



IX7NH MODBUS TCP COMMUNICATION GUIDE

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AUTOMATIONDIRECT FOREWORD

This communication guide will assist you with setting up Modbus TCP communications. For help getting your iX7NH drive configured and commissioned using Drive CM, please download the iX7NH Series AC Servo Drive Quick Start Guide first.

This Communication Guide is designed to support setting an iX7NH servo system to use Modbus TCP communications. This AutomationDirect Guide is a supplement to the LS Electric iX7NH User Manual. This Guide does not replace the manufacturer’s User Manual. For advanced features or options required by your application, you may still need to refer to the User Manual. Download and reference both this Communication Guide and the iX7NH User Manual when commissioning an iX7NH servo system.

A note on Part Numbers: LS Electric servo parts sold by AutomationDirect have part numbers that end with “-AD”. This suffix signifies special packaging and labeling for AutomationDirect. All the LS servo products with the “-AD” function and behave exactly the same as the standard LS Electric parts. Please note that when reading the LS electric User Manual or using the Drive CM software, the “-AD” will NOT appear in any part numbers. For example, AutomationDirect part iX7NHA004U-AD is just iX7NHA004U in the LS Electric documentation.

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WARNINGS AND CAUTIONS



WARNING: INSTALL BOTH THE SERVO DRIVE AND THE SERVO MOTOR BEFORE PERFORMING ANY WIRING.



WARNING: BEFORE WIRING OR INSPECTING, TURN OFF THE POWER, WAIT 15 MINUTES, MAKE SURE THE CHARGE LAMP IS OFF, AND CHECK THE VOLTAGE.



WARNING: ENSURE THIS PRODUCT IS CORRECTLY GROUNDED. ALL GROUNDING AND CIRCUIT PROTECTION METHODS MUST COMPLY WITH ALL LOCAL STANDARDS/REGULATIONS AND THE NATIONAL ELECTRICAL STANDARD (REFER TO NFPA 70: NATIONAL ELECTRICAL CODE, 202 Ed.)



WARNING: DO NOT CHANGE THE MOTOR OR DRIVE WIRING WHILE POWER IS ON.



WARNING: ONLY QUALIFIED AND TRAINED TECHNICIANS MAY PERFORM WIRING ON THIS PRODUCT.



WARNING: DO NOT OPERATE THE SERVO SYSTEM WITH WET HANDS.



WARNING: DO NOT OPEN THE SERVO DRIVE COVER DURING OPERATION.



WARNING: DO NOT OPERATE THE SERVO SYSTEM WITH THE SERVO DRIVE COVER REMOVED.



WARNING: DO NOT TOUCH THE HEAT SINK OF THE SERVO DRIVE WHEN IT IS CONNECTED TO POWER AND OPERATING THIS COMPONENT GETS VERY HOT AND WILL SCALD.



CAUTION: THE INSTALLATION LOCATION MUST BE FREE OF VAPOR AND CORROSIVE OR FLAMMABLE GAS.



CAUTION: WHEN WIRING, DO NOT CONNECT THE THREE-PHASE POWER SUPPLY TO THE MOTOR UVW CONNECTORS. INCORRECT WIRING MAY CAUSE DAMAGE TO THE SERVO DRIVE.



CAUTION: DO NOT DISASSEMBLE THE SERVO DRIVE.



CAUTION: VERIFY THE EMERGENCY STOP CAN BE ACTIVATED BEFORE THE SERVO DRIVE IS CONNECTED TO POWER AND PUT INTO OPERATION.

For additional warnings and precautions, please see pages **iii** through **vii** of the iX7NH User Manual.

USING MODBUS TCP TO CONTROL iX7NH SERVO DRIVES

Use Drive CM to configure and start up the iX7NH drive. See page 5 of the iX7NH Quick Start Guide for details. This Modbus TCP guide assumes you have a fully commissioned iX7NH system that has no warnings/errors and the motor can be moved with the Drive CM Jog Screen and the PTP Move Screen. This guarantees that the drive is ready to receive commands over Modbus TCP. Wire an Ethernet cable from your client (PLC, Modbus Poll, etc.) to the EtherCAT IN port (the upper RJ45) on the drive. The rotary dip switches on the front of the drive must be set to 98 or 99 for Modbus TCP. Node 99 allows Modbus TCP operation and provides a built-in webserver. For networks that do not allow device web servers, Node 98 allows Modbus TCP operation without the built-in webserver (firmware version 1.15 and above). These switches are only read at power-up, so cycle power to the drive for any changes to take effect.

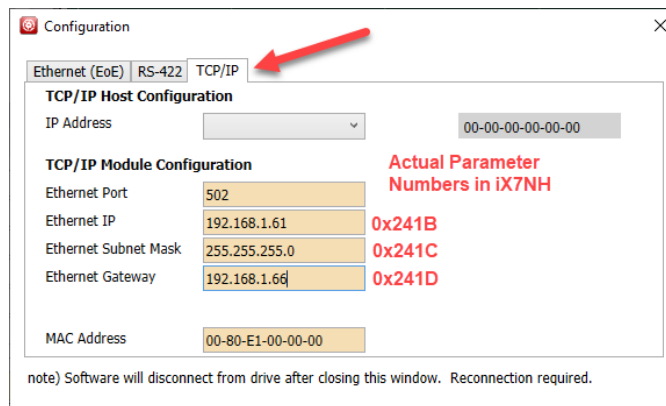
Since this drive is a “Network drive” (the “N” stands for Network), there is limited control when using digital inputs for motion commands. All motion should be done through comms. Of course, STO and field devices (POT, NOT, etc.) are available as wired inputs to the drive and should be used.

The Modbus TCP command and control registers are fairly basic. This guide will show how to set up the drive for basic motion in Position Mode. For additional information, please see the iX7NH User Manual. AutomationDirect also provides sample PLC programs that demonstrate communication control. Find those sample programs on each drive’s Item Page under Support Resources on AutomationDirect.com.

CONFIGURE THE IP ADDRESSES

In Drive CM, connect to the drive via USB. If using the SV_ON digital input, turn it OFF to disable the drive. If using software enable/disable control, go to one of the screens that has a “Drive OFF” button (PTP Move, Jog, Torque, Homing) and press “Drive OFF”. The Servo On (SV_ON) digital input must physically be OFF for the software Drive ON/Drive OFF buttons to function properly. The drive evaluates the physical digital input and the software buttons as an OR function for drive enable. Some of the following actions will not process correctly if the drive is enabled.

From the pull-down menu select Setup\Configuration. Click on the TCP/IP Tab. Type in the desired Ethernet IP and Ethernet Subnet Mask. Also fill in the desired Ethernet Gateway if known. Make sure to press Enter inside each of the entry fields to ensure the value is actually sent to the drive. A red value has not been sent to the drive.



Close the Configuration pop up window. Comms to the drive will be broken after this window is closed (even if connected via USB). Reconnect to the drive, then press (1) “Save to Memory” to save the settings to EEPROM. Then press (2) “Software Reset” or cycle power to the drive. The new IP addresses will not take effect until the drive is rebooted.



NOTE: The drive's current IP address can be read from parameter 0x241B in Drive CM's Parameter Editor window (select the Misc. tab). Change the view to Hexadecimal to view the entire IP address in one register. Each IP address octet is represented by two hex characters. Note that the order of the values are swapped (A.B.C.D for the address = 0xDCBA in the register). For an IP Address of 192.168.1.61 the value of 0x241B (in hex) = 0x3D01ABCO.



Hex Value Decimal Value

3D	61
01	1
AB	168
C0	192

Your client (PLC) will need to have compatible Ethernet settings. Use a direct connection or use an unmanaged switch for initial testing to minimize the chance of router issues.

- Ethernet IP: 192.168.1.xx (xx = any 0-255 value other than the drive IP address or Gateway address)
- Ethernet Subnet Mask: 255.255.255.0

CONFIGURE THE MAC ID

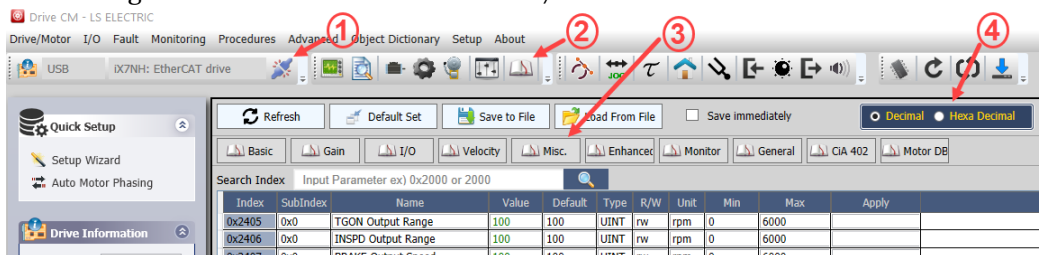
The iX7NH drive allows the user to set the MAC ID for the ethernet hardware. The MAC ID is not read-only. The default MAC ID for all iX7NH drives is 00:80:E1:00:00:00.

Having duplicate MAC IDs on a network goes against IEEE networking standards and should be avoided. Even if duplicate MAC IDs don't cause a problem in an application right now, they could as a company's network hardware, firmware, or IT rules change in the future.

The simple solution to prevent MAC ID duplication is to assign each drive with a unique MAC ID. AutomationDirect recommends keeping the default Vendor ID (00:80:E1) and setting the NIC ID to the last 5 digits of the drive's serial number. This ensures a unique MAC ID for every drive and also correlates drive hardware to the MAC ID setting.

To set the MAC ID:

- 1) Connect to the drive with Drive CM and go online,
- 2) Open the Parameter Editor,
- 3) Select the Misc parameter group,
- 4) Click "Hexadecimal" to view the parameter data in hex.
- 5) Enter the last 5 digits of the drive's serial number into parameter 0x241F. See the example below for formatting. This information is also in the iX7NH User Manual.



Example

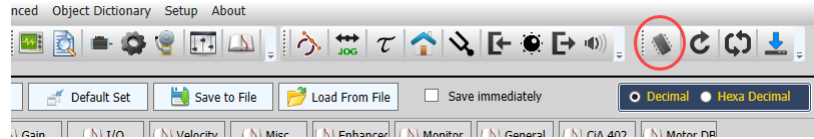
This drive's serial number is DC3E02407. Use the last 5 digits as the NIC portion of the MAC ID (parameter 0x241F). The NIC address will be 00:24:07. The hex value inside the parameter (using leading zeros) will be 0x002407. Type 0x002407 into parameter 0x241F and press ENTER while in the parameter field to actually send the value to the drive.



Values shown in hexadecimal. Values turn green after being sent to the drive.

0x241E	0x0	MAC Address (Vendor)*	0x80E1
0x241F	0x0	MAC Address (NIC)*	0x002407

Press the **Save to EEPROM** button to save the new value. Otherwise, the value will reset after a power cycle.



MODBUS TCP COMMUNICATION TIMEOUT

The iX7NH drive does not contain a built-in Modbus TCP communication timeout feature. AutomationDirect recommends monitoring the Modbus TCP traffic in your controller/PLC and removing the Servo Enable digital input (SV_ON) if communication is lost. Example: read the servo status every 500ms. If the message fails, drop the SV_ON digital input.

CONTROLLING THE DRIVE OVER MODBUS TCP

Using Modbus TCP, the iX7NH drive can be controlled in multiple ways.

- 1) **Protocol Command Codes:** Coils for simple control. Limited flexibility.
Examples: Servo enable (SV_ON), Start a move (START), Start Homing (HSTART)
- 2) **Control Word:** More flexibility to configure motion in run-time: define the Control Mode, define moves as absolute/relative, start a move immediately/wait for completion, etc.
- 3) **Status Word:** Read drive status and status of different functions.
- 4) **Procedure Command Code:** Provides a way to call special drive functions, some that are not otherwise available: manual jog, software reset, etc.
- 5) **State Machine:** Full control of the drive. Must follow the State Machine defined sequences.

The Modes of Operation (Parameter 0x6060) value is volatile and will reset to 1 on power cycle. If using the iX7NH in Profile Position mode (sending position moves from a controller), this is not an issue. If using the drive in Velocity or Torque Modes, remember to change this in your PLC code every power cycle.

PROTOCOL COMMAND CODES

Protocol Command Codes assist in easy control of the drive with single bits manipulated over ModbusTCP when using the Control Word.

Input Control Bits for the Protocol Command Codes are shown below:

Communication Address		Input Bits	Accessibility
Decimal Number	Hexadecimal Number		
0	0x0000	POT	RW
1	0x0001	NOT	RW
2	0x0002	HOME	RW
3	0x0003	STOP	RW
4	0x0004	PCON	RW
5	0x0005	GAIN2	RW
6	0x0006	P_CL	RW
7	0x0007	N_CL	RW
8	0x0008	PROBE1	RW
9	0x0009	PROBE2	RW
10	0x000A	EMG	RW
11	0x000B	A_RST	RW
12	0x000C	SV_ON	RW
13	0x000D	LVSF1	RW
14	0x000E	LVSF2	RW
15	0x000F	Reserved	RW
16-25	0x0010-0x0019	Reserved	RW
26	0x001A	ABSRQ	RW

Output Status Bits for the Protocol Command Codes are shown below. It is easiest to read all output status bits in one block (Modbus addresses 32-42) so the full status of the drive is always known. The Status Word can also be read for other information. Same should be done with the input control bits (Modbus addresses 0-14).

Communication Address		Input Bits	Accessibility
Decimal Number	Hexadecimal Number		
32	0x0020	BRAKE	RO
33	0x0021	ALARM	RO
34	0x0022	READY	RO
35	0x0023	ZSPD	RO
36	0x0024	INPOS1	RO
37	0x0025	TLMT	RO
38	0x0026	VLMT	RO
39	0x0027	INSPD	RO
40	0x0028	WARN	RO
41	0x0029	TGON	RO
42	0x002A	INPOS2	RO
43	0x002B	Reserved	RO
44	0x002C	Reserved	RO
45	0x002D	Reserved	RO
46	0x002E	Reserved	RO
47	0x002F	Reserved	RO

Some input control bits can also alter the state machine like the control word does such as SV_ON. All other standard control registers can be used for creating the motion profile.

CONTROL WORD

There are multiple modes of operation when using the control word for controlling motion. Profile Position (PP), Profile Velocity (PV), Profile Torque (PT), and Homing (HM) modes. CSP, CSV, and CST modes are for EtherCAT control only. For more information, see sections 5.2 (Operation Modes) and 13.3 of the iX7NH User Manual.

This example will show how to use Profile Position (move to a set position). The other modes are very similar. See user manual Chapter 13 and section 5.3.2 for more details. Profile Position Mode is selected when the Operation Modes parameter 0x6060 is set to 1.

Target Position:

Ensure Target Position is reading/writing correctly.

Parameter	Parameter Number	Decimal / Hex Address	Value to Enter
Target Position	0x607A	24613 / 0x6025	360 UU (1 motor rev)

This parameter is a double integer. It consumes two 16-bit Modbus addresses. Make sure that your client (PLC) can read back the value in the correct format. Read the value over Modbus, then compare the value to Drive CM’s Object Dictionary value for Target Position (under the CiA 402 tab). If the value is zero, change it to some other value with Drive CM (remember to press Enter after typing the value). Your client should be able to read the new value. Once you can read the value correctly, write a different value over Modbus. Then press “Refresh” on the Drive CM Object Dictionary screen to ensure the value was transferred correctly. If you will be using target positions greater than 65535 (16 bits), make sure your Modbus instruction is transferring 2 words and formatting the results as a 32-bit result. This will be the Target Position that each commanded move will use.

Servo On:

Program your client to set the SV_ON Modbus coil 00012 (0x00C) to 1 or turn on the SV_ON digital input to enable the servo. Coil 00012 (0x00C) is using the Protocol Command Code method to enable the servo instead of stepping through the State Machine using the Control Word. If successful, the drive’s LED display should change from P-.bb to P.-run (see section 6.1 of the user manual for a complete description of the LED display). Remember to use Protocol Addresses (Base 0). Other coils for Protocol Command Code method of control can be found in iX7NH user manual section 13.4.2.



NOTE: When using BOTH a physical digital input AND communications (coil 0x0012) for servo enable (SV_ON), both functions can enable and disable the drive, but comms cannot override a physical digital input SV_ON that is ON. If digital input SV_ON is ON, drive is enabled. If digital input SV_ON is OFF, drive can be enabled/disabled with coil 0x0012.

Control Word:

The Control Word Parameter 0x6040 (Modbus Address 24577 decimal / 0x6001 hex) has several bits to configure the type of move and a bit to initiate the move. The bits have different actions when in different Modes. See section 10.3 in the iX7NH user manual for a list of all options.

In PP mode, these are the relevant settings for Parameter 0x6040 (Modbus hex address 0x6001/ decimal address 24577):

Note that the rising edge of Bit 4 is the trigger to initiate the move.

Bit 9	Bit 5	Bit 4	Details
0	0	0→1	Proceeds to the next position when the operation at the current position is complete.
-	1	0→1	Drives to the next position immediately.
1	0	0→1	Drives from the current position to the profile position at the profile velocity before it applies the next position.

Bits	Function	Value	Description
6	Absolute/Relative	0	Sets the target position to an absolute value.
		1	Sets the target position to a relative value.
8	Halt	0	Runs an operation or continues an operation.
		1	Halts the operation according to the Halt Option code (0x605D).

Bits 5, 6, and 9 are setup bits. They are set to 1 or reset to 0 and can stay in one state (or can change from move to move). Bit 4 is the trigger bit. Once it is set (to start a move), it must be reset by the client (PLC) before it can trigger another move.

To set up a relative move (bit 6) that will occur immediately (bit 5), write this value to Control Word hex address 0x6001 / decimal address 24577 (remember, the Modbus address hex is 0x6001 even though the parameter number is different):

Decimal	Hex	Binary (bits 5, 6 = 1)
96	60	0110 0000

To initiate the move (set bit 4 in the control word), write this value:

Decimal	Hex	Binary (bits 4, 5, 6 = 1)
112	70	0111 0000

The motor should spin 1 revolution (if the Target Position and gearing was set as above).

Reset bit 4 by sending the first value 96 again.

This should be enough to show you the minimum procedure to set up the drive and PLC for Modbus TCP control. Refer to the iX7NH User Manual and this Quickstart Guide for more information and how to implement Homing Mode and the other control modes. Please also refer to ADC sample PLC programs that demonstrate the Modbus TCP capabilities of this drive and various PLCs. You will find the sample PLC programs on each drive’s Item Page under Support Resources on AutomationDirect.com.

This is a listing of all Parameters referenced above with their Parameter numbers and Modbus addresses. Please see the iX7NH User Manual for more parameters.

Parameter	Parameter Number	Decimal / Hex Address	Value to enter
Motor Revolutions	0x6091:1	24652 / 0x604C	524288 (19-bit encoder)
Encoder Revolutions	0x6091:2	24654 / 0x604E	360 (360 User Units/rev)
Operation Modes	0x6060	24584 / 0x6008	1 (PP: Profile Position)
Target Position	0x607A	24613 / 0x6025	360 UU (1 motor rev)
Profile Velocity	0x6081	24628 / 0x6034	360 UU/s
Profile Acceleration	0x6083	24630 / 0x6036	2000 UU/s ²
Profile Deceleration	0x6084	24632 / 0x6038	2000 UU/s ²
Target Position	0x607A	24613 / 0x6025	360 UU (1 motor rev)
Servo On (SV_ON)	0x000C	12 / 0x000C	0 or 1
Control Word	0x6040	24577 / 0x6001	See bits 4-9 above

STATUS WORD

Object 0x6041 is the Status Word (Address 0x6002). The Status Word indicates the current state and status of the drive. The bits indicate different information depending on which operation mode the drive is in.



NOTE: *the bit Function names below of the Status Word are very similar to the State Machine state names. Though the two are related, the function names and state names are different.*

Bits	Function	Description
0	Ready to switch on	Refer to the description in section 10.3 of the iX7NH user manual under 0x6041
1	Switched on	
2	Operation enabled	
3	Fault	
4	Voltage enabled	
5	Quick stop	
6	Switch on disabled	
7	Warning	
8	-	Reserved
9	Remote	Processed as a Controlword (0x6040)
10	Operation mode specific	Refer to the description of bits 10, 12 and 13 in user manual section 10.3
11	Internal limit active	Refer to the description of bit 11 in user manual section 10.3
12 to 13	Operation mode specific	Refer to the description of bits 10, 12 and 13 in user manual section 10.3
14	ABS position valid	Refer to the description of bit 14 in user manual section 10.3
15	-	Reserved

Bit 9 details: 0 indicates that that the internal processing of the statusword has started. Once the processing script has started this bit is set to 0. It will not change to 1 until the processing function has been completed correctly. If the processing function has not completed correctly then bit9 will remain 0.

PROCEDURE COMMAND

There are multiple auxiliary functions listed in section 9 of the iX7NH user manual . Some of these Procedures have similar functionality to the Control Word and to the Protocol Command Codes (coils). Some of these Procedures provide functionality that is only available with this method (reset, program jog, etc.).

The Procedure Commands are defined by a **Command Code** parameter (defines *what* will happen) and an **Argument** parameter (defines *how* it will happen). Available procedure commands are listed below. Further details on each Procedure Command can be found in the user manual in chapter 9.

Procedure Command	Code	Details
Manual JOG	0x0001	Operates manual JOG
Program JOG	0x0002	Operates program JOG
Alarm History Reset	0x0003	Deletes alarm history
Off-Line Auto-Tuning	0x0004	Performs off-line auto-tuning
Index Pulse Search	0x0005	Searches for Phase Z position
Absolute Encoder Reset	0x0006	Resets the absolute encoder
Max. Load Torque Clear	0x0007	Resets the instantaneous maximum operation overload (0x2604) value
Calibrate Phase Current Offset	0x0008	Performs phase current offset tuning
Software Reset	0x0009	Resets the software
Commutation	0x000A	Performs commutation
Tamagawa Encoder Reset	0x000B	Resets Tamagawa encoder
GB Preset	0x000D	Resets GB encoder

The Procedure Command uses the following parameters:

Parameter	Parameter Number	Decimal / Hex Address
Procedure Command Code	0x2700	9984 / 0x2700
Procedure Command Argument	0x2701	9985 / 0x2701

The Command Arguments must be written first then the Command Code written. You can only write one Command Argument at a time.

Example:

Using the below example for jog:

- 1) Write 1 to (0x2701) to populate the argument with SV_ON then write 1 to (0x2700) to send this argument to the Manual Jog Procedure.
- 2) Write 3 to (0x2701) to populate the argument with a positive jog command then write 1 to (0x2700) to send this argument to the Manual Jog Procedure.
- 3) Write 5 to (0x2701) to populate the argument with a Stop command, then write 1 to (0x2700) to send this argument to the Manual Jog Procedure.
- 4) Write 2 to (0x2701) to populate the argument with a Servo Off command then write 1 to (0x2700) to send this argument to the Manual Jog Procedure.

Command Code (write to 0x2700)	Command Argument (write to 0x2701)	Run Procedure
Manual Jog (0x0001)	1	Servo ON
	2	Servo OFF
	3	Positive (+) Operation (speed=0x2300)
	4	Negative (-) Operation (speed=0x2300)
	5	Zero Speed Stop

For a listing of all Procedure Command Codes and Arguments in the iX7 user manual, see Parameter 0x2700 Procedure Command Code and 0x2701 Procedure Command Argument. See further details in Chapter 9.



NOTE: When using BOTH a physical digital input AND the Procedure Command for servo enable/disable, both functions can enable and disable the drive, but the Procedure Command cannot override a physical digital input SV_ON that is ON.

Example:

Digital input SV_ON is ON: drive is enabled. Procedure Command cannot override.

Digital input SV_ON is OFF: drive can be enabled/disabled with the Procedure Command.

THE STATE MACHINE

To use the Control Word you must understand the state machine (section 5.1 in the iX7NH user manual). Below are the bit patterns for commanding the drive into different states. States 0 and 1 occur automatically on power on.

To move into a Servo Enabled state, you would perform the following:

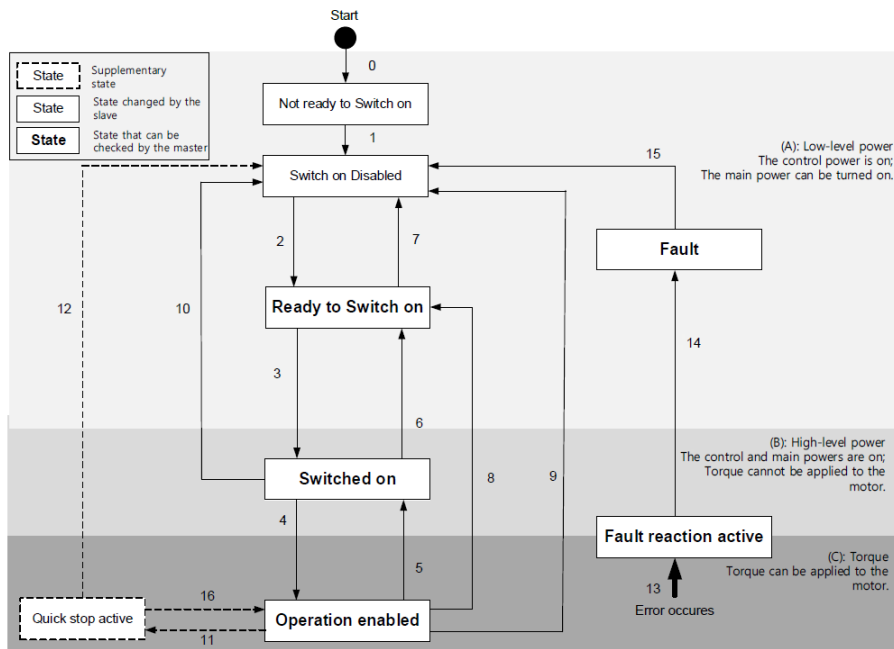
- 1) Turn on bits 1 and 2. This will move you from the “Switch On Disabled” state into the “Ready to Switch on” state.
- 2) Turn on bit 0. This will move you from the “Ready to Switch on” state into the “Switched on” state.
- 3) Turn on bit 3. This will move you from the “Switched on” state into the “Operation Enabled” state. At this point you will hear the drive relay apply power to the motor



NOTE: The sequence above can be immediately triggered with one bit using the Protocol Command Code “SV_ON” address 0x000C. See next section for details.

The state machine must be stepped through, you cannot jump from one state to another without following the State Change Paths in the right column. For example, looking at the State Machine diagram, you cannot jump from state “Fault” to “Operation Enabled”. You must transition through states “Switch on Disabled” → “Ready to Switch on” → “Switched on” → “Operation enabled” using the respective State Change paths 15 → 2 → 3 → 4.

Command	Bits of the Control Word (0x6040)					State Machine State Change Path
	Bit 7	Bit 3	Bit 2	Bit 1	Bit 0	
Shutdown	x	x	1	1	0	2, 6, 8
Switched on	x	0	1	1	1	3
Switched on + Enable Operation	x	1	1	1	1	3 + 4
Disable voltage	x	x	x	0	x	7, 9, 10, 12
Quick stop	x	x	0	1	x	7, 10, 11
Disable operation	x	0	1	1	1	5
Enable operation	x	1	1	1	1	4, 16
Fault reset	0 → 1	x	x	x	x	15



Bits 4-6, 8 and 9 of the Control Word have other uses depending on which Operation Modes the drive is in. See Object 0x6040 (Controlword) for more information.

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