driver switch is on.				
0	Ready to switch on	The driver is ready to switch.				

3.2.4 Simple Example

For this example, move the motor position to 10 revolutions and 0 degrees, then change it to 20 revolutions and 0 degrees in PP mode.

Steps	Register Address	Data	Description
1	6600h	0x01	Set the mode to profile position mode.
2	6400h	0x0006	Shutdown command.
3	6400h	0x000F	Switch on and enable operation command.
4	67A0h	0x000A0000	Set the target position to 10 rounds and 0 degrees.
5	6400h	0x001F	The new set point is active.
6	6410h	bit 10	Check the target reach flag.
7	67A0h	0x00140000	Set the target position to 20 rounds and 0 degrees.
8	6400h	0x000F	Clear the new set point active bit.
9	6400h	0x001F	The new set point is active.

3.3 Homing Mode

3.3.1 Function Description

Homing mode is used to find the home position (also called the datum, reference point, or zero point). There are various methods to achieve this using a limit switch at the end of travel, or a home switch (zero-point switch) in the middle of travel. Most of the methods also use the index (zero) pulse from an angle sensor (see Figure 8).

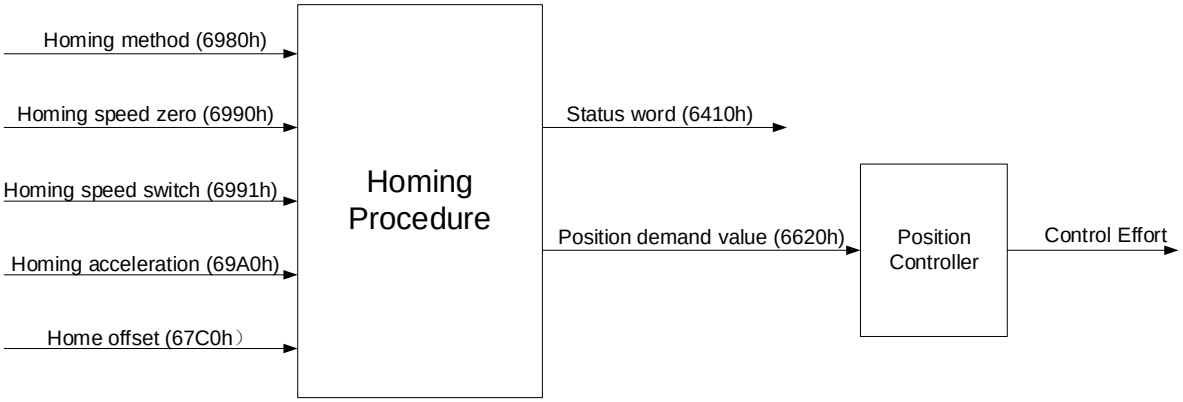


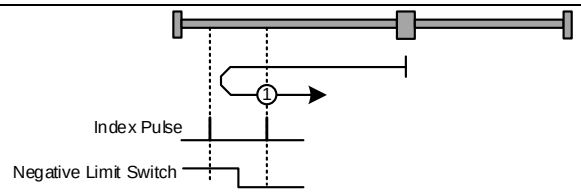
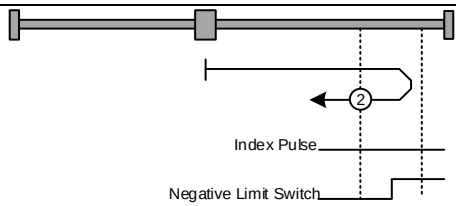
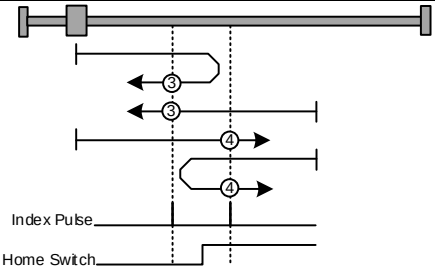
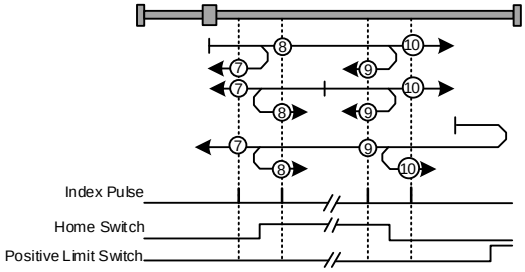
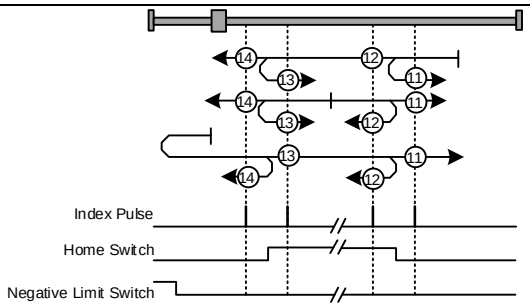
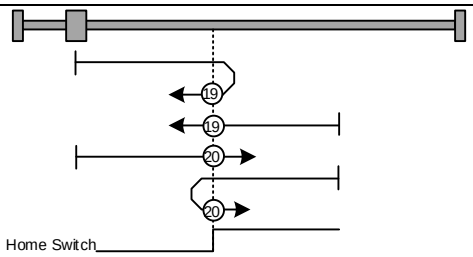
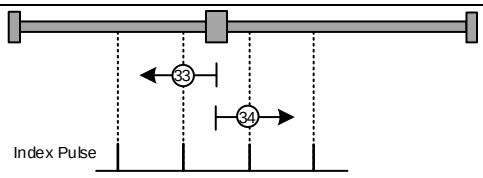
Figure 8: Homing Mode Block Diagram

The user should specify the speed, acceleration, and homing method. There are two homing speeds; typically, the faster speed is used to find the home switch (homing speed switch), and the slower speed is used to find the index pulse (homing speed zero).

The controller supports methods 1–14, methods 17–30, method 33, and method 34, as defined in the CiA DSP 402 standard. In addition, the controller also supports homing with torque limit methods. Table 7 lists the description and diagram for each method.

Table 7: Homing Methods

Method	Description	Diagram
-3	Homing clockwise with limited torque.	These two methods allow for homing without a limit switch or home switch. The motor goes in one direction until it reaches the mechanical range limit. The motor output torque is limited with the homing torque settings (register 2700h).
-2	Homing counterclockwise with limited torque.	

1	Homing on negative limit switch and index pulse.	
2	Homing on positive limit switch and index pulse.	
3, 4	Homing on positive home switch and index pulse.	
7–10	Homing on the home switch and index pulse (positive initial motion).	
11–14	Homing on the home switch and index pulse (negative initial motion).	
17–30	These methods are similar to methods 1–14 except that the home position is not dependent on the index pulse. It is only dependent on the relevant home or limit switch transitions. For example, methods 19 and 20 are similar to methods 3 and 4.	
33, 34	Homing on index pulse.	

3.3.2 Related Registers

Address	Description	Access	Data Type	Unit	Range	Default
2700h	Homing torque	R/W	UINT16	‰	UINT16	500
2701h	Homing time	R/W	UINT16	ms	UINT16	500
2072h	Power-on homing enable	R/W	UINT8	-	0 to 1	0
6400h	Control word	R/W	UINT16	-	UINT16	0
6410h	Status word	R/W	UINT16	-	UINT16	-
6600h	Operation modes	R/W	INT8	-	-4 to +6	0
6610h	Operation modes display	RO	INT8	-	-4 to +6	0
67C0h	Home offset	R/W	INT32	INC	INT32	0
6980h	Homing method	R/W	INT8	-	0 to 35	0
6990h	Homing speed switch	R/W	UINT32	INC/s	UINT32	0
6991h	Homing speed zero	R/W	UINT32	INC/s	UINT32	0
69A0h	Homing acceleration	R/W	UINT32	INC/s^2	UINT32	0

3.3.3 Use of “Control Word” and “Status Word”

Address	Description	Access	Data Type	Unit	Range	Default
6400h	Control word	R/W	UINT16	-	UINT16	0
Bits	**Name**	**Description**				
15:9	Reserved	Unused.				
8	Halt	Enable halt.				
7	Fault reset	Change from 0 to 1 to reset the internal fault status.				
6:5	Reserved	Unused.				
4	Homing operation	1: Homing operation enabled 0: Homing operation disabled				
3	Enable operation	Enter operation mode.				
2	Quick stop	Enter quick stop mode.				
1	Enable voltage	No effect, DC power is always enabled.				
0	Switch on	Enable power stage switch.				

Address	Description	Access	Data Type	Unit	Range	Default
6410h	Status word	RO	UINT16	-	UINT16	-
Bits	**Name**	**Description**				
15:14	Reserved	Unused.				
13	Homing error	1: A homing error has occurred 0: No homing error has occurred				
12	Homing attained	1: Homing is complete 0: Homing has not started (or is in progress)				
11	Internal limit active	1: The internal limit has been reached 0: The internal limit has not been reached				
10	Target reached	If the set point is reached, this bit is set.				
9	Remote	If set, parameters may be modified by communication.				
8	Reserved	Unused.				
7	Warning	0: No warning 1: Warning				
6	Switch on disabled	If set, the driver is at the switch on disabled state.				
5	Quick stop	1: Quick stop is able to perform 0: Quick stop is performing (or is unable to perform)				
4	Voltage enabled	Always 1. A high voltage is applied to the drive.				
3	Fault	If a fault occurs, this bit is set.				
2	Operation enabled	Operation enabled mode is entered.				
1	Switch on	The driver switch is on.				
0	Ready to switch on	The driver is ready to switch.				

3.3.4 Simple Example

For this example, homing the motor is accomplished using homing method 1.

Steps	Register Address	Data	Description
1	6600h	0x06	Set the homing mode.
2	6400h	0x0006	Shutdown command.
3	6400h	0x000F	Switch on + enable operation command.
4	6980h	0x01	Set the homing method to 1.
4	6990h	0x00020000	Set the homing speed switch to 120rpm.
5	6991h	0x00010000	Set the homing speed switch to 60rpm.
6	69A0h	0x00320000	Set the homing acceleration to 3000rpm/s.
7	6400h	0x001F	Enable homing operation.

3.4 Profile Velocity (PV) Mode

3.4.1 Function Description

In profile velocity (PV) mode, the user can set the profile velocity, profile acceleration, and profile deceleration. The controller automatically generates a smooth velocity curve. The velocity demand value generated by the trajectory generator goes to the velocity controller, and the controller performs closed-loop speed control.

The velocity monitor block monitors when the speed reaches the target and the motor speed zero status. This block sets the corresponding bits in “Status word” (see Figure 9).

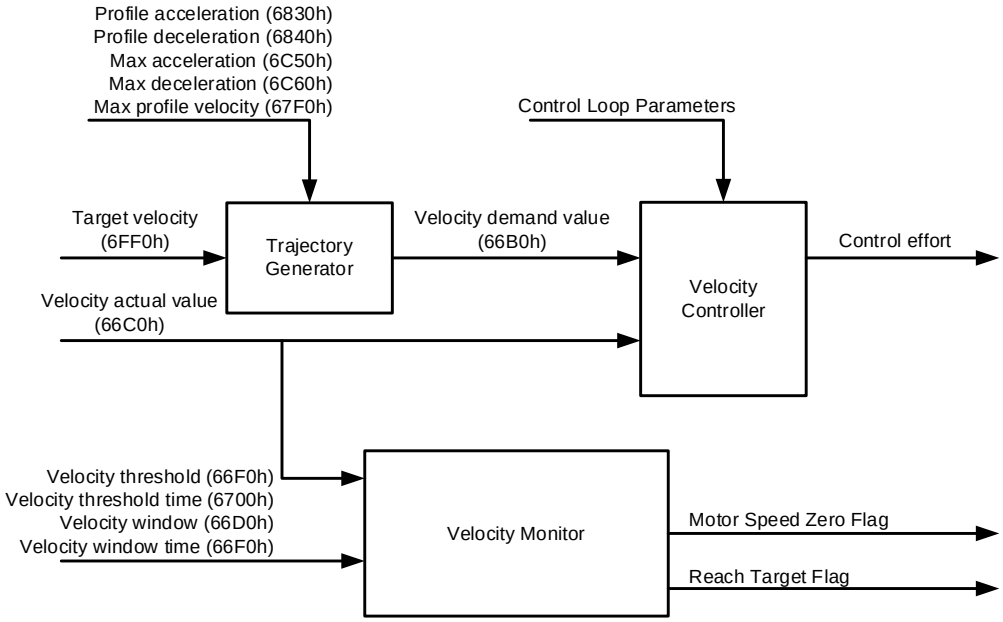


Figure 9: Profile Velocity Mode Block Diagram

A trapezoidal profile is supported (see Figure 10 on page 22). If the actual velocity value is below the target velocity after a new speed command is sent to the controller, the motor speed decreases. Otherwise, the motor speed increases.

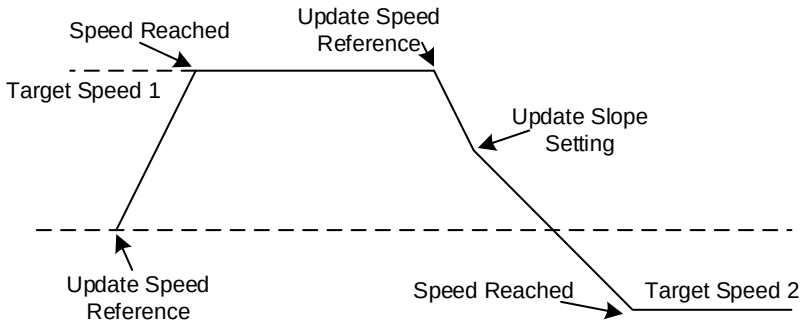


Figure 10: Trapezoidal Speed Profile

3.4.2 Related Registers

Address	Description	Access	Data Type	Unit	Range	Default
6400h	Control word	R/W	UINT16	-	UINT16	0
6410h	Status word	R/W	UINT16	-	UINT16	-
6600h	Operation modes	R/W	INT8	-	-4 to +10	0
6610h	Operation modes display	RO	INT8	-	-4 to +10	0
66B0h	Velocity demand value	RO	INT32	INC/s	INT32	0
66C0h	Velocity actual value	RO	INT32	INC/s	INT32	0
66D0h	Velocity window	R/W	UINT16	INC/s	UINT16	32768
66E0h	Velocity window time	R/W	UINT16	ms	UINT16	10
66F0h	Velocity threshold	R/W	UINT16	INC/s	UINT16	32768
6700h	Velocity threshold time	R/W	UINT16	ms	UINT16	10
6830h	Profile acceleration	R/W	UINT32	INC/s^2	UINT32	3276800
6840h	Profile deceleration	R/W	UINT32	INC/s^2	UINT32	3276800
6C50h	Max acceleration	R/W	UINT32	INC/s^2	UINT32	$2^{32} - 1$
6C60h	Max deceleration	R/W	UINT32	INC/s^2	UINT32	$2^{32} - 1$
6FF0h	Target velocity	R/W	INT32	INC/s	INT32	0

3.4.3 Use of “Control Word” and “Status Word”

Address	Description	Access	Data Type	Unit	Range	Default
6400h	Control word	R/W	UINT16	-	UINT16	0
Bits	**Name**	**Description**				
15:9	Reserved	Unused.				
8	Halt	Enable halt.				
7	Fault reset	Change from 0 to 1 to reset the internal fault status.				
6:4	Reserved	Unused.				
3	Enable operation	Enter operation mode.				
2	Quick stop	Enter quick stop mode.				
1	Enable voltage	No effect; the DC power is always enabled.				
0	Switch on	Enable the power stage switch.				

Address	Description	Access	Data Type	Unit	Range	Default
6410h	Status word	RO	UINT16	-	UINT16	-
Bits	**Name**	**Description**				
15:13	Reserved	Unused.				
12	Zero speed	1: Speed is equal to zero 0: Speed is not equal to zero				
11	Internal limit active	If the internal limit is reached, this bit is set.				
10	Target reached	0: Target not reached (if Halt equals 0); axis deceleration (if Halt equals 1) 1: Target reached (if Halt equals 0); velocity axis is 0 (if Halt equals 1)				
9	Remote	If set, parameters may be modified by communication.				
8	Reserved	Unused.				

7	Warning	0: No warning 1: Warning
6	Switch on disabled	If set, the driver is in switch on disabled state.
5	Quick stop	1: Quick stop is able to perform 0: Quick stop is performing (or is unable to perform)
4	Voltage enabled	Always 1. A high voltage is applied to the drive.
3	Fault	If a fault occurs, this bit is set.
2	Operation enabled	Operation enabled mode is entered.
1	Switch on	The driver switch is on.
0	Ready to switch on	The driver is ready to switch.

3.4.4 Simple Example

For this example, set the motor velocity to 1000rpm in PV mode.

Steps	Address	Data	Description
1	6600h	0x03	Set the mode to profile velocity mode.
2	6400h	0x0006	Shutdown command.
3	6FF0h	0x0010AAAB	Set the target speed to 1000rpm.
4	6830h	0x00320000	Set the profile acceleration to 3000rpm/s.
5	6840h	0x00320000	Set the profile deceleration to 3000rpm/s.
6	6400h	0x000F	Switch on + enable operation command.

3.5 Profile Torque (PT) Mode

3.5.1 Function Description

Profile torque (PT) mode allows the control device to command the target torque value, which is processed by the trajectory generator. The torque slope and maximum torque are required for the torque trajectory generator.

Figure 11 shows the PT mode block diagram. The trajectory generator calculates the torque demand value according to the profile parameter, then sends the value to the torque controller block. The torque controller performs closed-loop torque control according to the torque's demanded value and the torque's actual value.

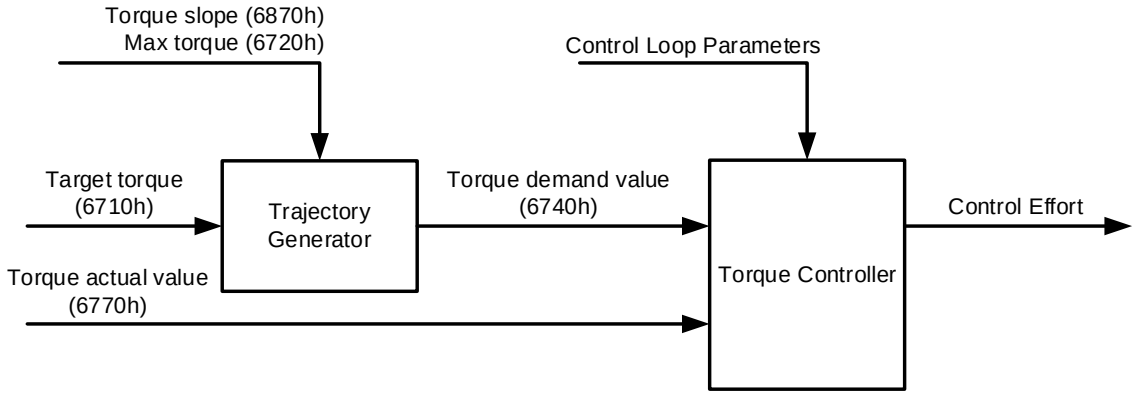


Figure 11: Profile Torque Mode Functional Block Diagram

3.5.2 Related Registers

Address	Description	Access	Data Type	Unit	Range	Default
6400h	Control word	R/W	UINT16	-	UINT16	0
6410h	Status word	RO	UINT16	-	UINT16	-
6600h	Operation modes	R/W	INT8	-	-4 to +10	0
6610h	Operation modes display	RO	INT8	-	-4 to +10	-
6710h	Target torque	R/W	INT16	‰	-3000 to +3000	100

6720h	Max torque	R/W	UINT16	‰	0 to 3000	3000
6730h	Max current	R/W	UINT16	‰	0 to 3000	3000
6740h	Torque demand value	RO	INT16	‰	-3000 to +3000	-
6770h	Torque actual value	RO	INT16	‰	-3000 to +3000	-
6780h	Current actual value	RO	INT16	‰	-3000 to +3000	-
6870h	Torque slope	R/W	UINT32	‰/s	UINT32	3000
6880h	Torque profile type	R/W	INT16	-	0	0

3.5.3 Use of “Control Word” and “Status Word”

Address	Description	Access	Data Type	Unit	Range	Default
6400h	Control word	R/W	UINT16	-	UINT16	0
Bits	**Name**	**Description**				
15:9	Reserved	Unused.				
8	Halt	Enable halt.				
7	Fault reset	Change from 0 to 1 to reset the internal fault status.				
6:4	Reserved	Unused.				
3	Enable operation	Enter operation mode.				
2	Quick stop	Enter quick stop mode.				
1	Enable voltage	No effect; the DC power is always enabled.				
0	Switch on	Enable the power stage switch.				

Address	Description	Access	Data Type	Unit	Range	Default
6410h	Status word	RO	UINT16	-	UINT16	-
Bits	**Name**	**Description**				
15:12	Reserved	Unused.				
11	Internal limit active	If the internal limit is reached, this bit is set.				
10	Target reached	0: Target not reached (if Halt equals 0); axis deceleration (if Halt equals 1) 1: Target reached (if Halt equals 0); velocity Axis is 0 (if Halt equals 1)				
9	Remote	If set, parameters may be modified by communication.				
8	Reserved	Unused.				
7	Warning	0: No warning 1: Warning				
6	Switch on disabled	If set, the driver is in switch on disabled state.				
5	Quick stop	1: Quick stop is able to perform 0: Quick stop is performing (or is unable to perform)				
4	Voltage enabled	Always 1. A high voltage is applied to the drive.				
3	Fault	If a fault occurs, this bit is set.				
2	Operation enabled	Operation enabled mode is entered.				
1	Switch on	The driver switch is on.				
0	Ready to switch on	The driver is ready to switch.				

3.5.4 Simple Example

For this example, run the motor in PT mode with a 100‰ target torque.

Steps	Register Address	Data	Description
1	6600h	0x04	Set the mode to profile torque mode.
2	6720h	0x0BB8	Set the max torque to 3000‰.
3	6870h	0x000003E8	Set the torque slope to 1000‰/s.
4	6710h	0x0064	Set the target torque to 100‰.
5	6400h	0x0006	Shutdown command.
6	6400h	0x000F	Switch on and enable operation command.

3.6 I/O-Controlled Multi-Position Mode

3.6.1 Function Description

I/O-controlled multi-position mode supports changing the target position according to the I/O signal levels. To use this mode, some of the I/Os must be selected as Multi-Point 1, Multi-Point2 and Multi-Point3. For the I/O function definitions, see register details of 2300h~230Fh beginning on page 63.

The target position, profile velocity, profile acceleration, and profile deceleration can be set separately for each stage. Table 8 shows the relationship between the I/O levels and selected target velocity. For example, when Multi-Point3 is 0, Multi-Point2 is 1, and Multi-Point1 is 1, stage 2 is selected. The motor moves as 3111h, 3121h, and 3131h in the defined profile.

To use I/O control as the system enable source, set “Enable source” (2030h), bit[0] to 1, then the start/stop of the motor can be controlled by the I/O level.

Table 8: Relationship between I/O Levels and Selected Stage Number

Multi-Point3	Multi-Point2	Multi-Point1	Stage Number
0	0	0	No change, remains at the previous selection
0	0	1	0
0	1	0	1
0	1	1	2
.....			
1	1	1	6

3.6.2 Related Registers

Address	Description	Access	Data Type	Unit	Range	Default
2027h	Command type	R/W	UINT8	-	0 to 4	0
2300h	DI1 function	R/W	UINT8	-	0 to 6	0
2301h	DI2 function	R/W	UINT8	-	0 to 6	0
2302h	DI3 function	R/W	UINT8	-	0 to 6	0
2303h	DI4 function	R/W	UINT8	-	0 to 3	0
2304h	DI5 function	R/W	UINT8	-	0 to 4	4
2305h	DI6 function	R/W	UINT8	-	0	0
2306h	DI7 function	R/W	UINT8	-	0	0
2307h	DI8 function	R/W	UINT8	-	0	0
2308h	DO1 function	R/W	UINT8	-	0 to 3	0
2309h	DO2 function	R/W	UINT8	-	0 to 3	0
230Ah	DO3 function	R/W	UINT8	-	0	0
230Bh	DO4 function	R/W	UINT8	-	0 to 3	3
230Ch	DO5 function	R/W	UINT8	-	0	0
230Dh	DO6 function	R/W	UINT8	-	0	0
230Eh	DO7 function	R/W	UINT8	-	0	0
230Fh	DO8 function	R/W	UINT8	-	0	0
2310h	I/O polarity	R/W	UINT8	-	-	0
2320h	Command source	R/W	UINT16	-	-	0
3100h~3106h	Multi-target position	R/W	INT32	INC	INT32	0
3110h~3116h	Multi-profile acceleration	R/W	UINT32	INC/s^2	UINT32	0
3120h~3126h	Multi-profile deceleration	R/W	UINT32	INC/s^2	UINT32	0
3130h~3136h	Multi-profile velocity	R/W	UINT32	INC/s	UINT32	0

3.6.3 Simple Example

Steps	Register Address	Data	Description
1	6600h	0x03	Set the mode to profile velocity mode.
2	2027h	0x04	Set the command type to I/O.
3	2300h~230Fh	-	Select the I/O functions. At least one multi-point function should be selected.
4	2310h	-	Select the I/O polarities according to the requirements.
5	3100h~3106h	-	Set the target position for each stage.
6	3110h~3116h	-	Set the profile acceleration for each stage.
7	3120h~3126h	-	Set the profile deceleration for each stage.
8	3130h~3136h	-	Set the profile velocity for each stage.
9	20D0h	0x65766173	Store the parameters to the NVM.

After repowering the motor, it should be configured to I/O-controlled multi-position mode. Pull the ENA signal high to start the motor, then change the I/O levels of Multi-Point1, Multi-Point2, and Multi-Point3. The motor moves according to the pre-defined profile.

3.7 I/O-Controlled Multi-Velocity Mode

3.7.1 Function Description

I/O-controlled multi-velocity mode supports changing target velocity according to the I/O signal levels. To use this mode, some of the I/Os must be selected as Multi-Point 1, Multi-Point2 and Multi-Point3. For the I/O function definitions, see register details of 2300h~230Fh beginning on page 63.

The target velocity, profile acceleration and profile deceleration can be set separately for each stage. Table 8 on page 25 shows the relationship between the I/O levels and selected target velocity. For example, when Multi-Point3 is 0, Multi-Point2 is 1, and Multi-Point1 is 1, stage 2 is selected. The motor moves as 3111h, 3121h, and 3141h in the defined profile.

To use I/O control as the system enable source, set “Enable source” (2030h), bit[0] to 1, then the start/stop of the motor can be controlled by the I/O level.

3.7.2 Related Registers

Address	Description	Access	Data Type	Unit	Range	Default
2027h	Command type	R/W	UINT8	-	0 to 4	0
2300h	DI1 function	R/W	UINT8	-	0 to 6	0
2301h	DI2 function	R/W	UINT8	-	0 to 6	0
2302h	DI3 function	R/W	UINT8	-	0 to 6	0
2303h	DI4 function	R/W	UINT8	-	0 to 3	0
2304h	DI5 function	R/W	UINT8	-	0 to 4	4
2305h	DI6 function	R/W	UINT8	-	0	0
2306h	DI7 function	R/W	UINT8	-	0	0
2307h	DI8 function	R/W	UINT8	-	0	0
2308h	DO1 function	R/W	UINT8	-	0 to 3	0
2309h	DO2 function	R/W	UINT8	-	0 to 3	0
230Ah	DO3 function	R/W	UINT8	-	0	0
230Bh	DO4 function	R/W	UINT8	-	0 to 3	3
230Ch	DO5 function	R/W	UINT8	-	0	0
230Dh	DO6 function	R/W	UINT8	-	0	0
230Eh	DO7 function	R/W	UINT8	-	0	0
230Fh	DO8 function	R/W	UINT8	-	0	0
2310h	I/O polarity	R/W	UINT16	-	-	0
2320h	Command source	R/W	UINT16	-	-	0
3100h~3106h	Multi-target position	R/W	INT32	INC	INT32	0
3110h~3116h	Multi-profile acceleration	R/W	UINT32	INC/s^2	UINT32	0
3120h~3126h	Multi-profile deceleration	R/W	UINT32	INC/s^2	UINT32	0

3140h~3146h	Multi-target velocity	R/W	UINT32	INC/s	UINT32	0

3.7.3 Simple Example

Steps	Register Address	Data	Description
1	6600h	0x03	Set the mode to profile velocity mode.
2	2027h	0x04	Set the command type to I/O.
3	2300h~230Fh	-	Select the I/O functions. At least one multi-point function should be selected.
4	2310h	-	Select the I/O polarities according to the requirements.
5	3110h~3116h	-	Set the profile acceleration for each stage.
6	3120h~3126h	-	Set the profile deceleration for each stage.
7	3140h~3146h	-	Set the target velocity for each stage.
8	20D0	0x65766173	Store the parameters to the NVM.

After repowering the motor, it should be configured to I/O-controlled multi-position mode. Pull the ENA signal high to start the motor, then change the I/O levels of Multi-Point1, Multi-Point2, and Multi-Point3. The motor moves according to the pre-defined profile.

Section 4. Advanced Functions

4.1 Parameter Identification

4.1.1 Function Description

To make the motor controller simple and easy to use, this solution implements parameter identification and loop auto-tuning. Users must only set a few basic motor and driver parameters (e.g. rated voltage, rated current, rated speed, pole pairs, and current-sense gain). The driver module identifies other parameters (e.g. motor phase resistance, phase inductance, friction ratio, and load inertia). Based on the identified parameters, the controller calculates the appropriate loop parameters that optimize the dynamic response and system noise.

A range-limited parameter identification function is provided to ensure that the solution is suitable for range-limited systems. The total allowed revolutions for the motor and the revolutions used for acceleration and deceleration should be provided. If using unlimited range parameter identification, these parameters are not required.

After several seconds, the motor and system load parameters are identified. The loop control parameters are also updated according to the identified results. Figure 12 shows the block diagram.

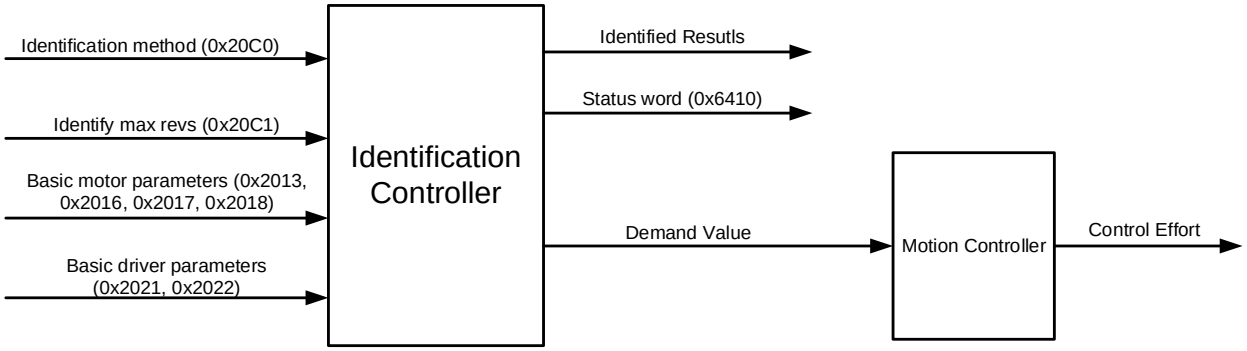


Figure 12: Parameter Identification Block Diagram

4.1.2 Related Registers

Address	Description	Access	Data Type	Unit	Range	Default
6400h	Control word	R/W	UINT16	-	UINT16	0
6410h	Status word	RO	UINT16	-	UINT16	-
6600h	Operation modes	R/W	INT8	-	-4 to +10	0
6610h	Operation modes display	RO	INT8	-	-4 to +10	-
2013h	Pole pairs	R/W	UINT8	-	UINT8	4
2016h	Rated voltage	R/W	UINT32	mV	UINT32	36000
2017h	Rated current	R/W	UINT32	mA	UINT32	5000
2018h	Rated speed	R/W	UINT32	rpm	UINT32	3000
2021h	Amplifier gain	R/W	UINT8	V/V	1 to 100	10
2022h	Current-sense resistor	R/W	UINT8	mΩ	1 to 100	10
20C0h	Identify method	R/W	UINT8	-	0 to 1	0
20C1h	Round max	R/W	UINT16	round	3 to 65535	50
20C2h	Round acceleration	R/W	UINT16	round	1 to 65535	10
20C3h	Round J	R/W	UINT16	round	1 to 65535	10
20C4h	Identification status	RO	UINT8	-	-	0
20C5h	Identified R_S	RO	UINT32	mΩ	-	0
20C6h	Identified L_D	RO	UINT32	µH	-	0
20C7h	Identified L_Q	RO	UINT32	µH	-	0
20C8h	Identified K_T	RO	UINT32	mNm/A	-	0
20C9h	Identified J	RO	UINT32	g x cm^2	-	0
20CAh	Identified B	RO	UINT32	mNm/rad	-	0
20CBh	Identified T_F	RO	UINT32	mNm	-	0

4.1.3 Use of “Control Word” and “Status Word”

Address	Description	Access	Data Type	Unit	Range	Default
6400h	Control word	R/W	UINT16	-	UINT16	0
Bits	**Name**	**Description**				
15:12	Reserved	Unused.				
11	Enable auto-tuning	1: Enabled 0: Disabled				
10:9	Reserved	Unused.				
8	Halt	Enable halt.				
7	Fault reset	Change from 0 to 1 to reset the internal fault status.				
6:4	Reserved	Unused.				
3	Enable operation	Enter operation mode.				
2	Quick stop	Enter quick stop mode.				
1	Enable voltage	No effect; the DC power is always enabled.				
0	Switch on	Enable the power stage switch.				

Address	Description	Access	Data Type	Unit	Range	Default
6410h	Status word	RO	UINT16	-	UINT16	-
Bits	**Name**	**Description**				
15	Reserved	Unused.				
14	Auto-tuning status	1: Finished 0: Ongoing or not started				
13:12	Reserved	Unused.				
11	Internal limit active	If position limit is reached, this bit is set.				
10	Target reached	If the set point is reached, this bit is set.				
9	Remote	If set, parameters may be modified by communication.				
8	Reserved	Unused.				
7	Warning	0: No warning 1: Warning				
6	Switch on disabled	If set, the driver is in a switch on disabled state.				
5	Quick stop	1: Quick stop is able to perform 0: Quick stop is performing (or is unable to perform)				
4	Voltage enabled	Always 1. A high voltage is applied to the drive.				
3	Fault	If a fault occurs, this bit is set.				
2	Operation enabled	Operation enabled mode is entered.				
1	Switch on	The driver switch is on.				
0	Ready to switch on	The driver is ready to switch.				

4.1.4 Simple Example

Identify the motor and mechanical system parameters with a range-limited method. The motor rated current is 9A, the rated voltage is 36V, the rated speed is 3000rpm, and the number of pole pairs is 4. For the motor driver, the current-sense resistor is 10mΩ, and the amplifier gain is 10. The maximum allowed motor revolutions is 50. Set the acceleration and deceleration revolutions to 10, and set the identify inertia revolution to 10.

Steps	Register Address	Data	Description
1	6600h	0xFC	Set the mode to profile torque mode.
2	2013h	0x04	Set the motor pole pairs to 4.
3	2016h	0x00008CA0	Set the rated voltage to 36000mV.
4	2017h	0x00002328	Set the rated current to 9000mA.
5	2018h	0x00000BB8	Set the motor rated speed to 3000rpm.
6	2022h	0x0A	Set the current-sense resistor to 10mΩ.

7	2021h	0x0A	Set the amplifier gain to 10V/V.
8	20C0h	0x01	Set the identify method to the range-limited method.
9	20C1h	0x0032	Set the identify max revs to 50 revolutions.
10	20C2h	0x000A	Set the identify max acceleration revolutions to 10 revolutions.
11	20C3h	0x000A	Set the identify max inertia revolutions to 10 revolutions.
12	6400h	0x0006	Shutdown command.
13	6400h	0x000F	Switch on + enable operation command.
14	20C4h	Read	Check identify status.
15	6400h	0x0006	Shutdown command after identification is complete.

4.2 INL Calibration

To improve the integral nonlinearity (INL) of the angle sensor, the controller embeds an INL calibration function to compensate the INL.

4.2.1 Function Description

To obtain the angle error between the sensor angle and the real mechanical angle, determine the reference angle. The driver module controls the motor to multiple even divided points in one mechanical revolution, then records the angle error between the magnet sensor and mechanical angle (see Figure 13). The driver module generates a lookup table based on the angle error, and uses the lookup table to compensate the INL during operation.

Use the MotionLAB GUI software to perform INL calibration.

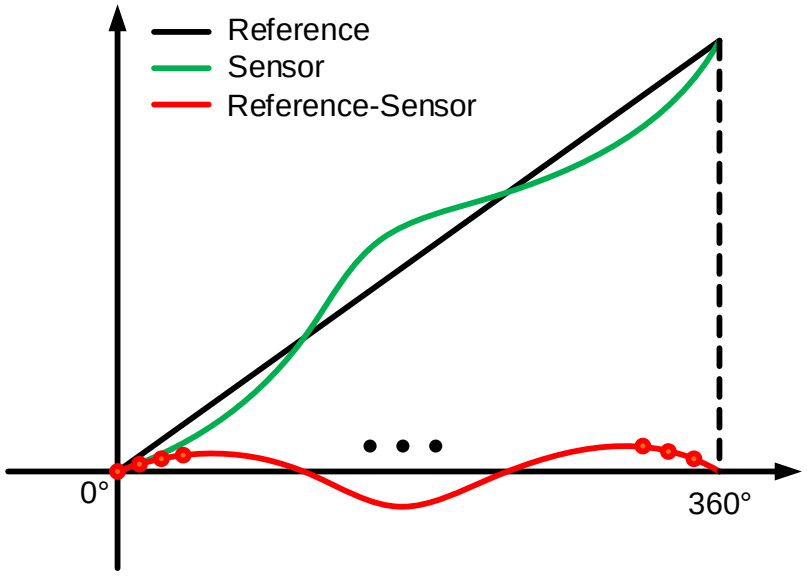


Figure 13: INL Calibration Principle

4.2.2 Related Registers

Address	Description	Access	Data Type	Unit	Range	Default
6400h	Control word	R/W	UINT16	-	UINT16	0
6410h	Status word	RO	UINT16	-	UINT16	-
6600h	Operation modes	R/W	INT8	-	-4 to +10	0
6610h	Operation modes display	RO	INT8	-	-4 to +10	-
2034h	INL enable	R/W	UINT8	-	0 to 1	0

4.2.3 Use of “Control Word” and “Status Word”

Address	Description	Access	Data Type	Unit	Range	Default
6400h	Control word	R/W	UINT16	-	UINT16	0
Bits	**Name**	**Description**				
15:12	Reserved	Unused.				
11	Enable	1: Enable INL calibration				
10:9	Reserved	Unused.				
8	Halt	1: Enable halt 0: Disable halt				
7	Fault reset	Change from 0 to 1 to reset the internal fault status.				
6:4	Reserved	Unused.				
3	Enable operation	Enter operation mode.				
2	Quick stop	Enter quick stop mode.				
1	Enable voltage	No effect; the DC power is always enabled.				
0	Switch on	Enable the power stage switch.				

Address	Description	Access	Data Type	Unit	Range	Default
6410h	Status word	RO	UINT16	-	UINT16	-
Bits	**Name**	**Description**				
15	Reserved	Unused.				
14	INL Status	1: INL calibration complete 0: INL calibration not started or ongoing				
13:12	Reserved	Unused.				
11	Internal limit active	If the position limit is reached, this bit is set.				
10	Target reached	If the set point is reached, this bit is set.				
9	Remote	If set, parameters may be modified by communication.				
8	Reserved	Unused.				
7	Warning	0: No warning 1: Warning				
6	Switch on disabled	If set, the driver is in switch on disabled state.				
5	Quick stop	1: Quick stop is able to perform 0: Quick stop is performing (or is unable to perform)				
4	Voltage enabled	Always 1. A high voltage is applied to the drive.				
3	Fault	If a fault occurs, this bit is set.				
2	Operation enabled	Operation enabled mode is entered.				
1	Switch on	The driver switch is on.				
0	Ready to switch on	The driver is ready to switch.				

4.3 Rotor Alignment

4.3.1 Function Description

To detect the rotor position, attach a magnet at the motor's shaft (see Figure 23). The magnetic angular sensor embedded in the driver module works as an absolute rotor position sensor. In the FOC algorithm, the electrical angle must be used for the Park and inverse Park transformations. The sensor only detects the magnetic field angle of the magnet attached to the motor shaft, which means that users should first determine the sensor position's biased angle compared to the rotor's permanent magnet flux.

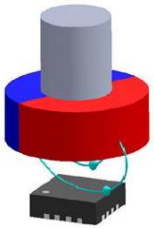


Figure 14: Sensing the Rotor Position

The device implements the find theta bias sequence by following the steps below:

1. Apply a current to the motor windings to generate torque.
2. Drag the rotor to a 300° electrical angle, then read the sensor data 1.
3. Apply a current to the motor windings to generate torque.
4. Drag the rotor to a 60° electrical angle, then read the sensor data 2.
5. Calculate THETA_BIAS and THETA_DIR from sensor data 1 and sensor data 2.
6. Store THETA_BIAS and THETA_DIR to the controller register.

The MotionLAB GUI software provides an automatic theta-bias function. After setting the biased current, send the find theta bias command. The controller should automatically follow the necessary steps.

4.3.2 Related Registers

Address	Description	Access	Data Type	Unit	Range	Default
6400h	Control word	R/W	UINT16	-	UINT16	0
6410h	Status word	RO	UINT16	-	UINT16	-
6600h	Operation modes	R/W	INT8	-	-4 to +10	0
6610h	Operation modes display	RO	INT8	-	-4 to +10	-
2026h	Theta bias current	R/W	UINT16	‰	0 to 3000	500

4.3.3 Use of “Control Word” and “Status Word”

Address	Description	Access	Data Type	Unit	Range	Default
6400h	Control word	R/W	UINT16	-	UINT16	0
Bits	**Name**	**Description**				
15:12	Reserved	Unused.				
11	Enable rotor alignment	1: Enabled 0: Disabled				
10:9	Reserved	Unused.				
8	Halt	Enable halt.				
7	Fault reset	Change from 0 to 1 to reset the internal fault status.				
6:4	Reserved	Unused.				
3	Enable operation	Enter operation mode.				
2	Quick stop	Enter quick stop mode.				
1	Enable voltage	No effect; the DC power is always enabled.				
0	Switch on	Enable the power stage switch.				

Address	Description	Access	Data Type	Unit	Range	Default
6410h	Status word	RO	UINT16	-	UINT16	-
Bits	**Name**	**Description**				
15	Reserved	Unused.				
14	Rotor aligning status	1: Rotor aligning finished 0: Rotor aligning on going or not started				
13:12	Reserved	Unused.				
11	Internal limit active	If the position limit is reached, this bit is set.				
10	Target reached	If the set point is reached, this bit is set.				
9	Remote	If set, parameters may be modified by communication.				
8	Reserved	Unused.				
7	Warning	0: No warning 1: Warning				
6	Switch on disabled	If set, the driver is in the switch on disabled state.				
5	Quick stop	1: Quick stop is able to perform 0: Quick stop is performing (or is unable to perform)				
4	Voltage enabled	Always 1. High voltage is applied to the drive.				
3	Fault	If a fault occurs, this bit is set.				
2	Operation enabled	Operation enabled mode is entered.				
1	Switch on	The driver switch is on.				
0	Ready to switch on	The driver is ready to switch.				

4.3.4 Simple Example

For this example, perform rotor alignment using a 500‰ bias current.

Steps	Register Address	Data	Description
1	6600h	0xFE	Set the mode to rotor aligning mode.
2	2026h	0x01F4	Set the biased current to 500‰ of the rated current.
2	6400h	0x0006	Shutdown command.
3	6400h	0x000F	Switch on and enable operation command.
4	6400h	0x080F	Enable rotor alignment.
5	6410h	Bit[14]	Check “Status word,” bit[14]; if it is 1, rotor aligning is complete.
6	6400h	0x0006	Shutdown command.

4.4 External I/O Function

For applications that need a simple control interface (e.g. PUL/DIR, PWM/DIR or A/B input signals), external I/O inputs are provided.

4.4.1 PUL/DIR Control

In PUL/DIR command control mode, the motor works in an incremental position mode similar to a stepper motor. Each rising edge on the PUL input moves the motor by a configurable increment. The number of pulses per revolution is set by Numerator and Denominator, and can be calculated with Equation (1):

$$\text{Pulses per revolution} = 65536 \times \text{Numerator} / \text{Denominator} \quad (1)$$

The movement direction is controlled by the DIR input signal. The polarity of the DIR input signal can be selected using “I/O polarity,” bit[4]. If the I/O polarity is non-inverted, a high level on the DIR input moves the motor clockwise.

4.4.2 PWM/DIR Control

In PWM/DIR command control mode, the motor velocity or torque is controlled by the PWM input’s duty cycle, while the direction is controlled by the signal on the DIR input.

In PV mode, the real motor speed is the target velocity multiplied by the PWM duty cycle.

In PT mode, the real motor torque is the target torque multiplied by the PWM duty cycle.

The PWM signal frequency should be between 100Hz and 10kHz to achieve an excellent adjustment resolution. The DIR input can control the velocity or torque direction. The polarity of the DIR input signal can be selected via “I/O polarity,” bit[4]. If I/O polarity is non-inverted, a high level on the DIR pin moves the motor clockwise.

4.4.3 A/B Control

In A/B control mode, quadrature signals can be inputted to the PUL and DIR inputs. The internal quadrature decoder calculates the target position from the A/B signals.

The number of pulses per revolution is set by Numerator and Denominator, estimated with Equation (2):

$$\text{Pulses per revolution} = 65536 \times \text{Numerator} / \text{Denominator} \quad (2)$$

The moving direction is controlled by the A/B signal logic (see Figure 15).

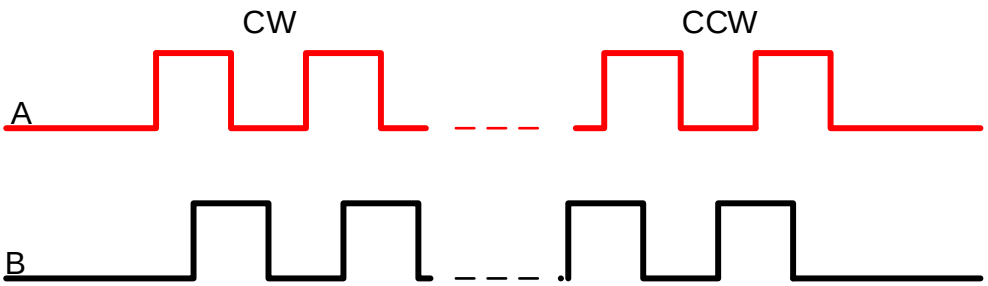


Figure 15: Quadrature Signal Logic

4.4.4 I/O Functions

The device has two outputs and four inputs to connect external control signals, such as a home switch, a negative switch, a positive switch, and pulse/PWM and direction control signals.

Each I/O has multiple functions that can be selected according to the application requirements. See the Register Details section on page 52 for more information about the I/O functions and polarity selection.

If using an optocoupler, the signal may need to be inverted, as the optocoupler output has an inverted polarity compared to the input.

4.4.5 Related Registers

Address	Description	Access	Data Type	Unit	Range	Default
2027h	Command type	R/W	UINT8	-	0 to 4	0
2300h	DI1 function	R/W	UINT8	-	0 to 6	0
2301h	DI2 function	R/W	UINT8	-	0 to 6	0
2302h	DI3 function	R/W	UINT8	-	0 to 6	0
2303h	DI4 function	R/W	UINT8	-	0 to 3	0
2304h	DI5 function	R/W	UINT8	-	0 to 4	4
2305h	DI6 function	R/W	UINT8	-	0	0
2306h	DI7 function	R/W	UINT8	-	0	0
2307h	DI8 function	R/W	UINT8	-	0	0
2308h	DO1 function	R/W	UINT8	-	0 to 3	0
2309h	DO2 function	R/W	UINT8	-	0 to 3	0
230Ah	DO3 function	R/W	UINT8	-	0	0
230Bh	DO4 function	R/W	UINT8	-	0 to 3	3
230Ch	DO5 function	R/W	UINT8	-	0	0
230Dh	DO6 function	R/W	UINT8	-	0	0
230Eh	DO7 function	R/W	UINT8	-	0	0
230Fh	DO8 function	R/W	UINT8	-	0	0
2310h	I/O polarity	R/W	UINT16	-	-	0
2320h	Command source	R/W	UINT16	-	-	0
2600h	Numerator	R/W	UINT32	-	UINT32	1
2601h	Denominator	R/W	UINT32	-	UINT32	1
6600h	Operation modes	R/W	INT8	-	-4 to +10	0
6610h	Operation modes display	RO	INT8	-	-4 to +10	-

4.4.6 Simple Example

For this example, set the pulses per revolution to 4000.

Steps	Index and Sub-Index	Data	Description
1	6600h	0x01	Set the mode to profile position mode.
2	2027h	0x02	Command source from PUL/DIR.
3	2600h	0x07D0	Set numerator to 2000.
4	2601h	0x8000	Set denominator to 32768.
5	2303h	0x00	Set I/O4 to PUL function.
6	2304h	0x00	Set I/O5 to DIR function.
7	2305h	0x00	Set I/O6 to ENA function.
8	2310h	0x0000	Set the PUL/DIR/ENA polarity to non-inverted.
9	20D0h	0x65766173	Store the parameters to the NVM.
10	20D0h	0x626F6F74	Reset the system command or reset power.

After setting these values, the position can be controlled by the PUL/DIR signals.

For this example, set the velocity to 3000rpm when the PWM duty cycle is 100%.

Steps	Register Address	Data	Description
1	6600h	0x03	Set the mode to profile speed mode.
2	2027h	0x03	Command source from PWM/DIR.
3	6FF0h	0x00320000	Set the target velocity to 3000rpm.
4	2303h	0x00	Set I/O4 to PUL function.
5	2304h	0x00	Set I/O5 to DIR function.
6	2305h	0x00	Set I/O6 to ENA function.
7	2310h	0x0000	Set the PUL/DIR/ENA polarity to non-inverted.
8	20D0h	0x65766173	Store the parameters to NVM.
9	20D0h	0x626F6F74	Reset the system command or reset power..

After setting these values, the motor speed can be controlled by the PWM/DIR signals.

4.5 Loop Tuning

4.5.1 Function Description

The driver module uses a three-loop control method. The innermost loop is the current loop, also called the torque loop. The middle loop is the speed loop, and the outer loop is the position loop. Figure 16 shows the block diagram.

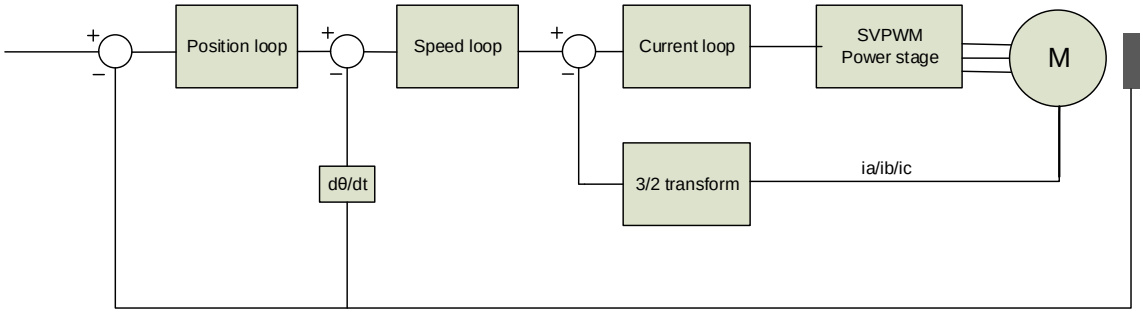


Figure 16: Control Loop Block Diagram

EZmotion provides an easy-to-use GUI to help engineers design and tune the loop parameters. Download the MotionLAB GUI from the EZmotion website.

To simplify tuning, the loop parameters are simplified to the loop bandwidth with the motor and load parameters. There is a tradeoff to optimize the loop parameters: a higher speed and position loop bandwidth improve dynamic response, but cause more vibrations and noise.

Current Loop

The current loop is the innermost loop. The driver module uses ID = 0 control, which controls the direct-axis current to 0. This makes the output torque proportional to the quadrature axis current (I_Q). It is recommended to set the loop between 1kHz and 2kHz. A good starting value for the current loop is 1kHz.

Speed Loop

In the speed loop, a PI compensator controls the motor speed. The input is the speed command, and the output is the reference of the current loop.

The speed loop limits the maximum peak current of the motor phase current, which limits the maximum output torque.

The recommended bandwidth setting is between 50Hz and 400Hz, with an integral time constant between 2Hz and 20Hz. A good starting value is to set the bandwidth between 200Hz and 2Hz for the integral time constant.

Position Loop

The position loop is the outermost loop, and is used to control the motor position. The input is the position command, and the output is a speed reference for the speed loop. The position loop uses proportional (P) control to avoid overshoot. Feed-forward functionality can be enabled if a low following error is required.

The position loop limit limits the maximum motor speed in position mode.

The recommended loop setting is between 10Hz and 100Hz. A good starting value for the loop setting is 50Hz.

4.5.2 Related Registers

Address	Description	Access	Data Type	Unit	Range	Default
2050h	Position loop bandwidth	R/W	UINT16	Hz	1 to 200	20
2052h	Speed loop bandwidth	R/W	UINT16	Hz	1 to 500	200

2053h	Speed loop integral constant	R/W	UINT16	Hz	1 to 500	200
2054h	Torque loop bandwidth	R/W	UINT16	Hz	200 to 2000	1000
2055h	Position loop out limit	R/W	UINT32	rpm	UINT32	3000
2056h	Speed loop out limit	R/W	UINT16	‰	UINT16	15
2057h	Torque loop speed limit	R/W	UINT32	rpm	UINT32	3000

4.5.3 Simple Example

For this example, set the current loop to 1000Hz, the speed loop to 200Hz, and the position loop to 20Hz. Limit the position loop output below 3000pm, and set speed loop output below 3000‰ of rated torque.

Steps	Index and Sub-zindex	Data	Description
1	2500h	0x0014	Set the position loop bandwidth to 20Hz.
2	2501h	0x0014	Set the position loop bandwidth to 20Hz.
3	2502h	0x00C8	Set the speed loop bandwidth to 200Hz.
4	2503h	0x03E8	Set the current loop bandwidth to 1000Hz.
5	2505h	0x00320000	Set the position loop limit to 3000rpm.
6	2506h	0x0BB8	Set the speed loop limit to 3000‰ of the rated torque.
7	20D0h	0xAA5555AA	Recalculate the loop parameters according to the settings.

4.6 Halt and Quick Stop Options

A halt or quick stop may be required during operation. The halt function slows the motor velocity according to the halt option, but the device remains in the operation enabled state. The quick stop function slows down the motor velocity and transitions to the switch on disabled state, or the device stays in the quick stop active state, according to the quick stop option settings.

4.6.1 Halt Option

If the halt option is set to the disable drive function, all of the inverter switches turn off and the motor velocity slows down with mechanical friction.

If the halt option is set to slow down ramp, the motor velocity slows down using the profile deceleration (set via 6840h). When the motor velocity falls below the brake speed threshold, the motor maintains its current position.

If the halt option is set to quick stop ramp, the motor velocity slows down using quick stop deceleration (set via 6850h). When the motor velocity falls below the brake speed threshold, the motor maintains its current position.

If the halt option is set to current limit, the motor velocity slows down by controlling the motor torque current. When the motor velocity is below the brake speed threshold, the motor maintains its current position.

4.6.2 Quick Stop Option

The quick stop command changes the motor status to quick stop active, and the motor velocity slows down according to the configured quick stop option.

If the quick stop option is set from 0 to 3, the status changes to switch on disabled once the motor velocity falls below the brake speed threshold.

If the quick stop option is set from 5 to 7, the status stays in the quick stop active state once the motor velocity falls below the brake speed threshold. Meanwhile, the motor maintains its current position.

4.6.3 Brake Control Logic

If a mechanical brake is required, the brake control logic can be used to control the brake relay. The control signal can be output from the I/O and BRAKE pins. The signal polarity can be configured (see the External I/O Function section on page 34 for more details).

The brake control logic is divided into several situations, described below.

Servo On

When the motor enters operation enabled mode, the brake is active after about 4ms (see Figure 17).

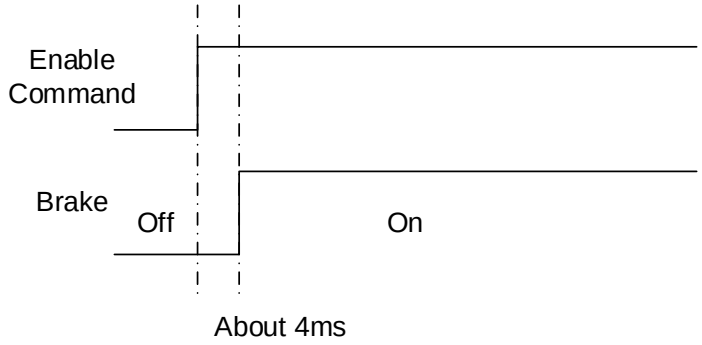


Figure 17: Brake Servo On Logic

Servo Off ("Brake Enable" Set to 1)

The brake has a turn-off time (typically several ms). If the motor turns off immediately when the disable operation command is received, the motor shaft may move a little during the brake's turn-off delay time, especially in a system with vertical movement. Set "Brake enable" to 1 to avoid this behavior (see Figure 18).

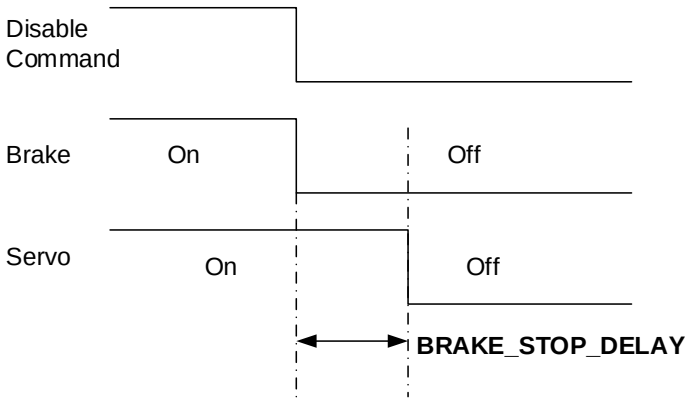


Figure 18: Brake Servo Off Logic (Brake Enable Set to 1)

Servo Off ("Brake Enable" Set to 0)

If users do not want a delay time between the disable operation command and when the servo turns off, set "Brake enable" to 0. The servo turns off immediately after the disable operation command is received (see Figure 19 on page 39).

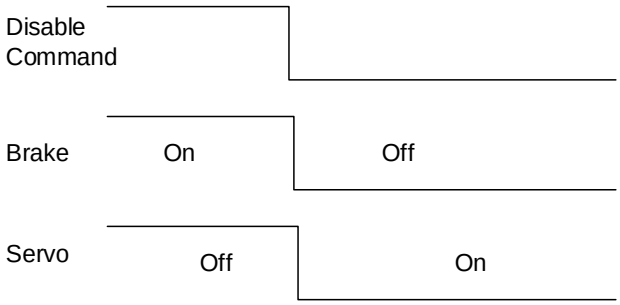


Figure 19: Brake Servo Off Logic (Brake Enable Set to 0)

Disable Operation (Or Error)

If a disable operation command is received during high-speed operation (or an error occurs), the servo turns off immediately. Two configurations affect the brake logic. If the motor speed is below BRAKE_OFF_SPEED or the delay time is longer than BRAKE_OFF_DELAY, the brake turns off (see Figure 20).

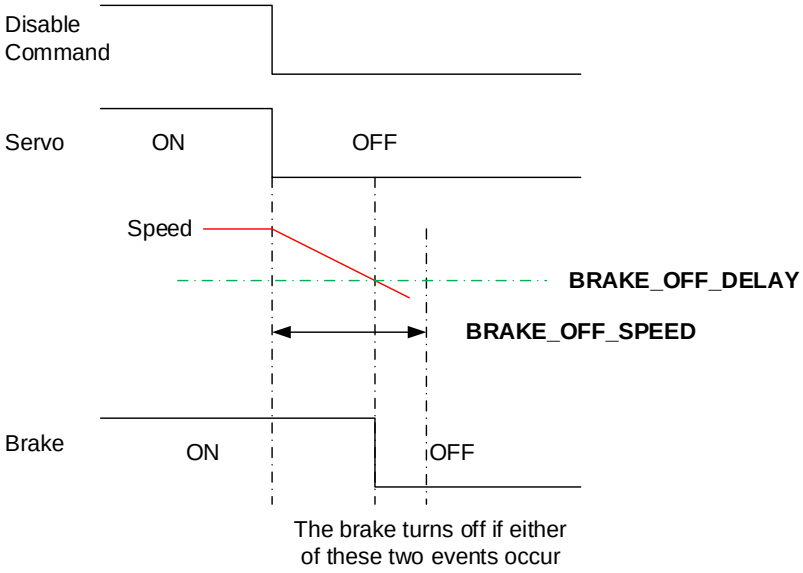


Figure 20: Brake Logic if an Error Occurs or Operation Is Disabled

Clear Error

The servo error must be cleared to enable operation again. The brake logic is the same as the servo on logic.

4.6.4 Related Registers

Address	Description	Access	Data Type	Unit	Range	Default
2024h	Brake current	R/W	UINT16	0.1%	0 to 3000	200
2025h	Brake speed threshold	R/W	UINT16	rpm	0 to 500	10
3080h	Brake enable	R/W	UINT8	-	0 to 1	0
3081h	Brake off speed	R/W	UINT16	rpm	0 to 1000	30
3082h	Brake off delay	R/W	UINT16	ms	1 to 65535	1000
3083h	Brake stop delay	R/W	UINT16	ms	1 to 65535	1
6400h	Control word	R/W	UINT16	-	UINT16	0
6410h	Status word	R/O	UINT16	-	UINT16	-
65A0h	Quick stop option code	R/W	INT16	-	INT16	2
65D0h	Halt option code	R/W	INT16	-	INT16	1
6850h	Quick stop deceleration	R/W	UINT32	INC/s^2	UINT32	3276800

4.6.5 Simple Example

For this example, if the motor is working in PV mode, halt the motor with halt option 1.

Steps	Register Address	Data	Description
1	6400h	0x010F	Halt command. The motor velocity slows down using profile deceleration. When the velocity is below the brake speed threshold, the motor changes to position mode and maintains the current position.
2			Delay a few seconds.
3	6400h	0x000F	Disable halt. The motor runs using the configured mode and profile.

4.7 Advanced Settings

Advanced settings, such as feed-forward and filter functions, are provided to improve control performance.

4.7.1 Feed-Forward

Speed Feed-Forward

Speed feed-forward can be used to minimize the position following an error. Figure 21 shows the block diagram. The speed reference for the speed loop is the sum of the speed feed-forward and the output of the position control loop. If the position reference changes, the speed reference changes immediately, without the position control loop delay. This makes the position response faster and minimizes the position following error.

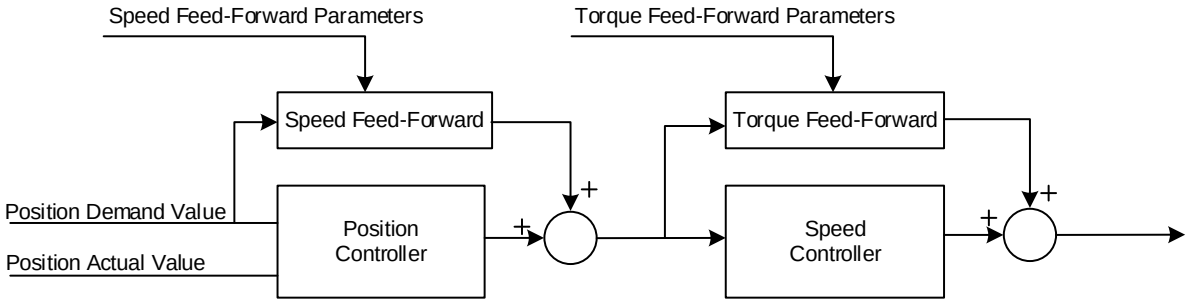


Figure 21: Feed-Forward Block Diagram

The speed feed-forward gain (2045h) and speed feed-forward time constant (2046h) can be set to obtain a filtered feed-forward value.

The speed feed-forward function can be disabled by setting “Feed-forward enable,” bit[2] (2040h) to 0.

Torque Feed-Forward

Torque feed-forward can make the speed loop control response faster (see Figure 21). The torque reference to the torque loop is the sum of the feed-forward and the output of speed loop controller. If the speed reference changes, the torque reference will change immediately without the speed control loop delay. This makes the speed response faster.

The torque feed-forward gain register (2043h) and torque feed-forward time constant register (2044h) can be set to obtain a filtered feed-forward value.

The torque feed-forward function can be disabled by setting “Feed-forward enable,” bit[1] (2040h) to 0.

Decoupling

From the voltage equations (Equation (3) and Equation (4)) of a PMSM motor, the $-\omega \times L_Q \times I_Q$ and $\omega \times (L_Q \times I_Q + \Psi_F)$ parts — from the motor’s back electromotive force (EMF) — should be decoupled to make the equation a linear equation.

Note that the decoupling function relies on accurate motor parameters for L_D, L_Q, and the flux (ψ_F). U_D and U_Q can be calculated with Equation (3) and Equation (4), respectively:

$$U_D = R \times I_D + L_D \times \frac{dI_D}{dt} - \omega \times L_Q \times I_Q \quad (3)$$

$$U_Q = R \times I_Q + L_Q \times \frac{dI_Q}{dt} + \omega \times (L_Q \times I_Q + \Psi_F) \quad (4)$$

The decoupling gain register (set via 2041h) and speed decoupling time constant register (set via 2043h) can be set to obtain a filtered decoupling value. The decoupling function can be disabled by setting “Feed-forward enable,” bit[0] (2040h). Figure 22 shows the decoupling block diagram.

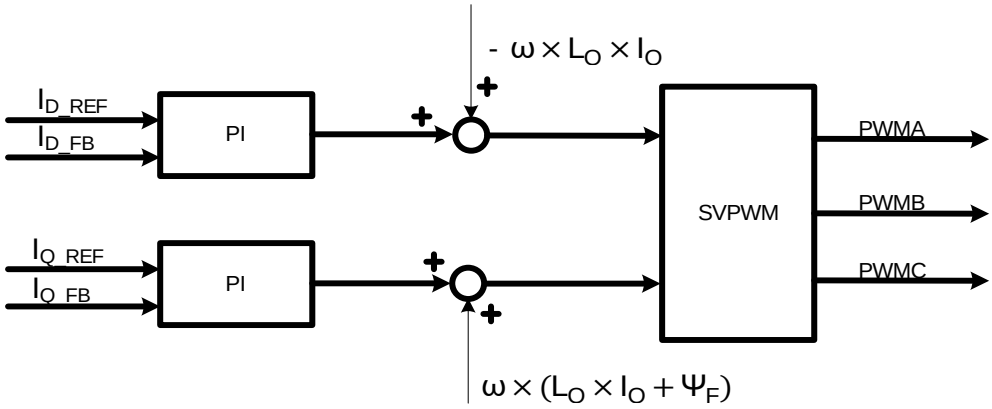


Figure 22: Decoupling Block Diagram

4.7.2 Filters

Position Feedback Filter

Because the position angle sensor has noise that can cause system vibrations and audible noise, it is recommended to use a position feedback filter to minimize the noise. It is typically recommended to set the position filter bandwidth to be 10 times greater than the position loop bandwidth to minimize the filter phase delay.

Speed Feedback Filter

The speed feedback signal is obtained from the deviation of the position feedback signal, which also has noise that can cause system vibrations. The speed filter’s first bandwidth and second bandwidth should be set below the noise level. It is typically recommended to set the filter bandwidth to be 5 to 10 times greater than the speed loop bandwidth.

Notch Filter

If the system has a resonant frequency, there may be a significant amount of system vibrations or even system instability. A notch filter can be used to filter out the resonant frequency component. The notch filter is a band-stop filter with a narrow stop band and deep filter depth.

To configure the notch filter, an appropriate resonant center frequency (in Hz), stop bandwidth (in Hz), and filter depth (in dB) should be selected. The notch filter parameters — a1, a2, b1, and b2 — can be calculated with Equation (5), Equation (6), Equation (7), and Equation (8), respectively:

$$a1 = \left(\left(2\pi \times f_C \times t_S \right)^2 + 10^{f_D/20} \times 2\pi \times f_B \times t_S - 2 \right) \times 10000 + 32768 \quad (5)$$

$$a2 = \left(1 - 10^{f_D/20} \times 2\pi \times f_B \times t_S \right) \times 10000 + 32768 \quad (6)$$

$$b1 = \left(\left(2\pi \times f_C \times t_S \right)^2 + 2\pi \times f_B \times t_S - 2 \right) \times 10000 + 32768 \quad (7)$$

$$b2 = \left(1 - 2\pi \times f_B \times t_S \right) \times 10000 + 32768 \quad (8)$$

Where f_C is the resonant center frequency, f_B is the bandwidth, and f_D is the filter depth.

The device has two notch filters that can be enabled separately.

4.7.3 Related Registers

Address	Description	Access	Data Type	Unit	Range	Default
2040h	Feed-forward enable	R/W	UINT8	-	UINT8	0
2041h	Decoupling gain	R/W	UINT8	%	0 to 200	100
2042h	Decoupling filter time constant	R/W	UINT16	ms	UINT16	0
2043h	Torque feed-forward gain	R/W	UINT8	%	0 to 200	100
2044h	Torque feed-forward filter time constant	R/W	UINT16	ms	UINT16	0
2045h	Speed feed-forward gain	R/W	UINT8	%	0 to 200	100
2046h	Speed feed-forward filter time constant	R/W	UINT16	ms	UINT16	0
2070h	Position filter bandwidth	R/W	UINT16	Hz	100 to 2000	200
2071h	Speed filter 1 bandwidth	R/W	UINT16	Hz	100 to 2000	1000
2074h	Speed filter 2 bandwidth	R/W	UINT16	Hz	100 to 2000	1000
2080h	Notch enable	R/W	UINT8	-	UINT8	0
2081h	Notch1_a1	R/W	UINT16	LSB	UINT16	0
2082h	Notch1_a2	R/W	UINT16	LSB	UINT16	0
2083h	Notch1_b1	R/W	UINT16	LSB	UINT16	0
2084h	Notch1_b2	R/W	UINT16	LSB	UINT16	0
2085h	Notch2_a1	R/W	UINT16	LSB	UINT16	0
2086h	Notch2_a2	R/W	UINT16	LSB	UINT16	0
2087h	Notch2_b1	R/W	UINT16	LSB	UINT16	0
2088h	Notch2_b2	R/W	UINT16	LSB	UINT16	0

4.7.4 Simple Example

For this example, set the position filter bandwidth and speed filter bandwidth to 1000Hz.

Steps	Register Address	Data	Description
1	2070h	0x03E8	Set the position filter bandwidth to 1000Hz.
2	2071h	0x03E8	Set the speed filter 1 bandwidth to 1000Hz.
3	2074h	0x03E8	Set the speed filter 2 bandwidth to 1000Hz.
4	20D0h	0xAA5555AA	Recalculate the control parameters to make the change take effect.

4.8 Hardware Settings

4.8.1 Driver Parameters

Registers 2000h~2004h identify controller versions. The “Controller part number” (2000h), “Motor part number” (2001h), “Encoder part number” (2002h), “Firmware version” (2003h) and “Hardware version” (2004h) registers are read-only. These registers identify the device versions.

4.8.2 Motor Parameters

Motor parameters are used for control loop design, among other operational functions. The user can set basic motor parameters and allow for other detailed parameters to be identified automatically (see the Parameter Identification section on page 28). If parameter identification cannot be performed, the user should set the motor parameters (set via 2010h~2018h) before running the motor.

4.8.3 Current-Sense Parameters

Current-sense parameters are used for motor phase current-sensing. The proper current-sense resistor and amplifier gain should be set to achieve the correct current feedback.

The current-sense resistor's (R_{CS}) power rating must be selected carefully. The overall power (P) dispatched on this resistor can be estimated with Equation (9):

$$P = I_{RMS}^2 \times R_{cs} \quad (9)$$

A good rule of thumb is to leave a 50% margin for the power rating to guarantee that the device can operate normally at high temperatures. Using Figure 23, the amplifier gain (G) can be calculated with Equation (10):

$$G = \frac{R_1}{R_2 + R_3} \quad (10)$$

Where R_1 is fixed to 20kΩ and R_2 is fixed to 1kΩ. This means that R_3 can be used to adjust G.

Select G so that is meets the condition estimated with Equation (11):

$$I_{MAX} \times R_{CS} \times G < 1.65V \quad (11)$$

Where I_{MAX} is the maximum allowed motor winding current, and R_{CS} is the current-sense resistor.

It is typically recommended to leave a minimum of a 20% margin to guarantee a robust design. Ensure that this value is not too small. To improve current-sense accuracy, the calculated value should be at least 60% of 1.65V. Figure 23 shows the current-sense diagram.

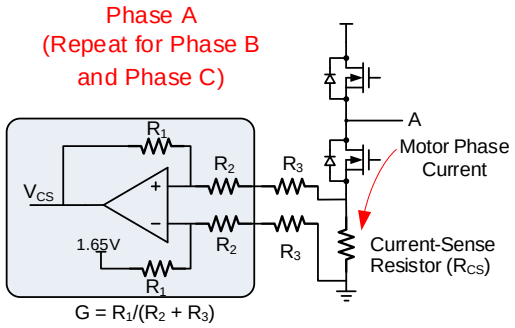


Figure 23: Current-Sense Diagram

The device supports three-phase or two-phase current-sensing. This value is set by "Current sample mode" (202Ah). If using two-phase current-sensing, only the phase A and phase C currents are used.

4.8.4 Pre-Driver Parameters

The device allows for two types of pre-drivers. If the driver type is set to 0, pre-drivers with 6 separate gate signals (GLx + GHx) are supported. If the driver type is set to 1, pre-drivers with (ENx + PWMx) signals are supported.

If using drivers with GLx + GHx signals, set a proper dead time. The dead time should be selected according to the MOSFET specifications as well as operational conditions, such as the operating voltage and current. For applications with a MOSFET, a dead time between 200ns and 500ns is typically sufficient.

4.8.5 Voltage-Sense Parameters

A voltage divider scales the DC link voltage to a reasonable voltage range so that the controller can sense the DC link voltage. Figure 24 shows how to set the voltage resistor dividers. Ensure that the voltage on the VDC pin is below 3.3V at the maximum DC link voltage.

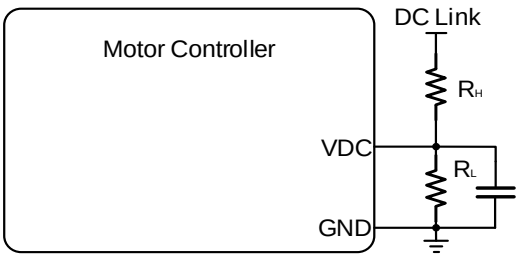


Figure 24: Voltage Divider

4.8.6 Related Registers

Address	Description	Access	Data Type	Unit	Range	Default
2000h	Controller part number	RO	UINT16	-		0x6720
2001h	Motor part number	RO	UINT16	-	-	0x0000
2002h	Encoder part number	RO	UINT16	-	-	0x0732
2003h	Firmware version	RO	UINT16	-	-	-
2004h	Hardware version	RO	UINT16	-	-	-
2010h	Phase resistance	R/W	UINT32	mΩ	UINT32	600
2011h	D-axis inductance	R/W	UINT32	µH	UINT32	700
2012h	Q-axis inductance	R/W	UINT32	µH	UINT32	700
2013h	Pole pairs	R/W	UINT8	-	UINT8	4
2014h	Torque constant	R/W	UINT32	mNm/A	UINT32	56
2015h	Inertia	R/W	UINT32	g x cm^2	UINT32	210
2016h	Rated voltage	R/W	UINT32	mV	UINT32	36000
2017h	Rated current	R/W	UINT32	mA	UINT32	5000
2018h	Rated speed	R/W	UINT32	rpm	UINT32	3000
2021h	Amplifier gain	R/W	UINT8	V/V	1 to 100	10
2022h	Current-sense resistor	R/W	UINT8	mΩ	1 to 100	10
2028h	Driver type	R/W	UINT8	-	0	0
2029h	Dead time	R/W	UINT16	ns	0 to 1000	500
202Ah	Current sample mode	R/W	UINT8	-	0 to 1	0
2500h	Lower divider	R/W	UINT16	kΩ	1 to 65535	10
2501h	Upper divider	R/W	UINT16	kΩ	1 to 65535	402

4.8.7 Simple Example

For this example, set the pre-driver type to the GLx + GHx type, and set the dead time to 500ns.

Steps	Register	Data	Description
1	2028h	0x00	Select the pre-drivers with GLx + GHx signals.
2	2029h	0x01F4	Set the dead time to 500ns.
3	20D0h	0x65766173	Store the parameters to the NVM.
4	20D0h	0x626F6F74	Reset the controller.

4.9 Store Parameters

4.9.1 Function Description

To store the tuned control parameters to the driver module's NVM, certain function codes can be sent to object 20D0h to trigger specific functions. The functions and function codes are listed below:

Function	Function Code	Description
Update control parameters	0xAA5555AA	Update the control parameters according to the register value. This command should be sent after new configurations. Control word, status word, operation mode, and the trajectory profile related parameters do not need to this function code to be activated.
Store parameters	0x65766173	Store all the control parameters to the controller's NVM.
Restore default parameters	0x64616F6C	Restore all the control parameters to the default values.
System reset	0x626F6F74	Restart the motor controller to simulate a power reset.

4.9.2 Related Registers

Address	Description	Access	Data Type	Unit	Range	Default
20D0h	Special command	R/W	UINT32	-	See the supported command above	0

4.9.3 Simple Example

For this example, store the parameters to the NVM.

Steps	Registers Address	Data	Description
1	20D0	0x65766173	Store the parameters to NVM.

Section 5. Protections and Errors

The device has rich protection functions to avoid unexpected failures and external component damage. The fault type can be determined from the value of the “Error status” (20BAh). During a fault, the ALARM signal outputs a low-level voltage, and the fault indication LED illuminates.

5.1 Function Description

5.1.1 Power Stage Fault Protection

If the power stage fault signal is connected to the controller’s nFT pin, the controller can detect the power stage fault.

If a power stage fault is detected, the controller shuts down the power stage to avoid further damage to the system.

5.1.2 Under-Voltage Lockout (UVLO) Protection

If under-voltage lockout (UVLO) protection is enabled, then the UVLO bit of “Error status” (200Bh-0Bh) is set when the DC link voltage drops below “UVLO threshold” (20B2h). If UVLO protection is triggered, the controller enters a fault state.

UVLO protection can be disabled by setting UVLO_EN to 0.

5.1.3 DC Link Voltage Limit Protection

The VDC pin senses the DC link voltage. If the DC link voltage exceeds the “DC link limit upper threshold” (20B8h), VDCCON starts switching. If the voltage falls below the “DC link limit lower threshold” (20B9h), VDCCON stops switching. This limits the voltage when energy is returned from the motor to the DC link.

The voltage to the VDC pin is sensed by a voltage divider. The correct divider voltage should be set via “Lower divider” (2500h) and “Upper divider” (2051h). Activating this protection does not cause the controller to enter a fault state.

This function can be disabled by setting VIN_LIMIT_EN to 0.

5.1.4 Rotor-Lock Protection

If the target velocity exceeds the “Lock speed threshold” (20B4h) and the angle that the motor shaft turns during the “Lock time window” (20B5h) is below the “Lock position threshold” (20B3h) in PV mode, then rotor-lock protection is triggered.

If the target position is not reached, and the angle that the motor shaft turns during the “Lock time window” (20B5h) is below the “Lock position threshold” (20B3h) in PP mode, then rotor-lock protection is triggered.

If rotor-lock protection is triggered, the lock bit of “Error status” (20BAh) is set, and the controller enters a fault state.

This protection can be disabled by setting LOCK_EN to 0.

5.1.5 Over-Current Protection (OCP)

Over-current protection (OCP) may occur if the components on the board are damaged or if a short circuit occurs. If OCP occurs, the device shuts down the power stage to avoid further damage to the system.

If any phase current exceeds the OCP threshold, then OCP is triggered, the OCP bit of “Error status” (20BAh) is set, and the controller enters a fault state.

5.1.6 Overload Protection (OLP)

To avoid damaging the mechanical system and the motor, overload protection (OLP) is triggered if the output torque exceeds the “Overload current threshold” (2421h) and lasts for longer than the “Overload time window” (2422h). The controller shuts down the power stage so that electrical power is not delivered to the motor or mechanical system.

OLP can be disabled by setting OVERLOAD_EN to 0, and the overload time window can be set.

If OLP is triggered, the OVERLOAD bit of “Error status” (20BAh) is set, and the controller enters a fault state.

5.1.7 Over-Temperature Protection (OTP)

If there is an NTC thermistor connected to the controller’s NTC pin, over-temperature protection (OTP) can be triggered.

Temperature sensing is optimized when using Murata’s NCU15XH103F60RC NTC. If using another NTC, the real temperature should be calibrated separately to obtain an accurate temperature measurement. If the sensed temperature exceeds the set value, OTP is triggered. The controller does not shut down the power stage when OTP is triggered; instead, it sends a fault signal and allows the user to respond.

5.2 Clearing Errors

To clear an error and restart the motor from a fault state without shutting down the motor, send the fault reset command (a rising edge on “Control word,” bit[7]) to the controller. If no errors are active, then the controller enters the switch on disabled status. Sending the switch on + enable operation command restarts the motor.

5.3 Error Identification

If any protection or warning is triggered, the corresponding error indication bit in “Error status” (20BAh) is set. If the motor enters a fault state, the fault indication LED is illuminated. See register 20BAh on page 58 for more details.

5.4 Related Registers

Address	Description	Access	Data Type	Unit	Range	Default
20B0h	Protection enable	R/W	UINT8	-	-	0
20B1h	OCP threshold	R/W	UINT16	A	UINT16	20
20B2h	UVLO threshold	R/W	UINT16	V	8 to 30	12
20B3h	Lock position threshold	R/W	UINT32	LSB	UINT32	182
20B4h	Lock speed threshold	R/W	UINT32	INC/s	UINT32	109226
20B5h	Lock time window	R/W	UINT16	ms	UINT16	1000
20B6h	Retry enable	R/W	UINT8	-	0 to 1	0
20B7h	Retry time	R/W	UINT16	ms	UINT16	3000
20B8h	DC link limit upper threshold	R/W	UINT16	V	UINT16	56
20B9h	DC link limit lower threshold	R/W	UINT16	V	UINT16	52
20BAh	Error status	RO	UINT16	-	-	0
2400h	Temperature	RO	INT16	°C	-40 to +125	-
2410h	OTP threshold	R/W	INT16	°C	-40 to +125	85
2420h	Overload enable	R/W	UINT8	-	-	0
2421h	Overload current threshold	R/W	UINT16	‰	0 to 3000	3000
2422h	Overload time window	R/W	UINT16	ms	UINT16	1000
2500h	Lower divider	R/W	UINT16	kΩ	1 to 65535	10
2501h	Upper divider	R/W	UINT16	kΩ	1 to 65535	402

5.5 Simple Example

For this example, set the OCP threshold to 2A and enable OCP.

Steps	Register	Data	Description
1	20B1h	0x0002	Set the OCP current to 2A.
2	20B0h	0x01	Enable OCP.
3	20D0h	0xAA5555AA	Recalculate the control parameters to make the change take effect.

Section 6. Register Table

Address	Description	Access	Data Type	Unit	Range	Default
2000h	Controller part number	RO	UINT16	-	0x6720	0x6720
2001h	Motor part number	RO	UINT16	-	-	0x0000
2002h	Encoder part number	RO	UINT16	-	-	0x0732
2003h	Software version	RO	UINT16	-	-	0x0100
2004h	Hardware version	RO	UINT16	-	-	0x0100
2010h	Phase resistance	R/W	UINT32	mΩ	UINT32	600
2011h	D-axis inductance	R/W	UINT32	uH	UINT32	700
2012h	Q-axis inductance	R/W	UINT32	uH	UINT32	700
2013h	Pole pairs	R/W	UINT8	-	1 to 255	4
2014h	Torque constant	R/W	UINT32	mNm/A	UINT32	56
2015h	Inertia	R/W	UINT32	g x cm^2	UINT32	210
2016h	Rated voltage	R/W	UINT32	mV	UINT32	36000
2017h	Rated current	R/W	UINT32	mA	UINT32	5000
2018h	Rated speed	R/W	UINT32	rpm	UINT32	3000
2021h	Amplifier gain	R/W	UINT8	V/V	1 to 100	5
2022h	Current-sense resistor	R/W	UINT8	mΩ	1 to 100	4
2023h	Reserved	-	-	-	-	-
2024h	Brake current	R/W	UINT16	‰	0 to 3000	200
2025h	Brake speed threshold	R/W	UINT16	rpm	0 to 500	10
2026h	Theta bias current	R/W	UINT16	‰	0 to 3000	500
2027h	Command type	R/W	UINT8	-	0 to 4	0
2028h	Driver type	R/W	UINT8	-	0 to 1	0
2029h	Dead time	R/W	UINT16	ns	0 to 1000	500
202Ah	Current sample mode	R/W	UINT8	-	0 to 1	0
2030h	Sensor bias	R/W	UINT32	INC	0 to 65535	0
2031h	Sensor direction	R/W	UINT8	-	0 to 1	0
2032h	Reserved	-	-	-	-	-
2033h	Reserved	-	-	-	-	-
2034h	INL enable	R/W	UINT8	-	0 to 1	0
2035h	Speed feedback source	R/W	UINT8	-	0 to 2	2
2040h	Feed-forward enable	R/W	UINT8	-	UINT8	0
2041h	Decouple gain	R/W	UINT8	%	0 to 200	100
2042h	Decoupling filter time constant	R/W	UINT16	ms	UINT16	0
2043h	Torque feed-forward gain	R/W	UINT8	%	0 to 200	100
2044h	Torque feed-forward filter time constant	R/W	UINT16	ms	UINT16	0
2045h	Speed feed-forward gain	R/W	UINT8	%	0 to 200	100
2046h	Speed feed-forward filter time constant	R/W	UINT16	ms	UINT16	0
2050h	Position loop bandwidth	R/W	UINT16	Hz	1 to 200	20
2051h	Reserved	-	-	-	-	-
2052h	Speed loop bandwidth	R/W	UINT16	Hz	1 to 500	200
2053h	Speed loop integral constant	R/W	UINT16	Hz	1 to 50	10
2054h	Torque loop bandwidth	R/W	UINT16	Hz	200 to 2000	1000
2055h	Position loop out limit	R/W	UINT32	INC/s	UINT32	3276800
2056h	Speed loop out limit	R/W	UINT16	‰	UINT16	3000
2057h	Torque loop speed limit	R/W	UINT32	rpm	UINT32	3000
2070h	Position filter bandwidth	R/W	UINT16	Hz	100 to 2000	200
2071h	Speed filter 1 bandwidth	R/W	UINT16	Hz	100 to 2000	1000
2072h	Reserved	-	-	-	-	-
2073h	Reserved	-	-	-	-	-
2074h	Speed filter 2 bandwidth	R/W	UINT16	Hz	100 to 2000	1000
2080h	Notch enable	R/W	UINT8	-	UINT8	0
2081h	Notch1_a1	R/W	UINT16	LSB	UINT16	0

2082h	Notch1_a2	R/W	UINT16	LSB	UINT16	0
2083h	Notch1_b1	R/W	UINT16	LSB	UINT16	0
2084h	Notch1_b2	R/W	UINT16	LSB	UINT16	0
2085h	Notch2_a1	R/W	UINT16	LSB	UINT16	0
2086h	Notch2_a2	R/W	UINT16	LSB	UINT16	0
2087h	Notch2_b1	R/W	UINT16	LSB	UINT16	0
2088h	Notch2_b2	R/W	UINT16	LSB	UINT16	0
20B0h	Protection enable	R/W	UINT8	-	-	0
20B1h	OCP threshold	R/W	UINT16	A	UINT16	20
20B2h	UVLO threshold	R/W	UINT16	V	8 to 30	12
20B3h	Lock position threshold	R/W	UINT32	INC	UINT32	182
20B4h	Lock speed threshold	R/W	UINT32	INC/s	UINT32	109226
20B5h	Lock time window	R/W	UINT16	ms	UINT16	1000
20B6h	Retry enable	R/W	UINT8	-	0 to 1	0
20B7h	Retry time	R/W	UINT16	ms	UINT16	3000
20B8h	DC link limit upper threshold	R/W	UINT16	V	UINT16	56
20B9h	DC link limit lower threshold	R/W	UINT16	V	UINT16	52
20BAh	Error status	RO	UINT16	-	-	0
20C0h	Identify method	R/W	UINT8	-	0 to 1	0
20C1h	Round max	R/W	UINT16	round	3 to 65535	50
20C2h	Round acceleration	R/W	UINT16	round	1 to 65535	10
20C3h	Round J	R/W	UINT16	round	1 to 65535	10
20C4h	Identification status	RO	UINT8	-	0 to 16	0
20C5h	Identified R_S	RO	UINT32	mΩ	-	0
20C6h	Identified L_D	RO	UINT32	µH	-	0
20C7h	Identified L_Q	RO	UINT32	µH	-	0
20C8h	Identified K_T	RO	UINT32	mNm/A	-	0
20C9h	Identified J	RO	UINT32	g x cm^2	-	0
20CAh	Identified B	RO	UINT32	mNm x s	-	0
20CBh	Identified T_F	RO	UINT32	mNm	-	0
20D0h	Special command	R/W	UINT32	-	-	0
20E0h	I_D	RO	INT16	mA	INT16	-
20E1h	I_Q	RO	INT16	mA	INT16	-
20E2h	U_D	RO	INT16	mV	INT16	-
20E3h	U_Q	RO	INT16	mV	INT16	-
20E4h	Torque	RO	INT16	mNm	INT16	-
20E5h	Sensor position	RO	UINT16	INC	UINT16	-
20E6h	Filtered position	RO	UINT16	INC	UINT16	-
20E7h	Reserved	-	-	-	-	-
20E8h	Filtered speed	RO	INT32	INC/s	UINT32	-
20E9h	Reserved	-	-	-	-	-
20F0h	Encoder PPR	R/W	UINT32	INC/r	UINT32	16384
2300h	DI1 function	R/W	UINT8	-	0 to 6	0
2301h	DI2 function	R/W	UINT8	-	0 to 6	0
2302h	DI3 function	R/W	UINT8	-	0 to 6	0
2303h	DI4 function	R/W	UINT8	-	0 to 3	0
2304h	DI5 function	R/W	UINT8	-	0 to 4	4
2305h	DI6 function	R/W	UINT8	-	0	0
2306h	DI7 function	R/W	UINT8	-	0	0
2307h	DI8 function	R/W	UINT8	-	0	0
2308h	DO1 function	R/W	UINT8	-	0 to 3	0
2309h	DO2 function	R/W	UINT8	-	0 to 3	0
230Ah	DO3 function	R/W	UINT8	-	0	0
230Bh	DO4 function	R/W	UINT8	-	0 to 3	3
230Ch	DO5 function	R/W	UINT8	-	0	0
230Dh	DO6 function	R/W	UINT8	-	0	0
230Eh	DO7 function	R/W	UINT8	-	0	0
230Fh	DO8 function	R/W	UINT8	-	0	0
2310h	I/O polarity	R/W	UINT16	-	-	0

2320h	Command Source	R/W	UINT16	-	-	0
2400h	Temperature	RO	INT16	°C	-40 to +125	-
2410h	OTP threshold	R/W	INT16	°C	-40 to +125	85
2420h	Overload enable	R/W	UINT8	-	0 to 1	0
2421h	Overload current threshold	R/W	UINT16	‰	0-3000	3000
2422h	Overload time window	R/W	UINT16	ms	UINT16	1000
2500h	Lower divider	R/W	UINT16	kΩ	1 to 65535	10
2501h	Upper divider	R/W	UINT16	kΩ	1 to 65535	402
2600h	Numerator	R/W	UINT32	-	1 to 65536	1
2601h	Denominator	R/W	UINT32	-	1 to 65536	1
2700h	Homing torque	R/W	UIN16	‰	UINT16	500
2701h	Homing time	R/W	UINT16	ms	UINT16	500
2702h	Power-on homing enable	R/W	UINT8	-	0 to 1	0
3050h	Modbus address	R/W	UINT8	-	1 to 247	0x01
3060h	Modbus baud rate	R/W	UINT16	100bps	-	0x0480
3070h	Modbus parity	R/W	UINT8	-	0 to 2	2
3080h	Brake enable	R/W	UINT8	-	0 to 1	0
3081h	Brake off speed	R/W	UINT16	rpm	0 to 1000	30
3082h	Brake off delay	R/W	UINT16	ms	1 to 65535	1000
3083h	Brake stop delay	R/W	UINT16	ms	1 to 65535	1
3100h~ 3106h	Multi-target position	R/W	INT32	INC	INT32	0
3110h~ 3116h	Multi-profile acceleration	R/W	UINT32	INC/s^2	UINT32	0
3120h~ 3126h	Multi-profile deceleration	R/W	UINT32	INC/s^2	UINT32	0
3130h~ 3136h	Multi-profile velocity	R/W	UINT32	INC/s	UINT32	0
3140h~ 3146h	Multi-target velocity	R/W	INT32	INC/s	INT32	0
4000h~ 4007h	Custom info	R/W	UINT16	-	UINT16	0
6400h	Control word	R/W	UINT16	-	UINT16	0
6410h	Status word	RO	UINT16	-	UINT16	-
65A0h	Quick stop option code	R/W	INT16	-	0 to 4	2
65D0h	Halt option code	R/W	INT16	-	0 to 8	1
6600h	Operation modes	R/W	INT8	-	-4 to +10	0
6610h	Operation modes display	RO	INT8	-	-4 to +10	-
6620h	Position demand value	RO	INT32	INC	INT32	-
6630h	Position actual internal value	RO	INT32	INC	INT32	-
6640h	Position actual value	RO	INT32	INC	INT32	-
6650h	Following error window	R/W	UINT32	INC	UINT32	182
6660h	Following error time out	R/W	UINT32	ms	UINT32	10
6670h	Position window	R/W	UINT32	INC	UINT32	182
6680h	Position window time	R/W	UINT16	ms	UINT16	10
66B0h	Velocity demand value	RO	INT32	INC/s	INT32	-
66C0h	Velocity actual value	RO	INT32	INC/s	INT32	-
66D0h	Velocity window	R/W	UINT16	INC/s	UINT16	32768
66E0h	Velocity window time	R/W	UINT16	ms	UINT16	10
66F0h	Velocity threshold	R/W	UINT16	INC/s	UINT16	32768
6700h	Velocity threshold time	R/W	UINT16	ms	UINT16	10
6710h	Target torque	R/W	INT16	‰	-3000 to +3000	0
6720h	Max torque	R/W	UINT16	‰	0 to 3000	3000
6730h	Max current	R/W	UINT16	‰	0 to 3000	3000
6740h	Torque demand value	RO	INT16	‰	-3000 to +3000	-
6770h	Torque actual value	RO	INT16	‰	-3000 to +3000	-
6780h	Current actual value	RO	INT16	‰	-3000 to +3000	-
6790h	DC link voltage	RO	UINT32	mV	UINT32	36000
67A0h	Target position	R/W	INT32	INC	INT32	0

67C0h	Home offset	R/W	INT32	INC	INT32	0
67D0h	Min position limit	R/W	INT32	INC	INT32	-2^{31}
67D1h	Max position limit	R/W	INT32	INC	INT32	$2^{32} - 1$
67E0h	Polarity	R/W	UINT8	-	0 - 1	0
67F0h	Max profile velocity	R/W	UINT32	INC/s	UINT32	3276800
6800h	Max motor speed	R/W	UINT32	rpm	UINT32	3000
6810h	Profile velocity	R/W	UINT32	INC/s	UINT32	655360
6830h	Profile acceleration	R/W	UINT32	INC/s^2	UINT32	3276800
6840h	Profile deceleration	R/W	UINT32	INC/s^2	UINT32	3276800
6850h	Quick stop deceleration	R/W	UINT32	INC/s^2	UINT32	3276800
6860h	Motion profile type	R/W	INT16	-	0	0
6870h	Torque slope	R/W	UINT32	‰/s	UINT32	3000
6880h	Torque profile type	R/W	INT16	-	0	0
6980h	Homing method	R/W	INT8	-	0 to 35	0
6990h	Homing speed switch	R/W	UINT32	INC/s	UINT32	655360
6991h	Homing speed zero	R/W	UINT32	INC/s	UINT32	65536
69A0h	Homing acceleration	R/W	UINT32	INC/s^2	UINT32	0
6B00h	Position offset	R/W	INT32	INC	INT32	0
6B10h	Velocity offset	R/W	INT32	INC/s	INT32	0
6B20h	Torque offset	R/W	INT16	‰	INT16	0
6C20h	Interpolation time period value	R/W	UINT8	-	1 to 255	1
6C21h	Interpolation time index	R/W	INT8	-	-4 to -3	-3
6C50h	Max acceleration	R/W	UINT32	INC/s^2	UINT32	$2^{32} - 1$
6C60h	Max deceleration	R/W	UINT32	INC/s^2	UINT32	$2^{32} - 1$
6F40h	Follow error actual value	RO	IN32	INC	INT32	-
6FC0h	Position demand value	RO	IN32	INC	INT32	0
6FF0h	Target velocity	R/W	IN32	INC/s	INT32	0
B020h	Supported drive modes	RO	UINT32	-	-	0x000003AD

Section 7. Register Details

This section provides detail function descriptions for each register.

2010h~2018h: Motor Parameters

Address	Description	Access	Data Type	Unit	Range	Default
2010h	Phase resistance	R/W	UINT32	mΩ	UINT32	600
Bits	**Name**	**Description**				
31:0	Phase resistance	Sets the motor winding phase resistance (in mΩ) for the torque loop parameter calculations. If using the parameter identification function, this value is updated with the identified value once parameter identification is complete.				

Address	Description	Access	Data Type	Unit	Range	Default
2011h	D-axis inductance	R/W	UINT32	μH	UINT32	700
Bits	**Name**	**Description**				
31:0	D-axis inductance	Sets the motor winding direct axis inductance (in μH) for the torque loop parameter calculation. If using the parameter identification function, this value is updated with the identified value after parameter identification is complete.				

Address	Description	Access	Data Type	Unit	Range	Default
2012h	Q-axis inductance	R/W	UINT32	μH	UINT32	700
Bits	**Name**	**Description**				
31:0	Q-axis inductance	Sets the motor winding quadrature axis inductance (in μH) for the torque loop parameter calculation. If using the parameter identification function, this value is updated with the identified value after parameter identification is complete.				

Address	Description	Access	Data Type	Unit	Range	Default
2013h	Pole pairs	R/W	UINT8	-	1 to 255	4
Bits	**Name**	**Description**				
7:0	Pole pairs	Sets the motor pole pairs. This parameter is vital to make the motor spin. The wrong value can make the motor stuck.				

Address	Description	Access	Data Type	Unit	Range	Default
2014h	Torque constant	R/W	UINT32	mNm/A	UINT32	56
Bits	**Name**	**Description**				
31:0	Torque constant	Sets the motor torque constant, which represents the motor's output torque per ampere current. The current unit is A_{RMS} (the root mean square current in amperes).				

Address	Description	Access	Data Type	Unit	Range	Default
2015h	Inertia	R/W	UINT32	g x cm^2	UINT32	210
Bits	**Name**	**Description**				
31:0	Inertia	Sets the inertia of the mechanical parts — including the rotor and load inertia — for speed loop and position loop parameter calculations. Set this parameter to an appropriate value. Use the parameter identification function to obtain this value automatically.				

Address	Description	Access	Data Type	Unit	Range	Default
2016h	Rated voltage	R/W	UINT32	mV	UINT32	36000
Bits	**Name**	**Description**				
31:0	Rated voltage	The motor-rated voltage is in mV.				

Address	Description	Access	Data Type	Unit	Range	Default

2017h	Rated current	R/W	UINT32	mA	UINT32	5000
Bits	**Name**	**Description**				
31:0	Rated current	The motor-rated current is in mA.				

Address	Description	Access	Data Type	Unit	Range	Default
2018h	Rated speed	R/W	UINT32	rpm	UINT32	3000
Bits	**Name**	**Description**				
31:0	Rated speed	The motor-rated speed is in rpm.				

2020h~202Ah: Driver Configuration

Address	Description	Access	Data Type	Unit	Range	Default
2021h	Amplifier gain	R/W	UINT8	V/V	1 to 100	5
Bits	**Name**	**Description**				
7:0	Amplifier gain	Sets the current-sense circuit's amplifier gain.				

Address	Description	Access	Data Type	Unit	Range	Default
2022h	Current sensing resistor	R/W	UINT8	mΩ	1 to 100	4
Bits	**Name**	**Description**				
7:0	Current sensing resistor	Sets the current-sense resistance (in mΩ). Works with the amplifier gain (2021h) to define the total current-to-voltage ratio for the current-sense circuit.				

Address	Description	Access	Data Type	Unit	Range	Default
2024h	Brake current	R/W	UINT16	‰	0 to 3000	200
Bits	**Name**	**Description**				
15:0	Brake current	Sets the Q-axis current during halt operation. It is a thousandth of the rated current.				

Address	Description	Access	Data Type	Unit	Range	Default
2025h	Brake speed threshold	R/W	UINT16	rpm	0 to 500	10
Bits	**Name**	**Description**				
15:0	Brake speed threshold	If the motor speed is below the brake speed threshold during braking, then braking is finished.				

Address	Description	Access	Data Type	Unit	Range	Default
2026h	Theta bias current	R/W	UINT16	‰	0 to 3000	500
Bits	**Name**	**Description**				
15:0	Theta bias current	Sets the current injected to the motor winding during the theta bias sequence. During rotor alignment, a current is injected into the motor windings to pull the rotor to certain positions. The controller can determine the theta bias between the rotor's electrical angle and the sensed angle via the angular sensor. Set this value between 200 and 500 for the sequence.				

Address	Description	Access	Data Type	Unit	Range	Default
2027h	Command type	R/W	UINT8	-	0 to 4	0
Bits	**Name**	**Description**				
7:0	Command type	Selects the command source. 0: CAN bus 1: A/B. Used for position mode only 2: PUL/DIR. Used for position mode only 3: FPWM/DIR. Used for speed and torque mode 4: The I/O signals. For I/O-controlled multi-position and multi-speed mode Others: Reserved				

Address	Description	Access	Data Type	Unit	Range	Default
2028h	Driver type	R/W	UINT8	-	0 to 1	0
Bits	**Name**	**Description**				
7:1	Reserved	Unused.				
0	Driver type	0: Support drivers with GLx and GHx signals 1: Support drivers with ENx and PWMx signals				

Address	Description	Access	Data Type	Unit	Range	Default
2029h	Dead time	R/W	UINT16	ns	0 to 1000	500
Bits	**Name**	**Description**				
15:0	Dead time	Sets the GLx and GHx signal dead time (in ns). This does not have to be set when using ENx and PWMx interface pre-drivers.				

Address	Description	Access	Data Type	Unit	Range	Default
202Ah	Current sample mode	R/W	UINT8	-	0 to 1	0
Bits	**Name**	**Description**				
7:1	Reserved	Unused.				
0	Current sample mode	0: Three-phase current sensing 1: Two-phase current sensing with phase A and phase C				

2030h~2035h: Position Sensor Configuration

Address	Description	Access	Data Type	Unit	Range	Default
2030h	Sensor bias	R/W	UINT32	INC	0 to 65535	0
Bits	**Name**	**Description**				
31:0	Sensor bias	Sets the theta bias between the rotor's electrical angle and the sensed angle via the angular sensor. The sensor bias and sensor direction are vital parameters to make the motor spin, and the rotor alignment procedure determines these values automatically. Does not have to be set manually.				

Address	Description	Access	Data Type	Unit	Range	Default
2031h	Sensor direction	R/W	UINT8	-	0 to 1	0
Bits	**Name**	**Description**				
7:1	Reserved	Unused.				
0	Sensor direction	0: The original angle is used in motor control 1: The complementary angle is used in motor control. See register 2030h above for more details				

Address	Description	Access	Data Type	Unit	Range	Default
2034h	INL enable	R/W	UINT8	-	0 to 1	0
Bits	**Name**	**Description**				
7:1	Reserved	Unused.				
0	INL enable	0: Disable INL calibration function. The angle feedback is the original signal 1: Enable INL calibration. The angle feedback is processed by the INL calibration block and then used for motor control				

Address	Description	Access	Data Type	Unit	Range	Default
2035h	Speed feedback source	R/W	UINT8	-	0 to 2	2
Bits	**Name**	**Description**				
7:2	Reserved	Unused.				
1:0	Speed feedback source	0: Use the speed's raw data as the feedback source 1: Reserved. Do not use this setting 2: Use the speed after the AccuFilter as the feedback source Others: Reserved				

2040h~2046h: Feed-Forward Parameters

Address	Description	Access	Data Type	Unit	Range	Default
2040h	Feed-forward enable	R/W	UINT8	-	UINT8	0
Bits	**Name**	**Description**				
7:3	Reserved	Unused.				
2	Speed feed-forward enable	If set, the speed feed-forward function is enabled. Speed feed-forward can reduce the position following error.				
1	Torque feed-forward enable	If set, the torque feed-forward function is enabled.				
0	Decoupling enable	If set, the decoupling function is enabled.				

Address	Description	Access	Data Type	Unit	Range	Default
2041h	Decoupling gain	R/W	UINT8	%	0 to 200	100
Bits	**Name**	**Description**				
7:0	Decoupling gain	Determines the percentage of the decoupling value that should be added to the current loop output.				

Address	Description	Access	Data Type	Unit	Range	Default
2042h	Decoupling filter time constant	R/W	UINT16	ms	UINT16	0
Bits	**Name**	**Description**				
15:0	Decoupling filter time constant	Determines the rising time constant of the decoupling value to avoid the voltage reference step.				

Address	Description	Access	Data Type	Unit	Range	Default
2043h	Torque feed-forward gain	R/W	UINT8	%	0 to 200	100
Bits	**Name**	**Description**				
7:0	Torque feed-forward gain	Determines the percentage of the torque feed-forward value that should be added to the speed loop output.				

Address	Description	Access	Data Type	Unit	Range	Default
2044h	Torque feed-forward filter time constant	R/W	UINT16	ms	UINT16	0
Bits	**Name**	**Description**				
15:0	Torque feed-forward filter time constant	Determines the rising time constant of the torque feed-forward value to avoid a torque reference step.				

Address	Description	Access	Data Type	Unit	Range	Default
2045h	Speed feed-forward gain	R/W	UINT8	%	0 to 200	100
Bits	**Name**	**Description**				
7:0	Speed feed-forward gain	Determines the percentage of the speed feed-forward value that should be added to the position loop output.				

Address	Description	Access	Data Type	Unit	Range	Default
2046h	Speed feed-forward filter time constant	R/W	UINT16	ms	UINT16	0
Bits	**Name**	**Description**				
15:0	Speed feed-forward filter time constant	Determines the rising time constant of the torque feed-forward value to avoid the speed reference step.				

2050h~2057h: Loop Parameters

Address	Description	Access	Data Type	Unit	Range	Default
2050h	Position loop bandwidth	R/W	UINT16	Hz	1 to 200	20
Bits	**Name**	**Description**				
15:0	Position loop bandwidth	Sets the position loop bandwidth (in Hz). This is the outermost loop of three-loop control. A reasonable range is 10Hz to 100Hz; this value should be 5 to 10 times smaller than the speed loop bandwidth (2052h).				

Address	Description	Access	Data Type	Unit	Range	Default
2052h	Speed loop bandwidth	R/W	UINT16	Hz	1 to 500	200
Bits	**Name**	**Description**				
15:0	Speed loop bandwidth	Sets the speed loop bandwidth (in Hz). A reasonable range is 50Hz to 400Hz. This value should be 5 to 10 times greater than the position loop bandwidth (2050h), and 5 to 10 times smaller than the torque loop bandwidth (2054h).				

Address	Description	Access	Data Type	Unit	Range	Default
2053h	Speed loop integral constant	R/W	UINT16	Hz	1 to 50	10
Bits	**Name**	**Description**				
15:0	Speed loop integral constant	Sets the speed loop integral constant. A reasonable range is 2Hz to 20Hz. A larger value results in a faster response, but creates a larger overshoot during speed transitions.				

Address	Description	Access	Data Type	Unit	Range	Default
2054h	Torque loop bandwidth	R/W	UINT16	Hz	200 to 2000	1000
Bits	**Name**	**Description**				
15:0	Torque loop bandwidth	Sets the torque loop bandwidth. A reasonable range is 1kHz to 2kHz. A larger value improves torque response. This value should be 5 to 10 times greater than the speed loop bandwidth (2052h).				

Address	Description	Access	Data Type	Unit	Range	Default
2055h	Position loop out limit	R/W	UINT32	INC/s	UINT32	3276800
Bits	**Name**	**Description**				
31:0	Position loop out limit	This value limits the output of the position controller, which limits the motor speed and prevents damage or controller saturation.				

Address	Description	Access	Data Type	Unit	Range	Default
2056h	Speed loop out limit	R/W	UINT16	‰	UINT16	3000
Bits	**Name**	**Description**				
15:0	Speed loop out limit	This value limits the speed controller output, which limits the motor torque.				

Address	Description	Access	Data Type	Unit	Range	Default
2057h	Torque loop speed limit	R/W	UINT32	rpm	UINT32	3000
Bits	**Name**	**Description**				
31:0	Torque loop speed limit	Sets the speed limit when the motor works in torque mode to prevent the motor from running too fast.				

2070h~2074h: Filter Parameters

Address	Description	Access	Data Type	Unit	Range	Default
2070h	Position filter bandwidth	R/W	UINT16	Hz	100 to 2000	200
Bits	**Name**	**Description**				
15:0	Position filter bandwidth	To minimize the phase delay caused by the filter, set this value to be 10 times greater than the position loop bandwidth.				

Address	Description	Access	Data Type	Unit	Range	Default
2071h	Speed filter 1 bandwidth	R/W	UINT16	Hz	100 to 2000	1000
Bits	**Name**	**Description**				
15:0	Speed filter 1 bandwidth	To minimize the phase delay caused by the filter, set this value to be 5 to 10 times greater than the speed loop bandwidth.				

Address	Description	Access	Data Type	Unit	Range	Default
2074h	Speed filter 2 bandwidth	R/W	UINT16	Hz	100 to 2000	1000
Bits	**Name**	**Description**				
15:0	Speed filter 2 bandwidth	To minimize the phase delay caused by the filter, set this value to be 5 to 10 times greater than the speed loop bandwidth.				

2080h~2088h: Notch Filter Parameters

Address	Description	Access	Data Type	Unit	Range	Default
2080h	Notch enable	R/W	UINT8	-	UINT8	0
Bits	**Name**	**Description**				
15:2	Reserved	Unused.				
1	Notch 2 enable	Enables notch filter 2.				
0	Notch 1 enable	Enables notch filter 1.				

Address	Description	Access	Data Type	Unit	Range	Default
2081h	Notch1_a1	R/W	UINT16	LSB	UINT16	0
Bits	**Name**	**Description**				
15:0	notch1_a1	Sets notch filter 1's parameter a1. See Section 4.7.2 on page 41 for the formula to calculate the notch filter parameter.				

Address	Description	Access	Data Type	Unit	Range	Default
2082h	Notch1_a2	R/W	UINT16	LSB	UINT16	0
Bits	**Name**	**Description**				
15:0	Notch1_a2	Sets notch filter 1's parameter a2.				

Address	Description	Access	Data Type	Unit	Range	Default
2083h	Notch1_b1	R/W	UINT16	LSB	UINT16	0
Bits	**Name**	**Description**				
15:0	Notch1_b1	Sets notch filter 1's parameter b1.				

Address	Description	Access	Data Type	Unit	Range	Default
2084h	Notch1_b2	R/W	UINT16	LSB	UINT16	0
Bits	**Name**	**Description**				
15:0	Notch1_b2	Sets notch filter 1's parameter b2.				

Address	Description	Access	Data Type	Unit	Range	Default
2085h	Notch2_a1	R/W	UINT16	LSB	UINT16	0
Bits	**Name**	**Description**				
15:0	Notch2_a1	Sets notch filter 2's parameter a1.				

Address	Description	Access	Data Type	Unit	Range	Default
2086h	Notch2_a2	R/W	UINT16	LSB	UINT16	0
Bits	**Name**	**Description**				
15:0	Notch2_a2	Sets notch filter 2's parameter a2.				

Address	Description	Access	Data Type	Unit	Range	Default
2087h	Notch2_b1	R/W	UINT16	LSB	UINT16	0
Bits	**Name**	**Description**				
15:0	Notch2_b1	Sets notch filter 2's parameter b1.				

Address	Description	Access	Data Type	Unit	Range	Default
2088h	Notch2_b2	R/W	UINT16	LSB	UINT16	0
Bits	**Name**	**Description**				
15:0	Notch2_b2	Sets notch filter 2's parameter b2.				

20B0h~20BAh: Protection Parameter

Address	Description	Access	Data Type	Unit	Range	Default
20B0h	Protection enable	R/W	UINT8	-	-	0
Bits	**Name**	**Description**				
7:4	RESERVED	Unused.				
3	VIN_LIMIT_EN	0: Disable the DC link voltage limit 1: Enable the DC link voltage limit				
2	LOCK_EN	0: Disable rotor-lock protection 1: Enable rotor-lock protection				
1	UVLO_EN	0: Disable under-voltage lockout (UVLO) protection 1: Enable UVLO protection				
0	OCP_EN	0: Disable over-current protection (OCP) 1: Enable OCP				

Address	Description	Access	Data Type	Unit	Range	Default
20B1h	OCP threshold	R/W	UINT16	A	UINT16	20
Bits	**Name**	**Description**				
15:0	OCP threshold	Sets the over-current threshold (in A). If any phase current exceeds this value, OCP is triggered and the motor stops.				

Address	Description	Access	Data Type	Unit	Range	Default

20B2h	UVLO threshold	R/W	UINT16	V	8 to 30	12
Bits	**Name**	**Description**				
15:0	UVLO threshold	Sets the under-voltage lockout (UVLO) threshold (in V). If the DC link voltage is below this value, UVLO protection is triggered and the motor stops.				

Address	**Description**	**Access**	**Data Type**	**Unit**	**Range**	**Default**
20B3h	Lock position threshold	R/W	UINT32	INC	UINT32	182
Bits	**Name**	**Description**				
31:0	Lock position threshold	If the position target is not reached and the difference between the position's actual value and the target position exceeds this value for longer than the lock time, then rotor-lock protection is triggered.				

Address	**Description**	**Access**	**Data Type**	**Unit**	**Range**	**Default**
20B4h	Lock speed threshold	R/W	UINT32	INC/s	UINT32	109226
Bits	**Name**	**Description**				
31:0	Lock speed threshold	If the target velocity is not reached and the velocity's actual value is below this value for longer than the lock time in speed mode, then rotor-lock protection is triggered.				

Address	**Description**	**Access**	**Data Type**	**Unit**	**Range**	**Default**
20B5h	Lock time window	R/W	UINT16	ms	UINT16	1000
Bits	**Name**	**Description**				
15:0	Lock time window	Used for the monitor rotor lock. See the 20B3h and 20B4h registers above for more details.				

Address	**Description**	**Access**	**Data Type**	**Unit**	**Range**	**Default**
20B6h	Retry enable	R/W	UINT8	-	0 - 1	0
Bits	**Name**	**Description**				
7:1	Reserved	Unused.				
0	Retry enable	0: Disable the protection retry function 1: Enable the protection retry function				

Address	**Description**	**Access**	**Data Type**	**Unit**	**Range**	**Default**
20B7h	Retry time	R/W	UINT16	ms	UINT16	3000
Bits	**Name**	**Description**				
15:0	Retry time	If protection retry is enabled and any protection is triggered, then the motor returns to the operation enable state after the protection retry time.				

Address	**Description**	**Access**	**Data Type**	**Unit**	**Range**	**Default**
20B8h	DC link limit upper threshold	R/W	UINT16	V	UINT16	56
Bits	**Name**	**Description**				
15:0	DC link limit upper threshold	If the DC link voltage exceeds this value, the VDCCON pin starts switching.				

Address	**Description**	**Access**	**Data Type**	**Unit**	**Range**	**Default**
20B9h	DC link limit lower threshold	R/W	UINT16	V	UINT16	52
Bits	**Name**	**Description**				
15:0	DC link limit lower threshold	If the DC link voltage falls below this value, the VDCCON pin stops switching.				

Address	**Description**	**Access**	**Data Type**	**Unit**	**Range**	**Default**
20BAh	Error status	RO	UINT16	-	-	0

Bits	Name	Description
15:7	RESERVED	Unused.
6	SENSOR_ERR	0: The position sensor is working normally 1: The position sensor is not working normally
5	POS_LIMIT	0: The position is in the allowed range 1: The position is out of range
4	OVERLOAD	0: Overload protection (OLP) has not been triggered 1: OLP has been triggered
3	VIN_LIMIT	0: VIN_LIMIT protection has not been triggered 1: VIN_LIMIT protection has been triggered
2	LOCK	0: Lock protection has not been triggered 1: LOCK protection has been triggered
1	UVLO	0: UVLO protection has not been triggered 1: UVLO protection has been triggered
0	OCP	0: OCP has not been triggered 1: OCP has been triggered

20C0h~20CBh: Parameter Identification

Address	Description	Access	Data Type	Unit	Range	Default
20C0h	Identify method	R/W	UINT8	-	0 to 1	0
Bits	**Name**	**Description**				
7:1	Reserved	Unused.				
0	Identify method	Sets the method for auto-tuning. 0: Range unlimited method 1: Range-limited method				

Address	Description	Access	Data Type	Unit	Range	Default
20C1h	Round max	R/W	UINT16	round	3 to 65535	50
Bits	**Name**	**Description**				
15:0	Round max	Sets the maximum allowed revolutions for the motor to spin. It is used in the range-limited method to guarantee that the motor movement does not exceed the mechanical limits.				

Address	Description	Access	Data Type	Unit	Range	Default
20C2h	Round acceleration	R/W	UINT16	round	1 to 65535	10
Bits	**Name**	**Description**				
15:0	Round acceleration	Sets the allowed maximum revolutions during acceleration. This value should be less than half of the identified max revolutions (20C1h).				

Address	Description	Access	Data Type	Unit	Range	Default
20C3h	Round J	R/W	UINT16	round	1 to 65535	10
Bits	**Name**	**Description**				
15:0	Round J	Sets the allowed maximum revolutions during identify inertia. This value should be less than half of the identified max revolutions (20C1h).				

Address	Description	Access	Data Type	Unit	Range	Default
20C4h	Identification status	RO	UINT8	-	0 to 16	0
Bits	**Name**	**Description**				
7:0	Identification status	Indicates the current identification status. 0: Idle 1: Preparation 2: Identifying phase resistor 3: Ready for inductor identification 4: Identifying D-axis inductor 5: Identifying Q-axis inductor 6: Finding theta bias 7: Identifying torque constant (range unlimited) 8: Identifying inertia (range unlimited) 9: Identifying inertia for the second time (range unlimited) 10: Identifying torque constant (range-limited) 11: Identifying inertia (range unlimited) 12: Identification complete 13: Homing 14: Identifying acceleration design 15: Identifying error handling 16: Identifying error				

Address	Description	Access	Data Type	Unit	Range	Default
20C5h	Identified R_S	RO	UINT32	mΩ	-	0
Bits	**Name**	**Description**				
31:0	Identified R_S	Indicates the identified phase resistance (in mΩ).				

Address	Description	Access	Data Type	Unit	Range	Default
20C6h	Identified L_D	RO	UINT32	µH	-	0
Bits	**Name**	**Description**				
31:0	Identified L_D	Indicates the identified motor D-axis inductance.				

Address	Description	Access	Data Type	Unit	Range	Default
20C7h	Identified L_Q	RO	UINT32	µH	-	0
Bits	**Name**	**Description**				
31:0	Identified L_Q	Indicates the identified motor Q-axis inductance.				

Address	Description	Access	Data Type	Unit	Range	Default
20C8h	Identified K_T	RO	UINT32	mNm/A	-	0
Bits	**Name**	**Description**				
31:0	Identified K_T	Indicates the identified motor torque constant (in mNm/A).				

Address	Description	Access	Data Type	Unit	Range	Default
20C9h	Identified J	RO	UINT32	g x cm^2	-	0
Bits	**Name**	**Description**				
31:0	Identified J	Indicates the identified system inertia (in g x cm^2).				

Address	Description	Access	Data Type	Unit	Range	Default
20CAh	Identified B	RO	UINT32	mNm x s	-	0
Bits	**Name**	**Description**				
31:0	Identified B	Indicates the identified system friction constant (in mNm x s).				

Address	Description	Access	Data Type	Unit	Range	Default

20CBh	Identified T_F	RO	UINT32	mNm	-	0
Bits	**Name**	**Description**				
31:0	Identified T_F	Indicates the identified static friction torque of the system (in mNm).				

20E0h~20E9h: Servo Internal Information

Address	**Description**	**Access**	**Data Type**	**Unit**	**Range**	**Default**
20E0h	I_D	RO	INT16	mA	INT16	-
Bits	**Name**	**Description**				
15:0	I_D	Indicates the direct axis current of the motor. Should be close to 0 since the controller is using the I_D = 0 control method.				

Address	**Description**	**Access**	**Data Type**	**Unit**	**Range**	**Default**
20E1h	I_Q	RO	INT16	mA	INT16	-
Bits	**Name**	**Description**				
15:0	I_Q	Sets the quadrature axis current of the motor, which is proportional to the motor's output torque.				

Address	**Description**	**Access**	**Data Type**	**Unit**	**Range**	**Default**
20E2h	U_D	RO	INT16	mV	INT16	-
Bits	**Name**	**Description**				
15:0	U_D	Sets the motor's direct axis voltage.				

Address	**Description**	**Access**	**Data Type**	**Unit**	**Range**	**Default**
20E3h	U_Q	RO	INT16	mV	INT16	-
Bits	**Name**	**Description**				
15:0	U_Q	Sets the motor's quadrature axis voltage.				

Address	**Description**	**Access**	**Data Type**	**Unit**	**Range**	**Default**
20E4h	Torque	RO	INT16	mNm	INT16	-
Bits	**Name**	**Description**				
15:0	Torque	Sets the motor's output torque, which is estimated by the torque observer.				

Address	**Description**	**Access**	**Data Type**	**Unit**	**Range**	**Default**
20E5h	Sensor position	RO	UINT16	INC	UINT16	-
Bits	**Name**	**Description**				
15:0	Sensor position	Sets the angular sensor's raw data. The relationship between the object value and the real angle is ANGLE = Value / 65536 x 360.				

Address	**Description**	**Access**	**Data Type**	**Unit**	**Range**	**Default**
20E6h	Filtered position	RO	UINT16	INC	UINT16	-
Bits	**Name**	**Description**				
15:0	Filtered position	Sets the angular sensor data after filtering, which is also used as the position feedback of the position control loop.				

Address	**Description**	**Access**	**Data Type**	**Unit**	**Range**	**Default**
20E8h	Filtered speed	RO	INT32	INC/s	UINT32	-
Bits	**Name**	**Description**				
31:0	Filtered speed	Sets the motor speed after the internal filter, which is also used as the speed feedback for the speed control loop.				

2300h~230Fh: I/O Functions

Address	**Description**	**Access**	**Data Type**	**Unit**	**Range**	**Default**

2300h	DI1 function	R/W	UINT8	-	0 to 6	0
Bits	**Name**	**Description**				
7:0	DI1 function	Selects the DI1 function. 0: DIR 1: Negative switch 2: Positive switch 3: Home switch 4: Multi-point 1 5: Multi-point 2 6: Multi-point 3				

Address	**Description**	**Access**	**Data Type**	**Unit**	**Range**	**Default**
2301h	DI2 function	R/W	UINT8	-	0 to 6	0
Bits	**Name**	**Description**				
7:0	DI2 function	Selects the DI2 function. 0: PUL/PWM 1: Negative switch 2: Positive switch 3: Home switch 4: Multi-point 1 5: Multi-point 2 6: Multi-point 3				

Address	**Description**	**Access**	**Data Type**	**Unit**	**Range**	**Default**
2302h	DI3 function	R/W	UINT8	-	0 to 6	0
Bits	**Name**	**Description**				
7:0	DI3 function	Selects the DI3 function. 0: ENA 1: Negative switch 2: Positive switch 3: Home switch 4: Multi-point 1 5: Multi-point 2 6: Multi-point 3				

Address	**Description**	**Access**	**Data Type**	**Unit**	**Range**	**Default**
2303h	DI4 function	R/W	UINT8	-	0 to 3	0
Bits	**Name**	**Description**				
7:0	DI4 function	Selects the DI4 function. 0: Homing enable 1: Negative switch 2: Positive switch 3: Home switch				

Address	Description	Access	Data Type	Unit	Range	Default
2304h	DI5 function	R/W	UINT8	-	0 to 4	4
Bits	**Name**	**Description**				
7:0	DI5 function	Selects the DI5 function. 0: Not used 1: Negative switch 2: Positive switch 3: Home switch 4: UART RX				

Address	Description	Access	Data Type	Unit	Range	Default
2305h	DI6 function	R/W	UINT8	-	0	0
Bits	**Name**	**Description**				
7:0	DI6 function	Selects the DI6 function. This register is reserved for future use.				

Address	Description	Access	Data Type	Unit	Range	Default
2306h	DI7 function	R/W	UINT8	-	0	0
Bits	**Name**	**Description**				
7:0	DI7 function	Selects the DI7 function. This register is reserved for future use.				

Address	Description	Access	Data Type	Unit	Range	Default
2307h	DI8 function	R/W	UINT8	-	0	0
Bits	**Name**	**Description**				
7:0	DI8 function	Selects the DI8 function. This register is reserved for future use.				

Address	Description	Access	Data Type	Unit	Range	Default
2308h	DO1 function	R/W	UINT8	-	0 to 3	0
Bits	**Name**	**Description**				
7:0	DO1 function	Selects the DO1 function. 0: PEND. 1: Alarm 2: Brake 3: Point 1 reached, this can be used in I/O-controlled position mode				

Address	Description	Access	Data Type	Unit	Range	Default
2309h	DO2 function	R/W	UINT8	-	0 to 3	0
Bits	**Name**	**Description**				
7:0	DO2 function	Selects the DO2 function. 0: PEND 1: Alarm 2: Brake 3: Point 2 reached, this can be used in I/O-controlled position mode				

Address	Description	Access	Data Type	Unit	Range	Default
230Ah	DO3 function	R/W	UINT8	-	0	0
Bits	**Name**	**Description**				
7:0	DO3 function	Selects the DO3 function. 0: Brake				

Address	Description	Access	Data Type	Unit	Range	Default
230Bh	DO4 function	R/W	UINT8	-	0 to 3	3
Bits	**Name**	**Description**				
7:0	DO4 function	Selects the DO4 function. 0: PEND 1: Alarm 2: Brake 3: UART TX				

Address	Description	Access	Data Type	Unit	Range	Default
230Ch	DO5 function	R/W	UINT8	-	0	0
Bits	**Name**	**Description**				
7:0	DO5 function	Selects the DO5 function. This register is reserved for future use.				

Address	Description	Access	Data Type	Unit	Range	Default
230Dh	DO6 function	R/W	UINT8	-	0	0
Bits	**Name**	**Description**				
7:0	DO6 function	Selects the DO6 function. This register is reserved for future use.				

Address	Description	Access	Data Type	Unit	Range	Default
230Eh	DO7 function	R/W	UINT8	-	0	0
Bits	**Name**	**Description**				
7:0	DO7 function	Selects the DO7 function. This register is reserved for future use.				

Address	Description	Access	Data Type	Unit	Range	Default
230Fh	DO8 function	R/W	UINT8	-	0	0
Bits	**Name**	**Description**				
7:0	DO8 function	Selects the DO8 function. This register is reserved for future use.				

2310h: I/O Polarity

Address	Description	Access	Data Type	Unit	Range	Default
2310h	I/O polarity	R/W	UINT16	-	-	0
Bits	**Name**	**Description**				
15	DO8 polarity	0: Non-inverted 1: Inverted				
14	DO7 polarity	0: Non-inverted 1: Inverted				
13	DO6 polarity	0: Non-inverted 1: Inverted				
12	DO5 polarity	0: Non-inverted 1: Inverted				
11	DO4 polarity	0: Non-inverted 1: Inverted				
10	DO3 polarity	0: Non-inverted 1: Inverted				
9	DO2 polarity	0: Non-inverted 1: Inverted				
8	DO1 polarity	0: Non-inverted 1: Inverted				
7	DI8 polarity	0: Non-inverted 1: Inverted				
6	DI7 polarity	0: Non-inverted 1: Inverted				
5	DI6 polarity	0: Non-inverted 1: Inverted				
4	DI5 polarity	0: Non-inverted 1: Inverted				
3	DI4 polarity	0: Non-inverted 1: Inverted				
2	DI3 polarity	0: Non-inverted 1: Inverted				
1	DI2 polarity	0: Non-inverted 1: Inverted				
0	DI1 polarity	0: Non-inverted 1: Inverted				

2320h: Command Source

Address	Description	Access	Data Type	Unit	Range	Default
2320h	Command dource	R/W	UINT16	-	-	0
Bits	**Name**	**Description**				
15:2	Reserved	Not used.				
1	Homing source	Select motor homing command source. 0: Data bus 1: I/O signal				
0	Enable source	Select motor enable command source. 0: Data bus 1: ENA I/O signal				

2400h: Temperature

Address	Description	Access	Data Type	Unit	Range	Default
2400h	Temperature	RO	INT16	°C	-40 to +125	-
Bits	**Name**	**Description**				
15:0	Temperature	Indicates the PCB's temperature.				

2410h: OTP Threshold

Address	Description	Access	Data Type	Unit	Range	Default
2410h	OTP threshold	R/W	INT16	°C	-40 to +125	85
Bits	**Name**	**Description**				
15:0	OTP threshold	Sets the over-temperature protection (OTP) threshold.				

2420h~2422h: Overload Settings

Address	Description	Access	Data Type	Unit	Range	Default
2420h	Overload enable	R/W	UINT8	-	0 to 1	0
Bits	**Name**	**Description**				
15:1	RESERVED	Unused.				
0	OVERLOAD_EN	0: Disable overload protection (OLP) 1: Enable OLP				

Address	Description	Access	Data Type	Unit	Range	Default
2421h	Overload current threshold	R/W	UINT16	‰	0 to 3000	3000
Bits	**Name**	**Description**				
15:0	Overload current threshold	Sets the OLP threshold, which is given in thousandths of the motor's rated current.				

Address	Description	Access	Data Type	Unit	Range	Default
2422h	Overload time window	R/W	UINT16	ms	UINT16	1000
Bits	**Name**	**Description**				
15:0	Overload time window	If the controller detects that the motor current exceeds the overload current threshold for longer than the overload time window, OLP is triggered. Set the time window to be longer than 1s to allow the motor current to exceed the overload current threshold for a short time. This is useful for applications that require a fast response.				

2500h~2501h: Voltage Divider

Address	Description	Access	Data Type	Unit	Range	Default
2500h	Lower divider	R/W	UINT16	kΩ	1 to 65535	10
Bits	**Name**	**Description**				
15:0	Lower divider	Sets the voltage divider used for the DC link voltage-sense lower resistor.				

Address	Description	Access	Data Type	Unit	Range	Default
2501h	Upper divider	R/W	UINT16	kΩ	1 to 65535	402
Bits	**Name**	**Description**				
15:0	Upper divider	Sets the voltage divider used for the DC link voltage-sense upper resistor.				

2600h~2601h: Electrical Gear Ratio

Address	Description	Access	Data Type	Unit	Range	Default
2600h	Numerator	R/W	UINT32	-	1 to 65536	1
Bits	**Name**	**Description**				
31:0	Numerator	Sets the electronic gear ratio numerator. Used together with the electronic gear ratio denominator (2601h). The pulses/revolution are defined as 65536 x Numerator / Denominator.				

Address	Description	Access	Data Type	Unit	Range	Default
2601h	Denominator	R/W	UINT32	-	1 to 65536	1
Bits	**Name**	**Description**				
31:0	Denominator	Electrical gear ratio. Used together with the electronic gear ratio numerator (2600h). The pulses/revolution are defined as 65536 x Numerator / Denominator.				

2700h~2702h: Homing Settings

Address	Description	Access	Data Type	Unit	Range	Default
2700h	Homing torque	R/W	UIN16	‰	UINT16	500
Bits	**Name**	**Description**				
15:0	Homing torque	Sets the maximum motor output torque limit during the torque-limited homing method (register 6980h equals -3 or -2). The homing torque should be set to exceed the load torque of the motor during the homing process. Otherwise, the motor may not reach the mechanical range limit.				

Address	Description	Access	Data Type	Unit	Range	Default
2701h	Homing time	R/W	UINT16	ms	UINT16	500
Bits	**Name**	**Description**				
15:0	Homing time	If the motor stalls for a period of time (the homing time) in torque limit homing mode, then the mechanical limit is reached. The controller then treats the current position as the homing position.				

Address	Description	Access	Data Type	Unit	Range	Default
2702h	Power-on homing enable	R/W	UINT8	-	0 to 1	0
Bits	**Name**	**Description**				
15:0	Power-on homing enable	0: Disable homing operation after power-on 1: Enable homing operation after power-on				

3050h: Modbus Address

Address	Description	Access	Data Type	Unit	Range	Default
3050h	Modbus address	R/W	UINT8	-	1 to 247	0x01
Bits	**Name**	**Description**				
7:0	Modbus address	Modbus slave address used for communication. The new address should be stored in the controller's NVM, and takes effect after restart.				

3060h: Modbus Baud Rate

Address	Description	Access	Data Type	Unit	Range	Default
3060h	Modbus baud rate	R/W	UINT16	100bps	-	0x0480
Bits	**Name**	**Description**				
15:0	Modbus baud rate	Modbus baud rate used for communication. The new baud rate should be stored in the controller's NVM, and takes effect after restart. The default baud rate is 115200bps.				

3070h: Modbus Parity

Address	Description	Access	Data Type	Unit	Range	Default
3070h	Modbus Parity	R/W	UINT8	-	0 to 2	2
Bits	**Name**	**Description**				
15:0	Modbus Parity	Modbus parity check bit. 0: No parity check 1: Odd parity check 2: Even parity check				

3080h~3083h: Brake Parameters

Address	Description	Access	Data Type	Unit	Range	Default
3080h	Brake enable	R/W	UINT8	-	0 to 1	0
Bits	**Name**	**Description**				
7:0	Brake enable	0: Disabled. The motor turns off immediately after the disable operation command is received 1: Enabled. If the motor is in position control mode and the target position is reached, the brake turns off immediately. After the disable operation command is received, the motor continues to remain in position mode for the brake stop delay time The brake has a turn-off time (several ms). If the motor turns off when the disable operation command is received, the motor shaft may move during the turn-off delay time. This feature prevents that behavior.				

Address	Description	Access	Data Type	Unit	Range	Default
3081h	Brake off speed	R/W	UINT16	rpm	0 to 1000	30
Bits	**Name**	**Description**				
15:0	Brake off speed	If the motor is running at a high speed and an error occurs (or the servo turns off), then the servo turns off immediately and waits for the speed to decrease. The brake turns off when the motor speed is below this value.				

Address	Description	Access	Data Type	Unit	Range	Default
3082h	Brake off delay	R/W	UINT16	ms	1 to 65535	1000
Bits	**Name**	**Description**				
15:0	Brake off delay	If the motor is running at a high speed and an error occurs (or the servo turns off), then the servo turns off immediately and waits for the speed to decrease. The brake turns off when the delay time exceeds this value.				

Address	Description	Access	Data Type	Unit	Range	Default
3083h	Brake stop delay	R/W	UINT16	ms	1 to 65535	1
Bits	**Name**	**Description**				
15:0	Brake stop delay	See register 3080h above for more details.				

3100h~3106h: Multi-Target Position

Address	Description	Access	Data Type	Unit	Range	Default
3100h~ 3106h	Multi-target position	R/W	INT32	INC	INT32	0
Bits	**Name**	**Description**				
31:0	Multi-target position	Sets the target position in I/O-controlled multi-position mode. See section 3.6.1 on page 25 for the relationship between the I/O levels and selected stage number.				

3110h~3116h: Multi-Profile Acceleration

Address	Description	Access	Data Type	Unit	Range	Default
3110h~ 3116h	Multi-profile acceleration	R/W	UINT32	INC/s^2	UINT32	0
Bits	**Name**	**Description**				
31:0	Multi-profile acceleration	Sets the profile acceleration for each stage. This is used for both I/O-controlled multi-position mode and I/O-controlled multi-velocity mode.				

3120h~3126h: Multi-Profile Deceleration

Address	Description	Access	Data Type	Unit	Range	Default
3120h~ 3126h	Multi-profile deceleration	R/W	UINT32	INC/s^2	UINT32	0
Bits	**Name**	**Description**				
31:0	Multi-profile deceleration	Sets the profile deceleration for each stage. This is used for both I/O-controlled multi-position mode and I/O-controlled multi-velocity mode.				

3130h~3136h: Multi-Profile Velocity

Address	Description	Access	Data Type	Unit	Range	Default
3130h~ 3136h	Multi-profile velocity	R/W	UINT32	INC/s	UINT32	0
Bits	**Name**	**Description**				
31:0	Multi-profile velocity	Sets the profile velocity for each stage.				

3140h~3146h: Multi-Target Velocity

Address	Description	Access	Data Type	Unit	Range	Default
3140h~ 3146h	Multi-target velocity	R/W	INT32	INC/s	INT32	0
Bits	**Name**	**Description**				
31:0	Multi-target velocity	Sets the selected target velocity in I/O-controlled multi-velocity mode. See section 3.7.1 on page 29 for the relationship between the I/O levels and selected stage number.				

6400h: Control Word

Address	Description	Access	Data Type	Unit	Range	Default
6400h	Control word	R/W	UINT16	-	UINT16	0
Bits	**Name**	**Description**				
15:11	Manufacturer specific	For more details, see the “Control Word” and “Status Word” sections of each operation mode.				
10	Reserved	Unused.				
9	Operation mode specific	For more details, see the “Control Word” and “Status Word” sections of each operation mode.				
8	Halt	Enable halt.				
7	Fault reset	Change from 0 to 1 to reset the internal fault status.				
6:4	Operation mode specific	For more details, see the “Control Word” and “Status Word” sections of each operation mode.				
3	Enable operation	Enter operation mode.				
2	Quick stop	Enter quick stop mode.				
1	Enable voltage	No effect; the DC power is always enabled.				
0	Switch on	Enable the power stage switch.				

6410h: Status Word

Address	Description	Access	Data Type	Unit	Range	Default
6410h	Status word	RO	UINT16	-	UINT16	-
Bits	**Name**	**Description**				
15:14	Manufacturer specific	For more details, see the “Control Word” and “Status Word” sections of each operation mode.				
13:12	Operation mode specific	For more details, see the “Control Word” and “Status Word” sections of each operation mode.				
11	Internal limit active	If position limit is reached, this bit is set.				
10	Operation mode specific	For more details, see the “Control Word” and “Status Word” sections of each operation mode.				
9	Remote	If set, parameters may be modified by communication.				
8	Manufacturer specific	For more details, see the “Control Word” and “Status Word” sections of each operation mode.				
7	Warning	0: No warning 1: Warning				
6	Switch on disabled	If set, the driver is in the switch on disabled state.				
5	Quick stop	1: Quick stop is able to perform 0: Quick stop is performing (or is unable to perform)				
4	Voltage enabled	Always set to 1. A high voltage is applied to the drive.				
3	Fault	If a fault occurs, this bit is set.				
2	Operation enabled	Indicates whether operation enabled mode is active.				
1	Switch on	Indicates whether the driver switch is on.				
0	Ready to switch on	Indicates whether the driver is ready to switch.				

65A0h: Quick Stop Option Code

Address	Description	Access	Data Type	Unit	Range	Default
65A0h	Quick stop option code	R/W	INT16	-	0 to 4	2
Bits	**Name**	**Description**				
15:0	Quick stop option code	Determines the response if the quick stop function is executed. 0: Disable the drive function 1: Slow down ramp and transition to the switch on disabled state 2: Quick stop ramp and transition to the switch on disabled state 3: Current limit and transition to the switch on disabled state 4: Reserved 5: Slow down the ramp and remain in the quick stop active state 6: Slow the quick stop ramp and remain in the quick stop active state 7: Current limit and remain in the quick stop active state 8: Reserved					

65D0h: Halt Option Code

Address	Description	Access	Data Type	Unit	Range	Default
65D0h	Halt option code	R/W	INT16	-	0 to 8	1
Bits	**Name**	**Description**				
15:0	Halt option code	0: Disable the drive function 1: Slow the down ramp and remain in the operation enable state 2: Execute the quick stop ramp and remain in the operation enable state 3: Current limit and remain in the operation enable state				

6600h: Operation Modes

Address	Description	Access	Data Type	Unit	Range	Default
6600h	Operation modes	R/W	INT8	-	-4 to +10	0
Bits	**Name**	**Description**				
7:0	Operation mode	Selects the operating mode. -4: Auto-tuning mode -3: INL calibration mode -2: Rotor aligning mode +1: Profile position (PP) mode +3: Profile velocity (PV) mode +4: Profile torque (PT) mode +6: Homing (HOME) mode +7: Reserved +8: Cyclic synchronous position (CSP) mode +9: Cyclic synchronous velocity (CSV) mode +10: Cyclic synchronous torque (CST) mode				

6610h: Operation Modes Display

Address	Description	Access	Data Type	Unit	Range	Default
6610h	Operation modes display	RO	INT8	-	-4 to +10	-
Bits	**Name**	**Description**				
7:0	Operation modes display	Shows the current operation mode. -4: Auto-tuning mode -3: INL calibration mode -2: Rotor aligning mode +1: Profile position (PP) mode +3: Profile velocity (PV) mode +4: Profile torque (PT) mode +6: Homing (HOME) mode +7: Reserved +8: Cyclic synchronous position (CSP) mode +9: Cyclic synchronous velocity (CSV) mode +10: Cyclic synchronous torque (CST) mode				

6620h: Position Demand Value

Address	Description	Access	Data Type	Unit	Range	Default
6620h	Position demand value	RO	INT32	INC	INT32	-
Bits	**Name**	**Description**				
31:0	Position demand value	Indicates the position demand output of the trajectory generator to the position control loop (in INC). The driver module has 65536 INC/revolution.				

6630h: Position Actual Internal Value

Address	Description	Access	Data Type	Unit	Range	Default
6630h	Position actual internal value	RO	INT32	INC	INT32	-
Bits	**Name**	**Description**				
31:0	Position actual internal value	Indicates the actual value of the position sensor, which is the feedback value of the position control loop. It is the same as the position's actual value (6640h).				

6640h: Position Actual Value

Address	Description	Access	Data Type	Unit	Range	Default
6640h	Position actual value	RO	INT32	INC	INT32	-
Bits	**Name**	**Description**				
31:0	Position actual value	Indicates the actual value of the position sensor, which is the feedback value of the position control loop.				

6650h: Following Error Window

Index	Description	Access	Data Type	Unit	Range	Default
6650h	Following error window	R/W	UINT32	INC	UINT32	182
Bits	**Name**	**Description**				
31:0	Following error window	Symmetrically defines a range of tolerated position values for the position demand value. If the position's actual value is out of the following error window, a following error occurs. A following error may occur if: • The motor is blocked • There is an unreachable profile velocity occurs • There are incorrect closed-loop parameters				

6660h: Following Error Timeout

Address	Description	Access	Data Type	Unit	Range	Default
6660h	Following error timeout	R/W	UINT32	ms	UINT32	10
Bits	**Name**	**Description**				
15:0	Following error timeout	If a following error occurs for longer than the defined timeout time, then "Status word," bit[13] is set to 1. In this condition, the motor continues running, and the user can determine the.				

6670h: Position Window

Address	Description	Access	Data Type	Unit	Range	Default
6670h	Position window	R/W	UINT32	INC	UINT32	182
Bits	**Name**	**Description**				
31:0	Position window	Defines a symmetrical range of acceptance relative to the target position. If the actual value of the position sensor is within the position window, the target is considered to be reached.				

6680h: Position Window Time

Address	Description	Access	Data Type	Unit	Range	Default
6680h	Position window time	R/W	UINT16	ms	UINT16	10
Bits	**Name**	**Description**				
15:0	Position window time	If the actual position is within the position window during the defined position window time, "Status word," bit[10] is set to 1.				

66B0h: Velocity Demand Value

Address	Description	Access	Data Type	Unit	Range	Default
66B0h	Velocity demand value	RO	INT32	INC/s	INT32	-
Bits	**Name**	**Description**				
31:0	Velocity demand value	Sets the output of the velocity trajectory generator for the velocity control loop.				

66C0h: Velocity Actual Value

Address	Description	Access	Data Type	Unit	Range	Default
66C0h	Velocity actual value	RO	INT32	INC/s	INT32	-
Bits	**Name**	**Description**				
31:0	Velocity actual value	Indicates the actual motor velocity, which is the feedback input of the velocity control loop.				

66D0h: Velocity Window

Address	Description	Access	Data Type	Unit	Range	Default
66D0h	Velocity window	R/W	UINT16	INC/s	UINT16	32768
Bits	**Name**	**Description**				
15:0	Velocity window	Monitors whether the target velocity has been reached. If the motor velocity is in the range for longer than the velocity window time, then the target value has been reached.				

66E0h: Velocity Window Time

Address	Description	Access	Data Type	Unit	Range	Default
66E0h	Velocity window time	R/W	UINT16	ms	UINT16	10
Bits	**Name**	**Description**				
15:0	Velocity window time	If the difference between the target velocity (66F0h) and actual velocity (66C0h) is within the velocity window (66D0) for longer than the velocity window time (66E0), the target has been reached.				

66F0h: Velocity Threshold

Address	Description	Access	Data Type	Unit	Range	Default
66F0h	Velocity threshold	R/W	UINT16	INC/s	UINT16	32768
Bits	**Name**	**Description**				
15:0	Velocity threshold	Sets the velocity threshold, which measures whether the motor is stationary. See register 6700h below for more details.				

6700h: Velocity Threshold Time

Address	Description	Access	Data Type	Unit	Range	Default
6700h	Velocity threshold time	R/W	UINT16	ms	UINT16	10
Bits	**Name**	**Description**				
15:0	Velocity threshold time	If the actual velocity (66C0h) exceeds the velocity threshold (66F0h) for longer than the velocity threshold time (6700h), the rotor is not stationary.				

6710h: Target Torque

Address	Description	Access	Data Type	Unit	Range	Default
6710h	Target torque	R/W	INT16	‰	-3000 to +3000	0
Bits	**Name**	**Description**				
15:0	Target torque	Sets the input value for the torque controller trajectory generator.				

6720h: Max Torque

Address	Description	Access	Data Type	Unit	Range	Default
6720h	Max torque	R/W	UINT16	‰	0 to 3000	3000
Bits	**Name**	**Description**				
15:0	Max torque	Sets the motor's maximum allowable torque (in thousandths of the rated torque).				

6730h: Max Current

Address	Description	Access	Data Type	Unit	Range	Default
6730h	Max current	R/W	UINT16	‰	0 to 3000	3000
Bits	**Name**	**Description**				
15:0	Max current	Sets the motor's maximum allowed torque-creating current (in thousandths of the rated torque).				

6740h: Torque Demand Value

Address	Description	Access	Data Type	Unit	Range	Default
6740h	Torque demand value	RO	INT16	‰	-3000 to +3000	-
Bits	**Name**	**Description**				
15:0	Torque demand value	Sets the torque trajectory generator output (in thousandths of the rated torque).				

6770h: Torque Actual Value

Address	Description	Access	Data Type	Unit	Range	Default
6770h	Torque actual value	RO	INT16	‰	-3000 to +3000	-
Bits	**Name**	**Description**				
15:0	Torque actual value	Indicates the actual motor electrical torque output (in thousandths of the rated torque).				

6780h: Current Actual Value

Address	Description	Access	Data Type	Unit	Range	Default
6780h	Current actual value	RO	INT16	‰	-3000 to +3000	-
Bits	**Name**	**Description**				
15:0	Current actual value	Indicates the actual motor Q-axis current (in thousandths of the rated torque).				

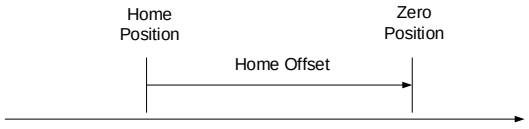
6790h: DC Link Voltage

Address	Description	Access	Data Type	Unit	Range	Default
6790h	DC link voltage	RO	UINT32	mV	UINT32	36000
Bits	**Name**	**Description**				
31:0	DC link voltage	Indicates the DC input voltage (in mV).				

67A0h: Target Position

Address	Description	Access	Data Type	Unit	Range	Default
67A0h	Target position	R/W	INT32	INC	INT32	0
Bits	**Name**	**Description**				
31:0	Target position	Sets the position that the motor should move to in PP mode. The target position is interpreted as absolute or relative, depending on the absolute/relative flag in "Control word." In CST mode, the target position is interpreted as an absolute value.				

67C0h: Home Offset

Address	Description	Access	Data Type	Unit	Range	Default
67C0h	Home offset	R/W	INT32	INC	INT32	0
Bits	**Name**	**Description**				
31:0	Home offset	Indicates the difference between the zero position for the application and the machine home position (found during homing). Once homing is complete, the zero position is offset from the homing position by adding the home offset to the home position. All of the subsequent, absolute moves are relative to this new zero position. 				

67D0h~67D1h: Software Position Limit

Address	Description	Access	Data Type	Unit	Range	Default
67D0h	Min position limit	R/W	INT32	INC	INT32	-2^{31}
Bits	**Name**	**Description**				
31:0	Min software position limit	Defines the absolute position limit for the demanded position. The demanded position does not exceed the minimum software position limit.				

Address	Description	Access	Data Type	Unit	Range	Default
67D1h	Max position limit	R/W	INT32	INC	INT32	$2^{31} - 1$
Bits	**Name**	**Description**				
31:0	Max software position limit	Defines the absolute position limit for the demanded position. The demanded position does exceed the maximum software position limit.				

67E0h: Polarity

Address	Description	Access	Data Type	Unit	Range	Default
67E0h	Polarity	R/W	UINT8	-	UINT8	0
Bits	**Name**	**Description**				
7	Position polarity	Indicates whether the demanded position value should be multiplied by +1 or -1. This flag has no influence on homing mode. This bit is used for PP mode and cyclic synchronous position (CSP) mode. 0: Multiply by +1 1: Multiply by -1				
6	Velocity polarity	Use for PV mode and cyclic synchronous velocity (CSV) mode. 0: Multiply by +1 1: Multiply by -1				
5:0	Reserved	Unused.				

67F0h: Max Profile Velocity

Address	Description	Access	Data Type	Unit	Range	Default
67F0h	Max profile velocity	R/W	UINT32	INC/s	UINT32	3276800
Bits	**Name**	**Description**				
31:0	Max profile velocity	Sets the maximum allowed profile velocity in each direction, and limits the target velocity in profile velocity mode.				

6800h: Max Motor Speed

Address	Description	Access	Data Type	Unit	Range	Default
6800h	Max motor speed	R/W	UINT32	rpm	UINT32	3000
Bits	**Name**	**Description**				
31:0	Max motor speed	Limits the maximum speed loop reference for speed control mode. It takes effect for both PV and CSV mode.				

6810h: Profile Velocity

Address	Description	Access	Data Type	Unit	Range	Default
6810h	Profile velocity	R/W	UINT32	INC/s	UINT32	655360
Bits	**Name**	**Description**				
31:0	Profile velocity	Returns the profile velocity, which is the velocity that is normally obtained at the end of the acceleration ramp during a profiled move. It is valid for both directions of motion.				

6830h: Profile Acceleration

Address	Description	Access	Data Type	Unit	Range	Default
6830h	Profile acceleration	R/W	UINT32	INC/s^2	UINT32	3276800
Bits	**Name**	**Description**				
31:0	Profile acceleration	Sets the acceleration during a profile move.				

6840h: Profile Deceleration

Address	Description	Access	Data Type	Unit	Range	Default
6840h	Profile deceleration	R/W	UINT32	INC/s^2	UINT32	3276800
Bits	**Name**	**Description**				
31:0	Profile deceleration	Sets the deceleration during a profile move.				

6850h: Quick Stop Deceleration

Address	Description	Access	Data Type	Unit	Range	Default
6850h	Quick stop deceleration	R/W	UINT32	INC/s^2	UINT32	3276800
Bits	**Name**	**Description**				
31:0	Quick stop deceleration	Set the deceleration ramp during a halt or quick stop period.				

6860h: Motion Profile Type

Address	Description	Access	Data Type	Unit	Range	Default
6860h	Motion profile type	R/W	INT16	-	0	0
Bits	**Name**	**Description**				
15:0	Motion profile type	0: Linear ramp profile Others: Reserved				

6870h: Torque Slope

Address	Description	Access	Data Type	Unit	Range	Default
6870h	Torque slope	R/W	UINT32	‰/s	UINT32	3000
Bits	**Name**	**Description**				
15:0	Torque slope	Indicates the motor's actual Q-axis current (in thousandths of the rated torque).				

6880h: Torque Profile Type

Address	Description	Access	Data Type	Unit	Range	Default
6880h	Torque profile type	R/W	INT16	-	0	0
Bits	**Name**	**Description**				
15:0	Torque profile type	0: Linear ramp profile Others: Reserved				

6980h: Homing Method

Address	Description	Access	Data Type	Unit	Range	Default
6980h	Homing method	R/W	INT8	-	0 - 35	0
Bits	**Name**	**Description**				
7:0	Homing method	-3: Homing clockwise with limited torque -2: Homing counterclockwise with limited torque -1: Reserved 0: No homing operation required +1~35: Methods 1–35 (see the Homing Mode section on page 18 for more details)				

6990h~6991h: Homing Speeds

Address	Description	Access	Data Type	Unit	Range	Default
6990h	Homing speed switch	R/W	UINT32	INC/s	UINT32	655360
Bits	**Name**	**Description**				
31:0	Homing speed switch	Sets the homing speed during a search for switch.				

Address	Description	Access	Data Type	Unit	Range	Default
6991h	Homing speed zero	R/W	UINT32	INC/s	UINT32	65536
Bits	**Name**	**Description**				
31:0	Homing speed zero	Sets the homing speed during a search for zero.				

609Ah: Homing Acceleration

Address	Description	Access	Data Type	Unit	Range	Default
69A0h	Homing acceleration	R/W	UINT32	INC/s^2	UINT32	0
Bits	**Name**	**Description**				
31:0	Homing acceleration	Sets the acceleration and deceleration during homing.				

6B00h: Position Offset

Address	Description	Access	Data Type	Unit	Range	Default
6B00h	Position offset	R/W	INT32	INC	INT32	0
Bits	**Name**	**Description**				
31:0	Position offset	The position offset should be an absolute value. It can be used to control the motor with relative values with regard to the target position.				

6B10h: Velocity Offset

Address	Description	Access	Data Type	Unit	Range	Default
6B10h	Velocity offset	R/W	INT32	INC/s	INT32	0
Bits	**Name**	**Description**				
31:0	Velocity offset	In CSP mode, the velocity offset is the value for velocity feed-forward. This is an optional selection, and can be used if a small following error is required.				

6B20h: Torque Offset

Address	Description	Access	Data Type	Unit	Range	Default
6B20h	Torque offset	R/W	INT16	‰	INT16	0
Bits	**Name**	**Description**				
15:0	Torque offset	Torque offset can be used as torque feed-forward in this mode. It is optional to perform cyclic synchronous position control.				

6C20h~6C21h: Interpolation Time Period

Address	Description	Access	Data Type	Unit	Range	Default
6C20h	Interpolation time period value	R/W	UINT8	-	1 to 255	1
Bits	**Name**	**Description**				
7:0	Interpolation time period value	Determines the interpolation time period with register 6C21h. For example, if register 6C20h is 1 and register 6C21h is -3, then the interpolation time period is 1^(-3)s = 1ms. The loop calculation period is 50µs. There are 20 calculation cycles in one interpolation period, and the motor control module interpolates the position/velocity and torque command linearly to make the motion smooth.				

Address	Description	Access	Data Type	Unit	Range	Default
6C21h	Interpolation time index	R/W	INT8	-	-4 to -3	-3
Bits	**Name**	**Description**				
7:0	Interpolation time index	See register 6C20h above for more details.				

6C50h: Max Acceleration

Address	Description	Access	Data Type	Unit	Range	Default
6C50h	Max acceleration	R/W	UINT32	INC/s^2	UINT32	$2^{32} - 1$
Bits	**Name**	**Description**				
31:0	Max acceleration	Sets the maximum acceleration to prevent damage and limit the maximum acceleration to an acceptable value.				

6C60h: Max Deceleration

Address	Description	Access	Data Type	Unit	Range	Default
6C60h	Max deceleration	R/W	UINT32	INC/s^2	UINT32	$2^{32} - 1$
Bits	**Name**	**Description**				
31:0	Max deceleration	Sets the maximum deceleration to prevent damage and limit the maximum deceleration to an acceptable value.				

6F40h: Following Error Actual Value

Address	Description	Access	Data Type	Unit	Range	Default
6F40h	Follow error actual value	RO	IN32	INC	INT32	-
Bits	**Name**	**Description**				
31:0	Following error actual value	Represents the actual value of the following error.				

6FF0h: Target Velocity

Address	Description	Access	Data Type	Unit	Range	Default
6FF0h	Target velocity	R/W	IN32	INC/s	INT32	0
Bits	**Name**	**Description**				
31:0	Target velocity	Sets the input for the trajectory generator in PV mode.				

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	5/10/2023	Initial Release	-
1.1	9/26/2023	Added the MMP740100-55-R2-1, MMP740050-55-R2-1, MMS740100-24-R2-1, and MMS740050-24-R2-1 to Table 1	8