ECAT-2072A

EtherCAT Two Channel BISS-C/SSI Absolute Encoder Master

User Manual

(Version 1.4)





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1 Product Overview



1.1 Introduction

The EtherCAT slave ECAT-2072A is an absolute encoder master. ECAT-2072A provides two channels. Each channel is independent of each other. It supports two serial transmission interfaces: SSI (Serial Synchronous Interface) & BiSS-C (BiSS Continuous Mode, unidirectional). ECAT-2072A also supports a maximum transmission frequency of 10MHz, a maximum transmission bit of 48bit(Including error bit, warning bit, CRC in BiSS-C mode), and Automatic compensation of cable delays in BiSS-C mode. The maximum cable length supported is 70 meters.

1.2 Technical Data

Features:

- EtherCAT slave
- 2 channel absolute encoder master station
- Transmission interface: SSI, BiSS-C (unidirectional)
- Maximum transmission frequency: 10MHz
- Transmission data format: binary code, gray code
- Maximum transmission data bits: 48 bit (BiSS-C includes error, warning, CRC)
- BiSS-C mode can automatically compensate the delay caused by the length of the cable. The maximum cable length supported is 70 meters.
- Safety detection in BiSS-C mode: error, warning, CRC

1.3 Specification

- **Encoder input specification:**
  - Parallel I/O Module:
    2 Channel ,absolute encoder
  - Transmission interface:
    - C SSI mode
    - BiSS-C mode (unidirectional)
  - Maximum Counting Rate:
    - 10M pulse/sec
  - Output/Input Signal:
    - Input Signal : difference signal (RS422)
    - Output Signal : difference signal (RS422)
    - Voltage Level : -6V~+6V (Maximum Voltage)
- **EtherCAT specification:**
  - 2 x RJ-45 bus interface
  - Distance between stations up to 100 m (100BASE-TX)
  - Support daisy chain connection
  - EtherCAT conformance test tool verified
  - Supports Free-Run, Distributed Clock (DC) operation modes
  - Cycle times: As low as 0.1 ms
- **LED indicators for EtherCAT and encoder status**

Item	Specification
Encoder	
Number of encoder inputs	2 encoder channel
Sampling type	Simultaneous
Resolution	max. 48 bit position
Maximum input pulse frequency	10MHz
Input level:	• 5V (default)
Photo-Isolation	2500 V_{DC}
LED Indicators	
Diagnostic LED	Power, EtherCAT status, signal status of each encoder input
Communication Interface	
Connector	2 x RJ-45
Protocol	EtherCAT
Distance between stations	Max. 100 m (100BASE-TX)
Data transfer medium	Ethernet/EtherCAT Cable (Min. CAT 5), Shielded
Power	
Input voltage range	20 V_{DC} ~ 30V_{DC}
Power consumption	Maximum 4.5W
EMS Protection	
ESD (IEC 61000-4-2)	4 KV Contact for each channel
EFT (IEC 61000-4-4)	Signal: 1 KV Class A; Power: 1 KV Class A
Surge (IEC 61000-4-5)	1 KV Class A
Mechanism	
Installation	DIN-Rail
Dimensions (LxWxH) [mm]	110mm x 90mm x 33mm (without connectors)
Case material	UL 94V-0 housing
Environment	
Operating temperature	-25℃ ~ 70℃
Storage temperature	-30℃ ~ 80℃
Relative humidity	10 ~ 90%, No condensation

Table 1: Technical data

1.4 Dimensions

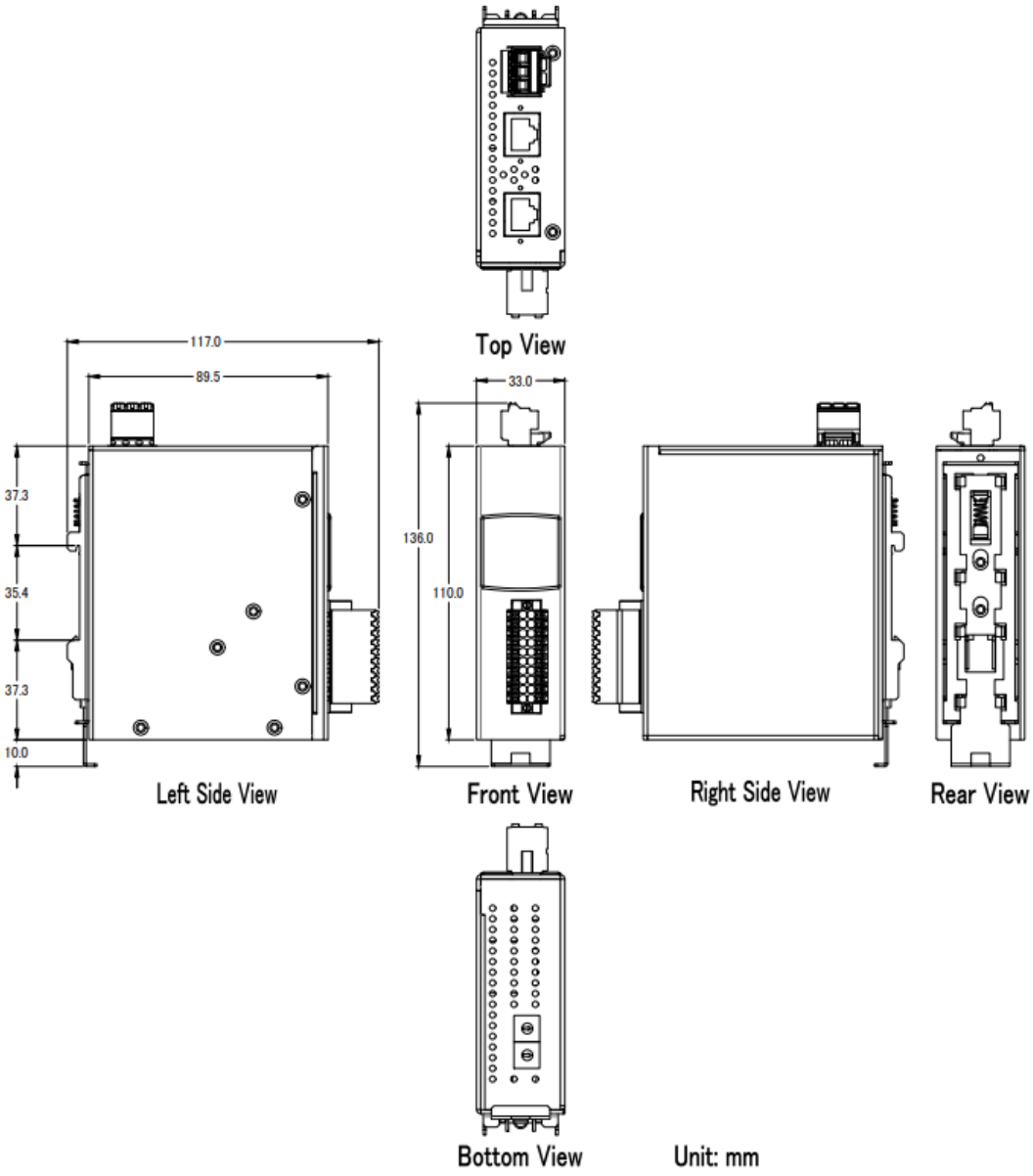


Figure 1: Dimensions of the ECAT-2072A

2 Scope of Delivery

The shipping package includes the following items:

- 1 x ECAT-2072A
- 1 x 20-pin plug-in connector
- 1 x 3-pin plug in connector (for power supply)
- 1 x Quick Start manual



Figure 2: ECAT-2072A module and Quick Start manual

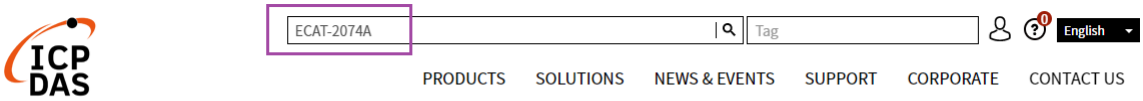
Note:

If any of these items are missing or damaged, please contact your local distributor. Please keep the original retail box with all retail packaging (Styrofoam, inner boxes, fasteners, etc.) in case you need to return the product.

More information about the ECAT-2072A is available on the product website. Enter the product name in the search function of the main ICPDAS website to access the product website:

Step 1: Go to the ICPDAS main website
http://www.icpdas.com

Step 2: Enter "ECAT-2072A" in the search editor to access the ECAT-2072A website



The User Manual, Quick-Start, EtherCAT Slave Information (ESI) file and FAQ can be downloaded from the website.

- Technical support:
  service@icpdas.com

3 LED Definition

The ECAT-2072A provides on the front side several diagnostic LEDs which indicates the signal status of each encoder channel. To disable the channel, set object 0x80n0:08 (n - represents the channel number) to Disable.
Furthermore there are three LEDs to show the EtherCAT network status. The exact meaning of each LED is described in the following tables:



Figure 3: ECAT-2072A LEDs

EtherCAT LED	Color	State	Description
RUN	red		This LED indicates the operation state of the EtherCAT slave:
		Off	Device is in INIT state
		Flashing	Device is in PREOP state
		Single flash	Device is in SAFEOP state Outputs remain in safe state
		On	Device is in OP state
IN	green		Indicates the communication status of the EtherCAT port IN
		Off	No connection
		Flashing	Link and activity (e.g. data exchange with the master)
		On	Link without any activity
OUT	green		Indicates the communication status of the EtherCAT port OUT. Further EtherCAT slave can be connected to the port OUT
		Off	No EtherCAT slaves are connected to port OUT
		Flashing	Link and activity (e.g. data exchange connected slaves)
		On	Link without any activity

Table 2: EtherCAT status indicator

ECAT-2072A Diagnostic LEDs:

Control LED	Color	Description
*	red	- Power indicator
* * (Enable) 0 1 * * (Error) 23	green	- LED 0: channel 0 enabled status - LED 1: channel 1 enabled status - LED 2: channel 0 error - LED 3: channel 1 error -

Table 3: ECAT-2072A Diagnostic LEDs

4 Rotary switch definition

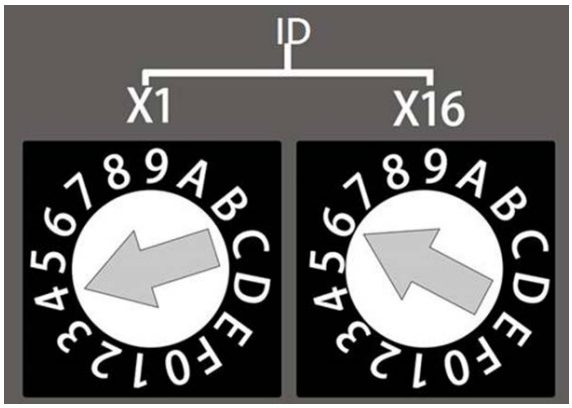


Figure 4: ECAT-2072A alias rotary switch

The alias rotary switch is divided into two, X16 is the high bit, X1 is the low bit, and the range is 0x00~0xFF.

5 Wiring

5.1 Connection Interfaces



Figure 5: ECAT-2072A side view with power supply and EtherCAT connection

Name	Signal	Description
F.G	Frame ground	
GND	Power supply: Ground 0V (from negative power contact)	Feeding for ECAT-2072A
+Vs	Power supply: +24 V_{DC} (from positive power contact)	
IN	EtherCAT signal input	Incoming EtherCAT cable
OUT	EtherCAT signal output	Outgoing EtherCAT cable

Table 5: ECAT-2072A power supply and EtherCAT interfaces



Figure 6: ECAT-2072A front view with encoder inputs

ECAT-2072A Connection interfaces of the encoder:

Name	Signal	Signal Description	
C0-	Input	Encoder Input CLK0-	Encoder Channel 0
C0+	Input	Encoder Input CLK0+	
D0-	Input	Encoder Input Data0-	
D0+	Input	Encoder Input Data0+	
C1-	Input	Encoder Input CLK1-	Encoder Channel 1
C1+	Input	Encoder Input CLK1+	
D1-	Input	Encoder InputData1-	
D1+	Input	Encoder InputData1+	
C2-	Input	Encoder Input CLK2-	Encoder Channel 2
C2+	Input	Encoder InputCLK2+	
D2-	Input	Encoder InputData2-	
D2+	Input	Encoder InputData2+	
C3-	Input	Encoder Input CLK3-	Encoder Channel 3
C3+	Input	Encoder InputCLK3+	
D3-	Input	Encoder InputData3-	
D3+	Input	Encoder InputData3+	
+5V		+5VDC, for testing purposes only. For long-term use, please provide an external power supply for the encoder	
GND		0V	

Table 6: ECAT-2072A Connection interfaces of the encoder

5.2 Encoder Connection

ECAT-2072A can accept the absolute encoder input of SSI and BISS interface. By default it is set to support the BISS interface.

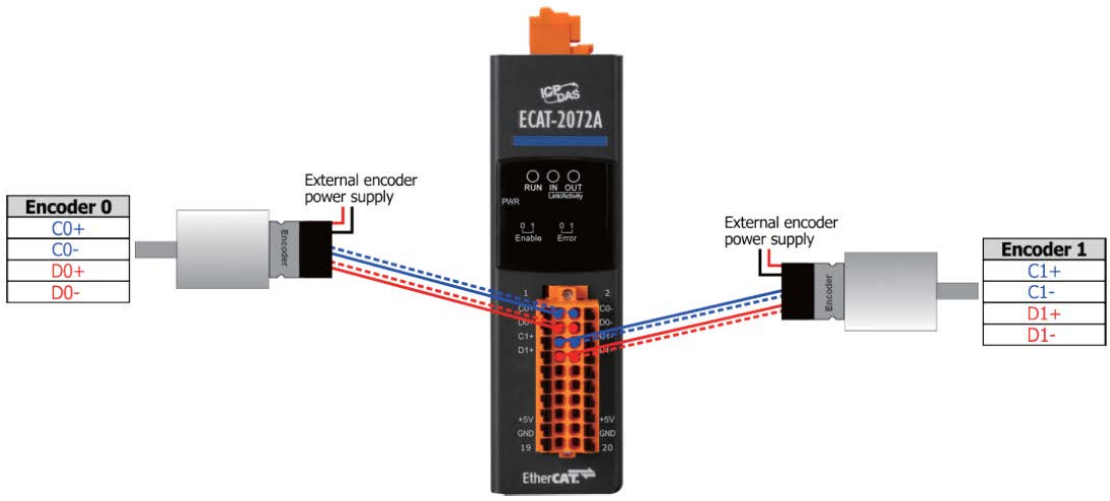


Figure 7: ECAT-2072A encoder connection

6 Basics Communication

6.1 EtherCAT Cabling

The cable length between two EtherCAT devices must not exceed 100 m.

Cables and connectors
For connecting EtherCAT devices only Ethernet connections (cables + plugs) that meet the requirements of at least category 5 (CAT5) according to EN 50173 or ISO/IEC 11801 should be used. EtherCAT uses 4 wires for signal transfer.
The pin assignment is compatible with the Ethernet standard (ISO/IEC 8802-3).

6.2 EtherCAT State Machine

The state of the EtherCAT master and slave is controlled via the EtherCAT State Machine (ESM) . The state determines which functions are accessible or executable in the EtherCAT slave. State changes are typically initiated by requests of the master and acknowledged by the slave after the successful initialization. In case of an internal error, the slave automatically changes to a lower state.

The ECAT-2072A supports four states:
- Init (state after Reset)
- Pre-Operational
- Safe-Operational
- Operational

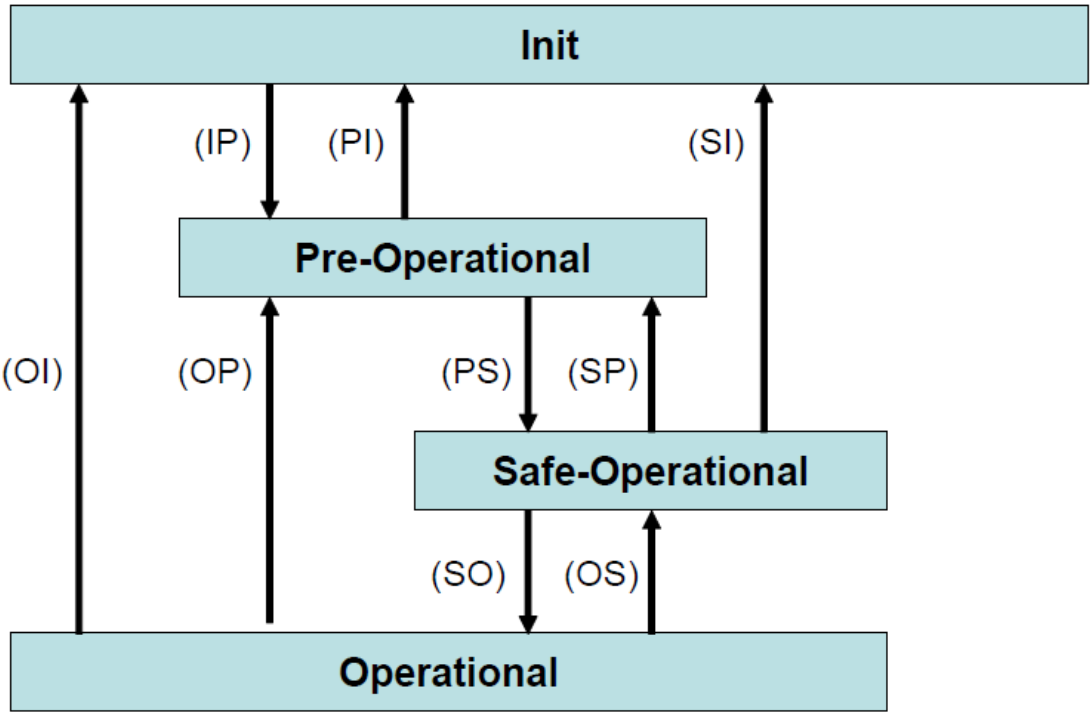


Figure 9: EtherCAT state machine

Init

After switch-on the EtherCAT slave is in the initial state. Only ESC register communication is possible, but no mailbox or process data communication. The slave initializes the service object data with default value or with values previously stored to the local memory. The EtherCAT master assigns the station address and configures the sync manager channels 0 and 1 for acyclic mailbox communication.

Pre-Operational (Pre-Op)

In Pre-Op state acyclic mailbox communication is possible, but not process data communication. In this state the EtherCAT master does the following configurations:

- Set the sync manager 2 and 3 of the ECAT-2072A for process data communication (from sync manager channel 2)
- The FMMU channels
- PDO mapping or the sync manager PDO assignment
- The user has the option to save motion control related configuration data (0x8000 - 0x8020) to a non-volatile memory.

Safe-Operational (Safe-Op)

In Safe-Op state both mailbox and process data communication are enabled, but the slave keeps its outputs in a safe state, while the input data are updated cyclically. The slave will ignore the output data sent by the master and just return the current input

data (e.g. digital input, encoder value, etc.)

The sync manager watchdog expires when the master application does not provide new output process data within the configured watchdog time. In this case the slave will automatically go from operational state to ERROR-SAFEOP state.

Operational (Op)
Here both the process data object (PDO) and service data object (SDO) are fully enabled. Master sends cyclic output data and read input data. The ECAT-2072A supports three type of Op modes: Free Run mode, SM-Synchron and Distributed Clock (DC) mode.

6.3 Synchronization Modes

ECAT-2072A devices support two different modes:

- Free Run: The master cycle time and slave cycle time are independent and not synchronized.
- Distributed Clock (DC): The cycle time and interval is fixed and deterministic. Both the master and slave cycle time are synchronized. The slave processes data at a fixed and deterministic time interval (DC cycle time). The slave expect the master to exchange process data at a fixed time interval. If the master does not send/read data within the set time interval then an synchronization error will be generated by the slave.

6.3.1 Free Run Mode

The slave operates autonomously based on its own cycle and is not synchronized with the EtherCAT cycle. The master cycle time and the slave cycle time are fully independent which means each slave device reads/writes its own process data according to its local time, independent of the master's cycle time.

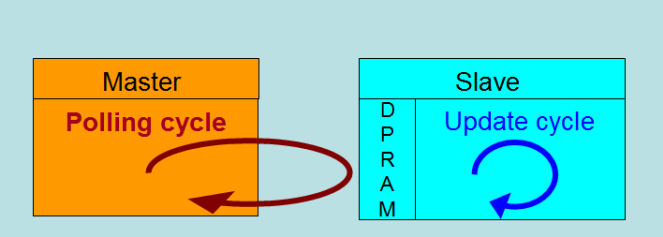


Figure 10: Master-slave cycle in Free Run mode

The following diagram shows the process timing of the slave in Free Run mode in detail:

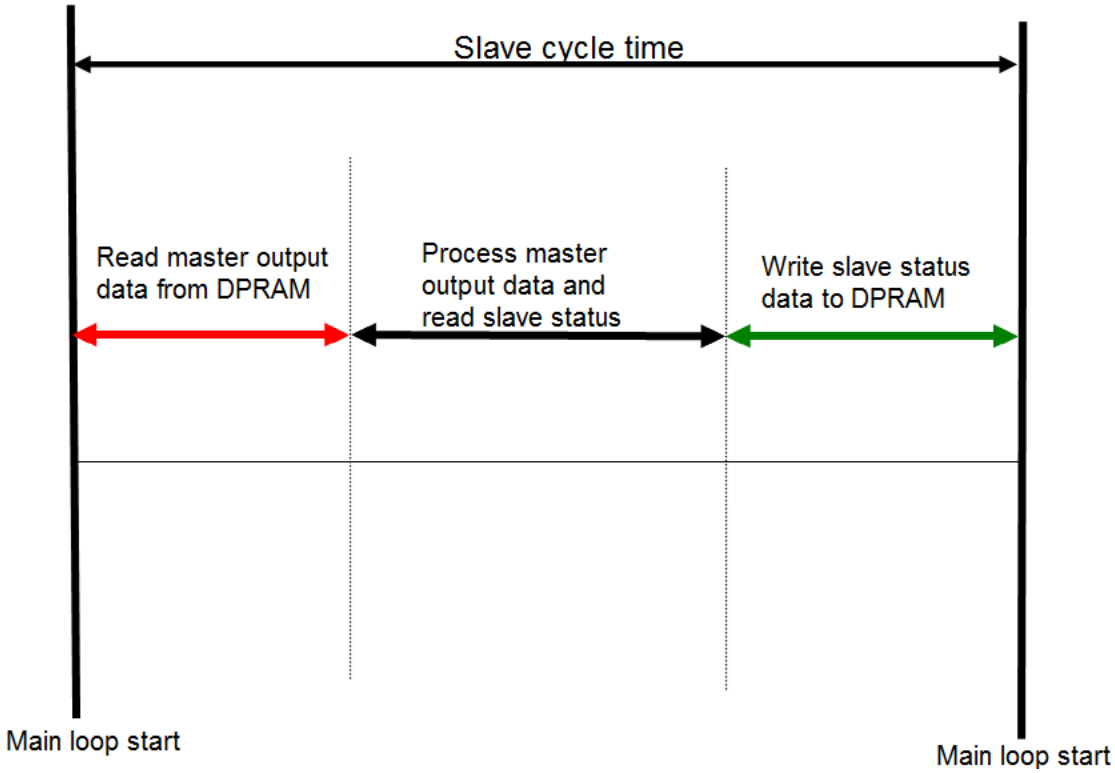


Figure 11: Slave processing sequence in Free-run mode

The slave firmware checks in each cycle time the memory of the EtherCAT slave chip (ESC) whether new output data has been received from the master. Newly received data will be processed. In the next step the encoder input status are being read from the FPGA chip. In the final step the read status are being written to the DPRAM, so that the master can retrieve the data ESC DPRAM in the next cycle time.
Free Run synchronization parameter has to be set in PREOP mode:
0x1C33.1 = 0

The setting of the Free Run synchronization parameter can be done in TwinCAT by clicking on the "CoE online" tab of the ECAT-2072A slave. Make sure the slave is set into PreOP mode before modifying the synchronization parameters

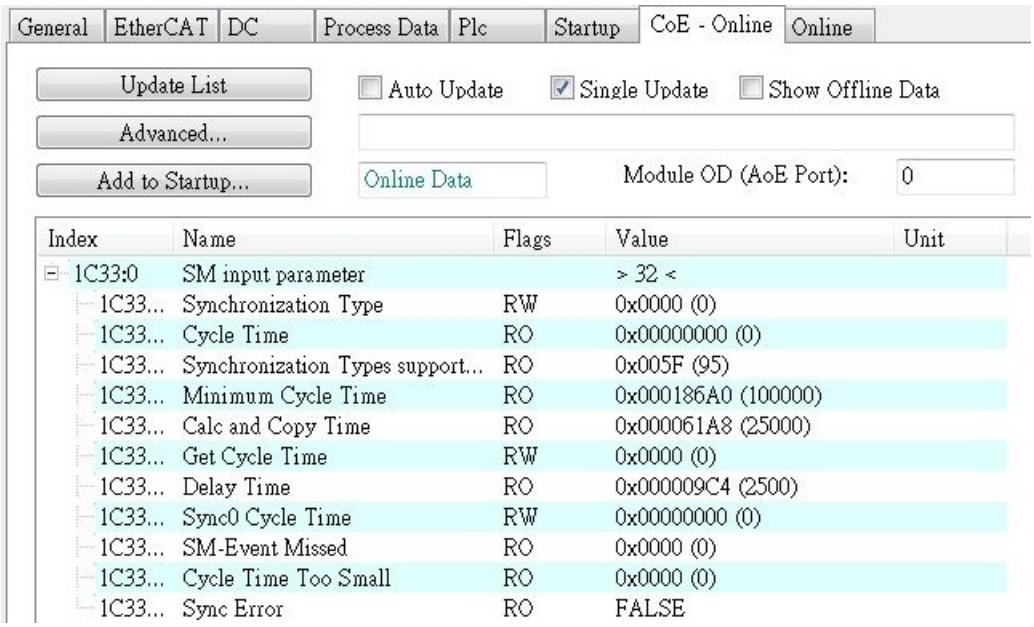


Figure 12: SyncManager setting for Free-Run mode

6.3.2 Distributed Clocks (DC Mode)

DC clock synchronization enables all EtherCAT devices (master and slaves) to share the same EtherCAT system time. The EtherCAT slaves in the network can be synchronized to each other. This enables the master to simultaneously set the output (e.g. digital output, pulse output) or to synchronously read inputs (e.g. digital input, encoder counter) of different slaves in the EtherCAT network.

For system synchronization all slaves are synchronized to one reference clock. Normally the first EtherCAT slave closest to the master with Distributed Clocks capability becomes the clock base for the master as well as for other DC slaves.

The EtherCAT slave is synchronized with the SYNC0 or SYNC1 event of the distributed clock system. After the EtherCAT network has been set into DC communication mode by the master, the ESC (EtherCAT slave chip) of each slave generates fixed time hardware interrupt which triggers the slave firmware to process the PDO data received from the master. The master cycle time and the ESC hardware interrupt time interval are fully synchronized to the first slave in the network that is used as a reference clock with the SYNC0 signal.

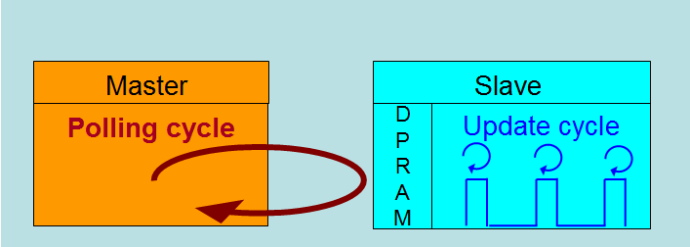


Figure 13: Master-slave cycle in DC mode

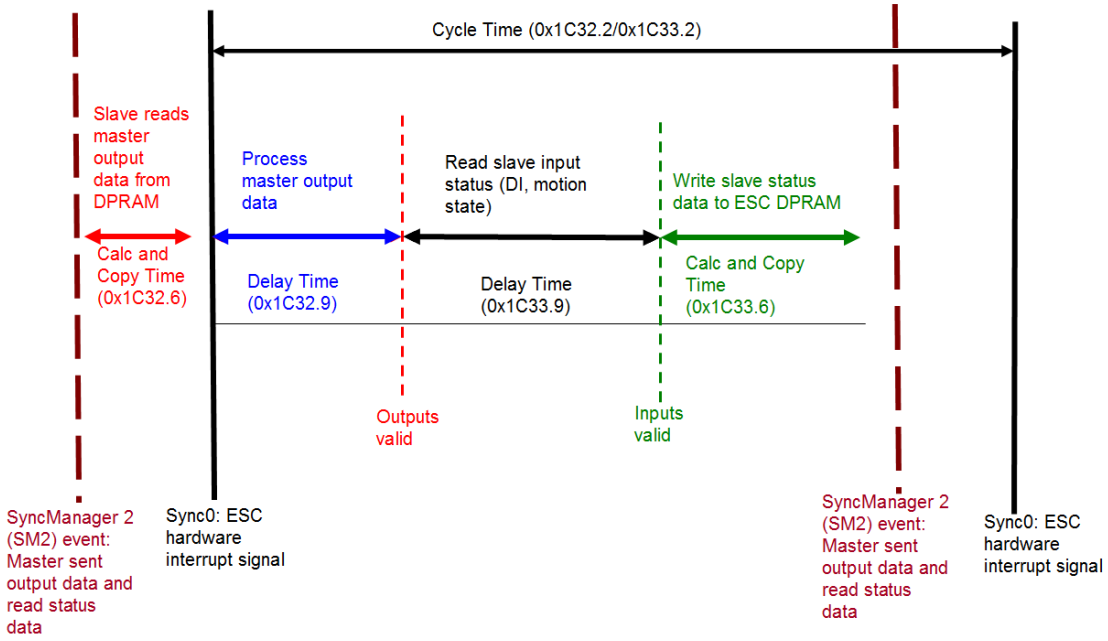


Figure 14: Internal slave processing sequence in DC mode

Once the slave receives process data (RxPDOs) from the master the SM2 event is triggered which causes the firmware to read the data from the ESC memory. The ESC interrupts the firmware at fixed time interval to process the data received from the master and write the status data to the ESC memory. Every time when the master fails to sent process data within the DC cycle time the internal sync error counter is being increase by three counts. This error counter is being decreased by one count for every successful DC cycle. Once the error counter reached the maximum count (default 4) a sync error will be generated and the slave goes into Safe OP mode (Sync Error 0x1C33:20 TRUE). The maximum count value can be set by changing the default value of the "Sync Error Counter Limit" (0x10F1:02).

Index	Name	Flags	Value
10F1:0	Error Settings		> 2 <
10F1:01	Local Error Reaction	RW	0x00000001 (1)
10F1:02	Sync Error Counter Limit	RW	0x0004 (4)

Figure 15: Sync error counter limit object

The setting of the sync manager for the output and input data is available at the TwinCAT "CoE online" tab.

Index	Name	Flags	Value
1C32:0	SM output parameter		> 32 <
1C32:01	Synchronization Type	RW	0x0002 (2)
1C32:02	Cycle Time	RO	0x00000000 (0)
1C32:04	Synchronization Types supported	RO	0x401F (16415)
1C32:05	Minimum Cycle Time	RO	0x001E8480 (2000000)
1C32:06	Calc and Copy Time	RO	0x0007A120 (500000)
1C32:08	Get Cycle Time	RW	0x0001 (1)
1C32:09	Delay Time	RO	0x000927C0 (600000)
1C32:0A	Sync0 Cycle Time	RW	0x005B8D80 (6000000)
1C32:0B	SM-Event Missed	RO	0x0000 (0)
1C32:0C	Cycle Time Too Small	RO	0x0000 (0)
1C32:20	Sync Error	RO	FALSE

Figure 16: SyncManager 2 parameters

SyncManager parameter description (time unit: nanosecond):

- Calc and Copy Time (0x1C33.6): Required time to copy the process data from the ESC to the local memory and calculate the output value.
- Delay Time (0x1C33.9): Delay from receiving the trigger to set the output or latch the input.
- Cycle Time (0x1C33.2): The current cycle time for the application. When using DC synchronization the value is read from register 0x9A0:0x9A3.
- 0x1C33.5 (Min Cycle Time): Minimum cycle time for the application. It is the total execution time of all slave application related operations.

7 Project Integration

In this chapter the integration of the ECAT-2072A device into a TwinCAT controlled EtherCAT network is being described. In general the ECAT-2072A is a standard EtherCAT slave which can be controlled by any standard EtherCAT master (e.g. Acontis, CODESYS, etc.).

7.1 ESI File

A ESI file describes the properties and functions supported by the ECAT-2072A. By using the ESI file an easy and abstract integration of an EtherCAT device in a project tool is realized. With the help of the ESI file a detailed knowledge of EtherCAT is not required to configure the device. The TwinCAT EtherCAT master/System Manager needs the device description files in order to generate device configuration in online or offline mode.

7.1.1 Import of ESI File

Copy the XML description file "ECAT-2072A.xml" of the ECAT-2072A device into the TwinCAT system directory and restart the TwinCAT system.
For TwinCat 3.1 copy the ESI file "ECAT-2072A.xml" in the following directory:
C:\TwinCAT\3.1\Config\Io\EtherCAT

Software	Default directory path
Beckhoff EtherCAT Configuration	C:\EtherCAT Configurator\EtherCAT
Beckhoff TwinCAT 3.x	C:\TwinCAT\3.x\Config\Io\EtherCAT
Beckhof TwinCAT 2.x	C:\TwinCAT\Io\EtherCAT

Table 8: ESI file target directory

7.2 Device Setup and Configuration

In this manual only the online configuration of the slave module will be discussed. For offline configuration procedure please consult the TwinCAT user manual.

The following conditions must be met before a configuration can be set up:

- The ECAT-2072A slave devices must be connected via EtherCAT cables to the EtherCAT master. In this manual TwinCAT 3.1 version is being used as the EtherCAT master and

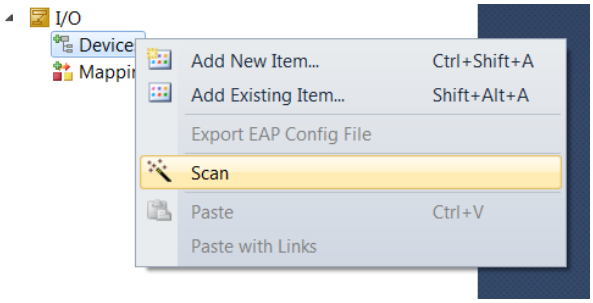
configuration tool

- The ECAT-2072A devices has to be connected to a power supply and ready for communication
- Set the TwinCAT in CONFIG mode.

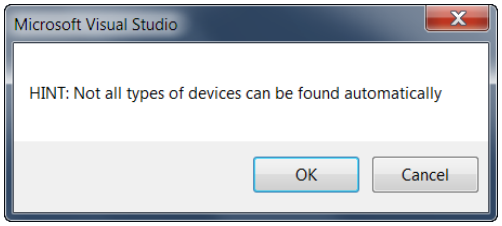
7.2.1 Scanning of the EtherCAT Device

After the TwinCAT has been set into CONFIG mode the online device search can be started.

Step 1: Right-click the “Devices” in the configuration tree to open the scan dialog. Click "Scan" to search the ECAT-2072A device.



Step 2: Select "OK"



Step 3: Select the Ethernet device (Ethernet chip) to which the ECAT-2072A is connected to. Confirm the selection with "OK".

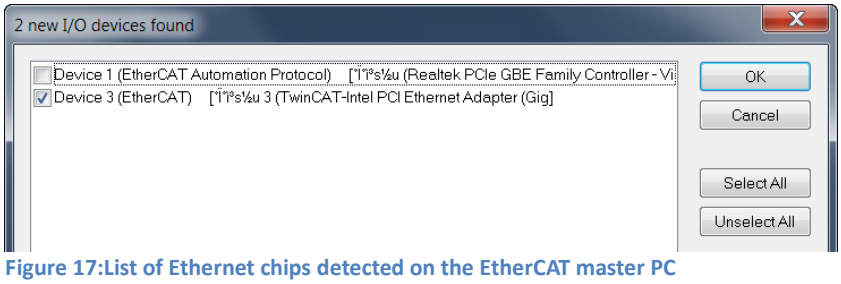
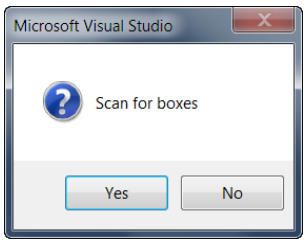
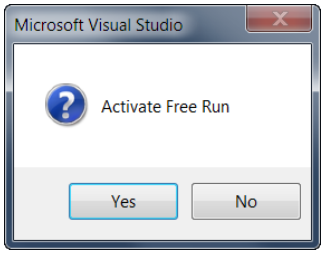


Figure 17:List of Ethernet chips detected on the EtherCAT master PC

Step 4: Start the scan process by clicking "Yes"



Step 5: Set the ECAT-2072A into Free-Run mode by clicking "Yes"



By default all three encoder channels are displayed in the tree view:

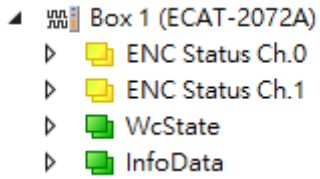


Figure 18: Default parameter selection for the ECAT-2072A

7.2.2 Encoder Counter Configuration

The configuration of the ECAT-2072A device such as Transmission interface, bit number of position, etc. only needs to be done once before the actual encoder counting starts. These parameters have to be accessed via the CANopen over EtherCAT (CoE) protocol and are listed in the "CoE online" tab. The CoE protocol has a lower priority than the cyclic process data object (PDO) communication. Therefore the CoE parameters will not be updated in every cycle but only when the master has spare time.

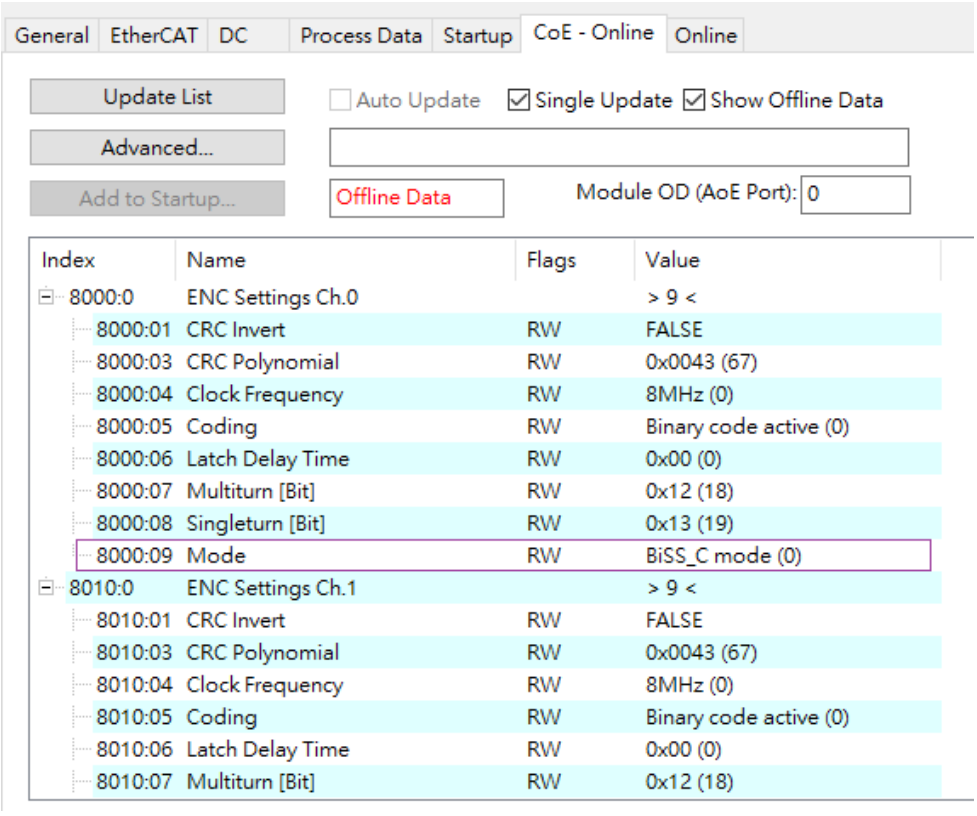
Encoder relevant CoE parameter are listed in the Encoder setting object (Index 0x8000, 0x8010, 0x8020, 0x8030)

For each channel the following configuration procedure has to be done:
- Transport interface mode setting
- Multiturn [Bit] and Singleturn [Bit]
- Data encoding mode
- Transmission frequency
- CRC polynomial

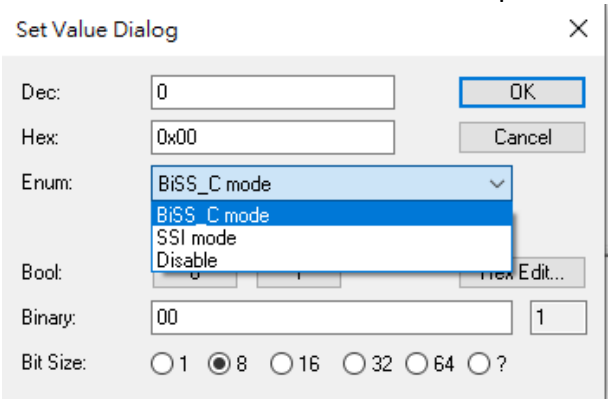
- CRC inverted setting

Example of setting the encoder counting mode for each channel:

Step 1: Go to "ENC Setting Ch.0" of a channel. Extend the index tree and double click " mode" with the index 8000:09 for channel 0.

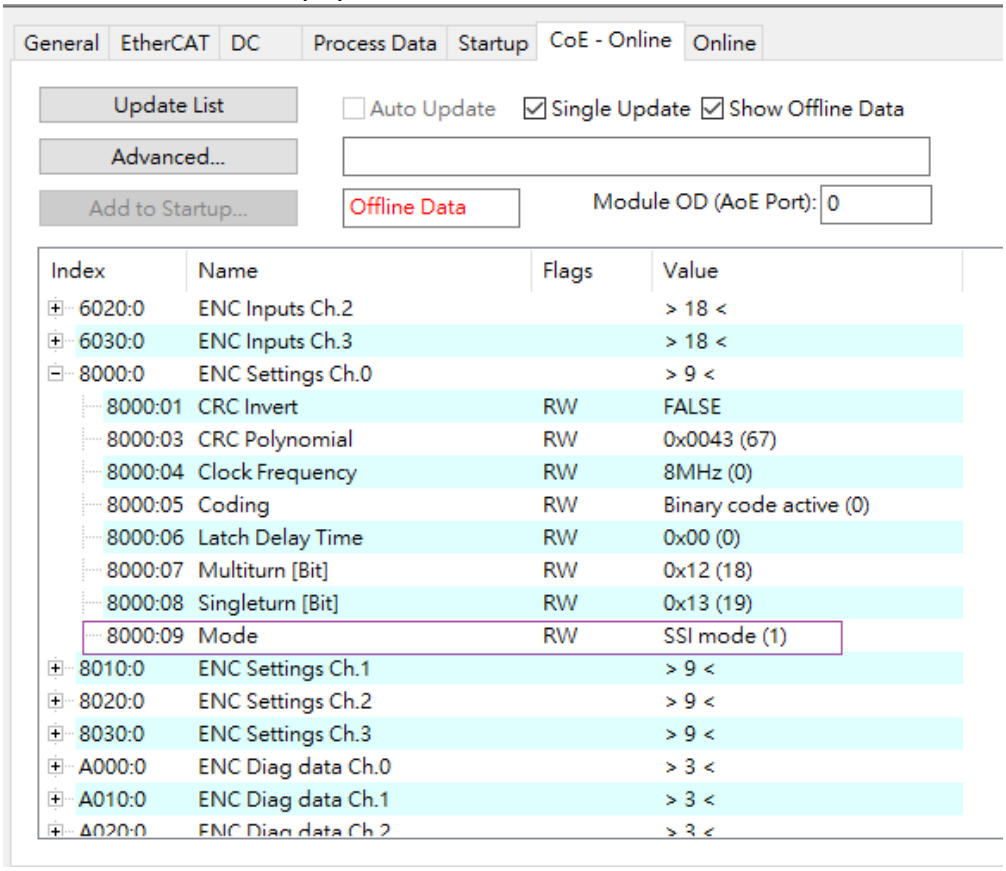


Step 2: Select one of the modes listed in the drop list and click "OK"



Step 3: Once the setting has been successfully sent to the slave it will be displayed in the CoE online parameter list. In the figure below " SSI mode " has been selected for channel 0. This value needs only to be set once and therefore does not

have to be sent in every cycle time.



All the relevant encoder configurations have to be set first before the polling of the encoder counter starts. Once the parameters are set, the encoder counter is basically ready for operation.

If required, the configuration can be permanently save to an internal non-volatile memory of the ECAT-2072A. After powering on the device it will immediately be initialized according configuration setting. For saving configuration data follow the instruction of chapter 9.2.

7.2.3 EtherCAT Slave Process Data Assignment

The user has to select the process data which has to be transferred between the EtherCAT master and slave during each cycle (Process Data Objects, PDOs). The process data exist of two parts:

- TxPDO: Data which is being read by the master (e.g. encoder channel status) .
- RxPDO: Data or parameters which is being sent to the slave (This module has no parameters for this part).

Once the parameters of the process data image has been defined by the user the master

will exchange the in- and output data in every cycle.

The ECAT-2072A allows the user to select for each encoder channel the process data to be transmitted. In TwinCAT the supported process data objects are listed in the "PDO Assignment (0x1C13)" boxes.

PDO selection procedure:

1. Activate the "Process Data" tab of the ECAT-2072A slave
2. For TxPDO selection: click in the "Sync Manager" window the "Inputs" line and in the "PDO Assignment (0x1C13)" window select for each encoder channel the required TxPDO. The process data contains status variables for the encoder and latch values, and signal status information. It is necessary to select this process data object otherwise it is not possible to retrieve any status information from the encoder channel.

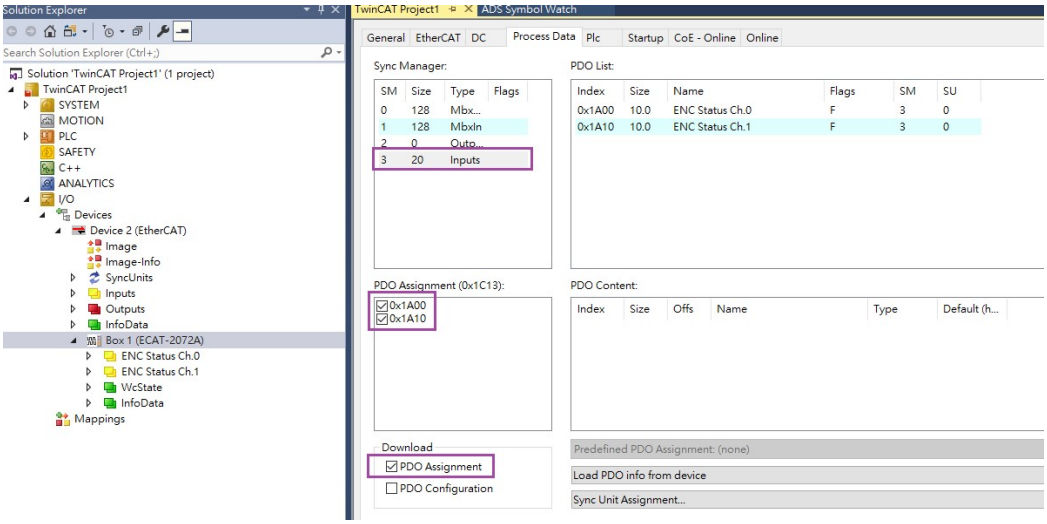


Figure 19: Predefined PDO assignment selection

Download the new PDO assignment to the Sync manager of the slave by clicking "Restart TwinCAT (Config Mode)" in the drop down menu. Make sure the check box next "PDO Assignment" is enabled.

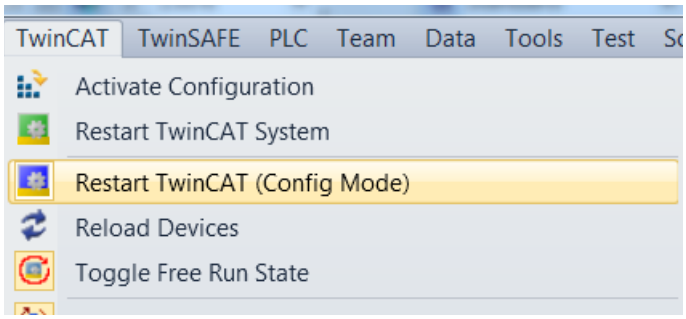


Figure 20: Download PDO assignment and restart TwinCAT

The device is now ready to be set into Free-Run or DC mode.

8 Parameter Description

8.1 Transmission Mode

The ECAT-2072A encoder master supports two modes:

- SSI (Serial Synchronous Interface)
- BiSS-C (BiSS Continuous Mode, unidirectional)

The encoder counter mode has to be set via CoE (0x80n0:08, n - represents the channel number), To disable the channel, you can set this object to Disable.

SSI mode: The encoder master station will transmit periodic pulses to the encoder, the encoder will transmit data according to the rising edge of the pulse, and the encoder master will latch data on the falling edge. After the transmission is completed, the encoder master will maintain a high potential, and the encoder will turn to a high potential after a period of Timeout, and the next transmission can be transmitted at this time.

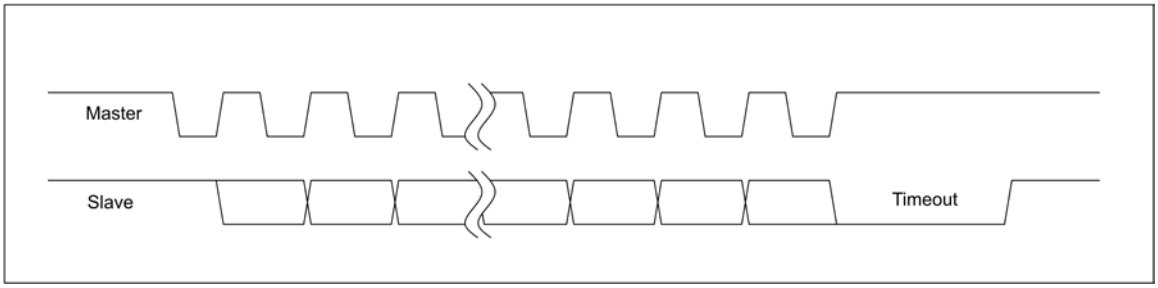


Figure 21: SSI mode

BiSS-C mode (unidirectional): The encoder master will transmit periodic pulses to the encoder, and the encoder will Ack on the second rising edge of MA. At this time, SLO will remain at low potential until the encoder is ready for data, and then transmit a high potential "Start" bit, there will be a low potential "0" bit immediately after the "start" bit to transmit the position data, after the position data transmission is completed, the error bit and warn bit will be transmitted, both the error bit and the warn bit are effective at low potential (active low), and then transmit the CRC check code. When the CRC check code is transmitted, the MA will maintain a high potential, and the SLO will return to a high potential after a period of low potential Timeout, and then the next transmission can be transmitted.

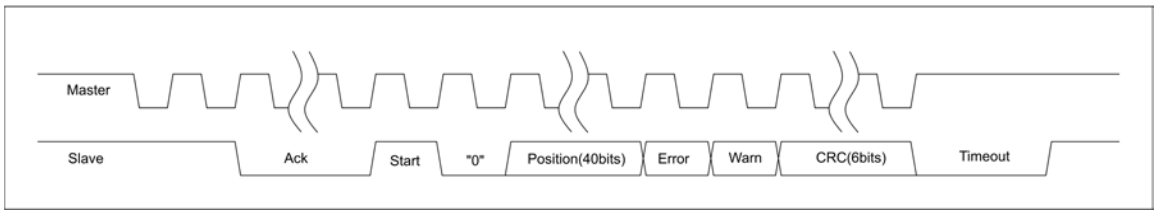


Figure 22: BiSS-C mode (unidirectional)

8.2 Number of Position Bits

Set the number of bits for Multiturn and Singleturn. These number has to be set via CoE:
Multiturn : 0x80n0：06
Singleturn : 0x80n0：07
n - represents the channel number

Set this parameter according to the number of pisition bits by the encoder. The maximum number of bits for Multiturn and Singleturn can be set to 32bit individually, but there is a limitation on the total number of bits, SSI must not exceed 48bits, BiSS-C is changed according to the setting of CRC generator polynomial, the equation is 46 minus CRC bits, For example: if the setting is CRC-6, then the maximum number of bits is 46-6=40.

If the encoder only has Singleturn, then set Multiturn to 0.

8.3 Transmission Pulse Frequency

The encoder master station will transmit pulse according to the frequency, and the encoder will transmit data at the same frequency. Notice to the maximum and minimum frequencies supported by the encoder, otherwise the correct data may not be read.

Clock Frequency number	Clock Frequency
0	10MHz
1	5MHz
2	2.5MHz
3	1.25MHz
4	625KHz
5	312.5KHz
6	156.25KHz

Table 9: Filter clock frequencies

The transmission pulse frequency has to be set via CoE (0x80n0:04,)

8.4 Data Encoding Mode

The encoder master supports two data encoding modes:

- Binary code
- Gray code

Data encoding mode has to be set via CoE (0x80n0:05)
n - represents the channel number

Set this parameter according to the data encoding mode of the encoder. The encoding mode is divided into Binary code and -Gray code. The biggest difference between the two is that Gray code only one bit will be changed as moves to the next position. Therefore, it can reduce the occurrence of errors in reading values

8.5 CRC Generator Polynomial

In BISS-C mode, the encoder will add a CRC code at the end of the data, and this check code is generated according to the CRC generator polynomial, so the encoder master needs to know the CRC generator polynomial used by the encoder. to check the data.

The CRC generator polynomial setting must include the highest bit, and Up to 8 bits can be set, which is CRC-7. For example, The commonly used polynomial is: :x6 + x1 + x0(CRC-6), expressed in binary as 1000011, that is, set to 67 (Hex: 0x43).
CRC generator polynomial has to be set via CoE. (0x80n0:03)
n - represents the channel number

8.6 CRC Invert

In the BISS-C mode, the encoder will add the CRC code at the end of the data. Some encoders will invert the calculated CRC code before transmitting. In this case, this parameter must be set to true.

CRC invert has to be set via CoE. (0x80n0:01)
n - represents the channel number

8.7 Measured Data Delay Time

The signal transmitted between the encoder master and the encoder will be delayed due to the length of the cable. The longer the line length is ,This delay time will not be affected at low transmission frequency (the delay time is much shorter than the transmission period), But at high transmission frequencies, it is necessary to set the delay compensation to get the correct value

This value is the data delay time measured by ECAT-2072A. 0x80n0：09，n - represents the channel number 。

8.8 Latch Data Delay Time

In BiSS-C mode, ECAT-2072A has an automatic compensation mechanism for data delay. The module will set it after calculation according to the measured delay time and the currently set frequency. This value is automatically set by the module and does not need to be set by the user.

0x80n0：0A，n - represents the channel number 。

8.9 Encoder Status

This section will describe all the variables listed in the TxPDOs: 0x1An0 (n - represents the channel number). These variables basically show the status and position value of the each channel .

Parameter	Object	Description
BiSS Warning bit (nWarning)	0x60n0:01	In BiSS-C mode, the encoder transmits the Warning bit to the encoder master, and this signal is active low.
BiSS Error bit (nError)	0x60n0:03	In BiSS-C mode, the encoder transmits the error bit to the encoder master, and this signal is active low.
Ready	0x60n0:04	Displays whether the data has been ready.
CRC Error	0x60n0:05	Displays whether the CRC check result is correct or not.
Input cycle counter	0x60n0:09	Displays whether new data has been successfully transmitted, plus one if the data is successfully read.
Multiturn Position	0x60n0:0F	Display the Multiturn position read by the encoder master.
Singleturn Position	0x60n0:10	Display the Singleturn position read by the encoder master.

Table 10: Encoder status variables

9 CoE Interface

9.1 General Description

The CoE interface (CANopen over EtherCAT) is used for parameter management of EtherCAT devices. The CoE interface displays all the objects and parameters which are required for operating and diagnosing the ECAT-2072A device. Some parameters are fixed and can not be modified, they for example indicate the operating status of the device or the device properties. Encoder configuration parameters need to be set before the actual motion control starts. These parameter setting are determined by the encoder type and the setup of the system.

CoE parameters has to be accessed via the CAN over EtherCAT protocol. The EtherCAT master accesses the local CoE lists of the slaves via CAN over EtherCAT. The user does not need to understand the CoE protocol when using the TwinCAT System Manager for CoE parameter configuration.

The CoE parameters describe a wide range of features such as manufacturer ID, device name, process data settings and configuration parameters.

The relevant ranges of the CoE list are:

- 0x1000: Stores fixed information of the device, including name, manufacturer, serial number etc.. In addition stores information about the current and available process data configurations.
  - 0x1A00: TxPDO mapping
- 0x8000: Stores all the configuration data which are required for the encoder counter.
- 0x6000: Input PDOs ("input" from the perspective of the EtherCAT master)

The figure 23 shows all of the CoE objects available for the ECAT-2072A device, ranging from 0x1000 to 0xF009. The parameters of the objects can be accessed by expanding the tree in the "CoE-Online" tab. The objects and their properties are described in chapter 10.

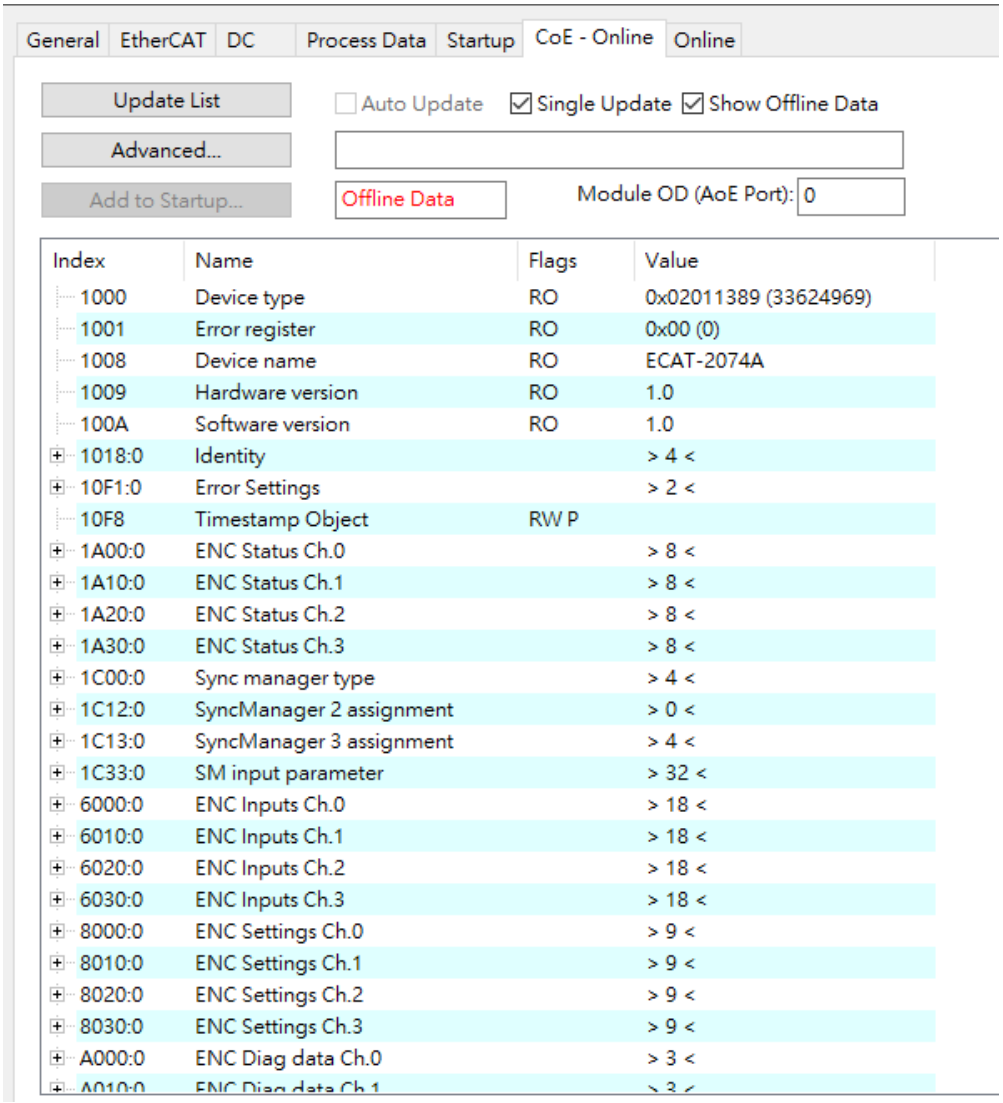


Figure 23: "CoE - Online " tab

9.2 Save Configuration Data to Memory

In this section the procedure of saving encoder configuration parameters to the non-volatile memory of the ECAT-2072A is being discussed.

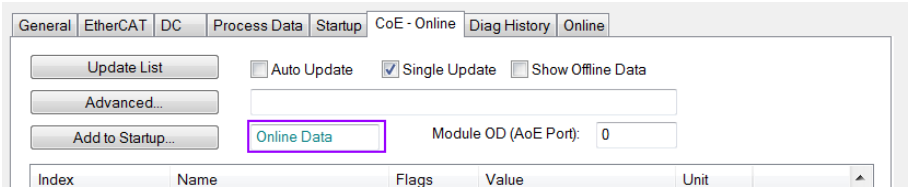
The CoE object range 0x8000 to 0x8030 contains all the parameters needed to configure the ECAT-2072A. TwinCAT allows the user to set the configuration parameters via the System Manager, or from a TwinCAT PLC via ADS (TcEtherCAT.lib library).

If slave CoE parameters are set online, the ECAT-2072A device does not automatically store the data to its non-volatile memory, therefore the data will be lost once the device

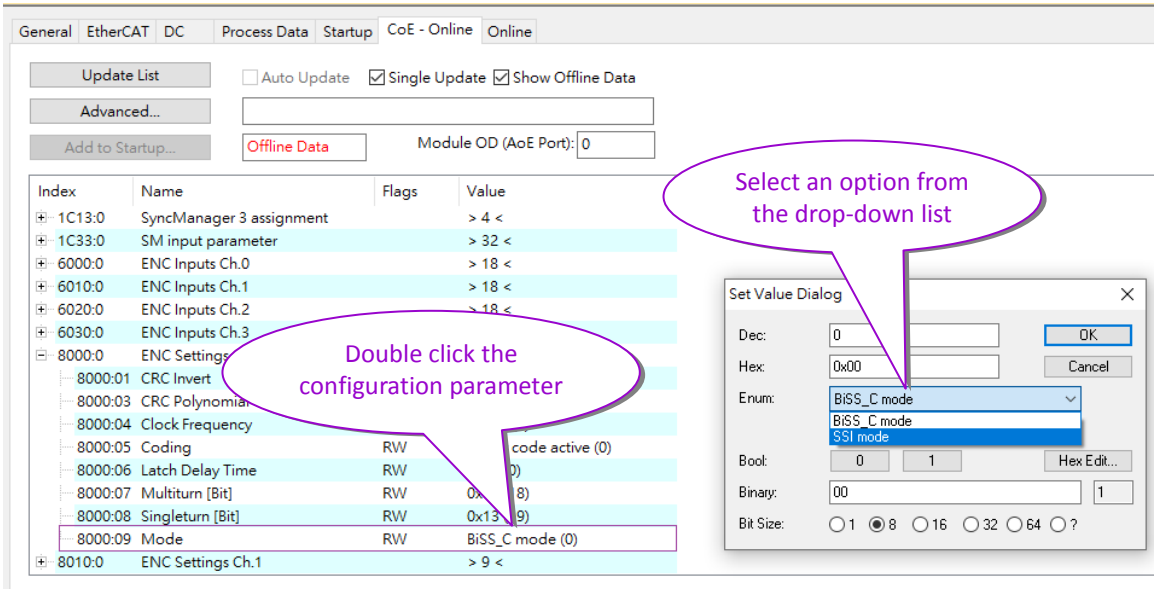
is switched off. The 0xF008 object provides functions to store the configuration data permanently to the non-volatile memory of the ECAT-2072A and the setting will be immediately available immediately after a restart.

Procedure for storing configuration data to the local ECAT-2072A memory:

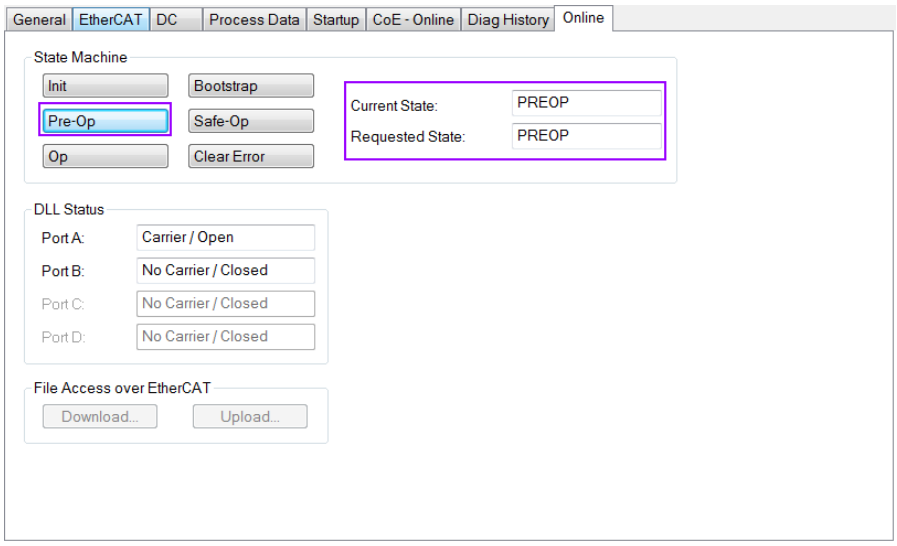
Step 1: Make sure the TwinCAT System Manager is connected to the ECAT-2072A and the "CoE-Online" tab is showing that the slave is online.



Step 2: Do all the necessary configuration by entering the correct parameter values for the configuration objects (0x8000, 0x8010, 0x8020, 0x8030). The setting is being done by double clicking the configuration parameter and selecting an option from the shown drop list box . In the following picture the signal polarity of the transmission mode of encoder channel 0 is being set.



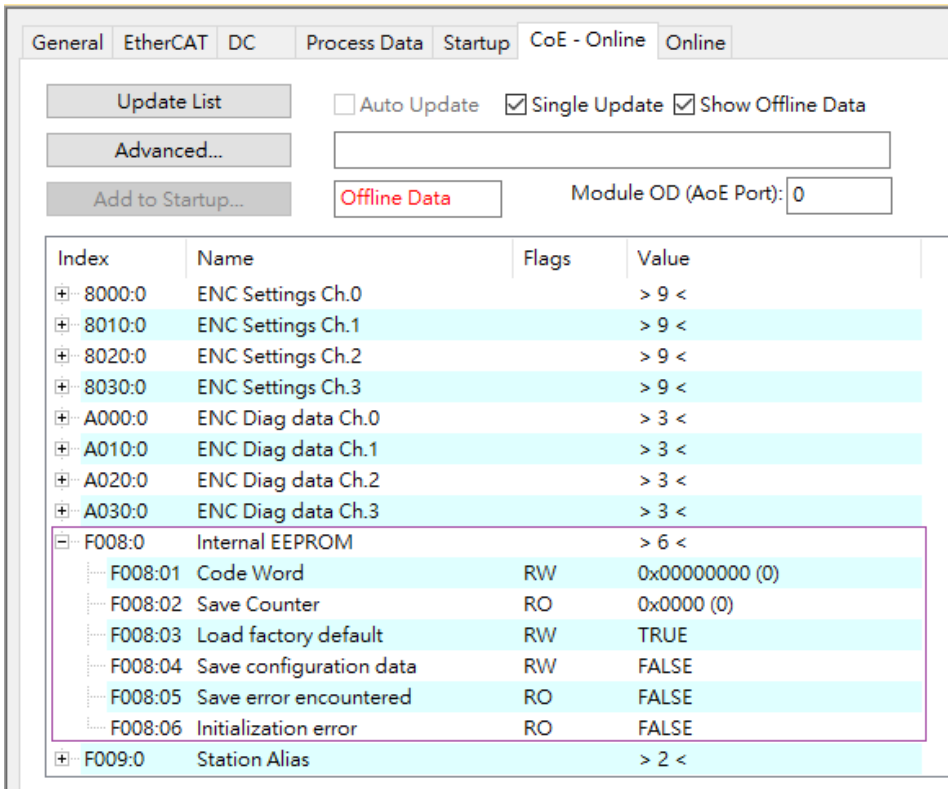
Step 3: After all the configurations have been done set the slave into Pre-Op mode. Data can only be stored to the local device if it is in Pre-Op mode. On the "Online" tab click the "Pre-OP" button to put the slave into Pre-OP mode.



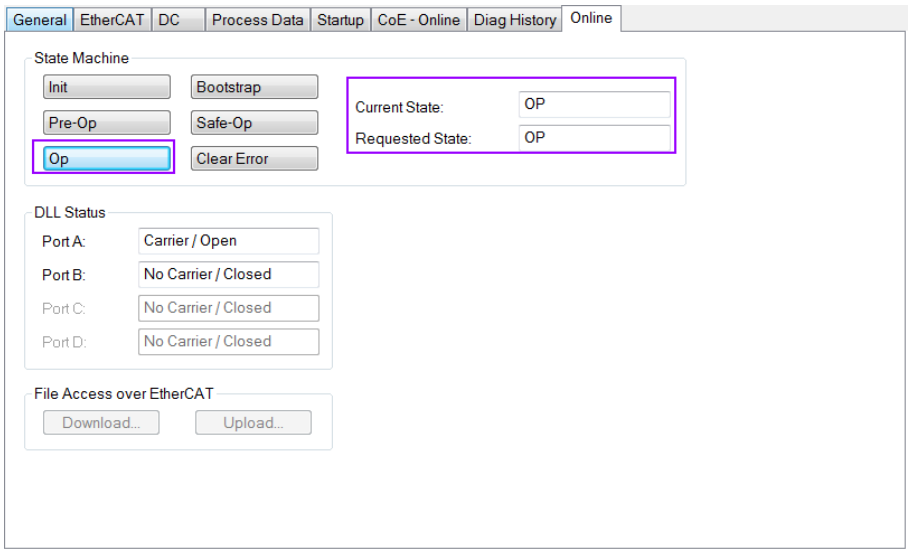
Step 4: The parameters of the 0xF008 object handles the save procedure.

1. Scroll to the end of the "CoE-Online" list and expand the tree view of the 0xF008 object
2. Enter the value 0x12345678 for the "Code Word"
3. Set the "Save configuration data" from FALSE to TRUE in order to save the configuration data to the internal EEPROM. The parameter "Save error encountered" (F008:05) indicates whether an error occurred during the save process.
4. In order for the configuration data to be loaded after a device restart set the "Load factory default" to FALSE. It is always possible to return to the factory default setting by setting this value back to TRUE.
5. The "Save Counter" (F008:02) shows how often configuration data has been stored to the local memory in the lifetime of the device.

   ATTENTION:
   The local memory only supports a limited number of save operations. Depending on the memory version once the save operation exceeds 10000 cycles it can no longer be guaranteed that data are reliably saved or are still readable. Therefore the "Save configuration data" (F008:04) and the "Load factory default" (F008:03) should not be continuously set from the controlling application program.



Step 5: Set the ECAT-2072A back into OP mode.



10 Object Description and Parameterization

10.1 Standard Objects

Index 1000 Device type

Index (hex)	Name	Description	Data type	Flags	Default
1000:0	Device type	Device type of the EtherCAT slave	UINT32	RO	0x00020000

Index 1008 Device name

Index (hex)	Name	Description	Data type	Flags	Default
1008:0	Device name	Device name of the EtherCAT slave	STRING	RO	ECAT-2072A

Index 1009 Hardware version

Index (hex)	Name	Description	Data type	Flags	Default
1009:0	Hardware version	Hardware version of the EtherCAT slave	STRING	RO	1.0 (or greater)

Index 100A Software version

Index (hex)	Name	Description	Data type	Flags	Default
100A:0	Software version	Software version of the EtherCAT slave	STRING	RO	1.0 (or greater)

Index 1018 Identity

Index (hex)	Name	Description	Data type	Flags	Default
1018:0	Identity		UINT8	RO	0x04
1018:01	Vendor ID	Vendor ID of the EtherCAT slave	UINT32	RO	0x00494350
1018:02	Product code	Product code of the EtherCAT slave	UINT32	RO	0x00207241 (2072A)
1018:03	Revision	Revision number of the EtherCAT slave	UINT32	RO	0x00010000
1018:04	Serial number	Serial number of the EtherCAT slave (not supported)	UINT32	RO	0x00000000

Index 10F1 Error settings

Index (hex)	Name	Description	Data type	Flags	Default
10F1:0	Error settings		UINT8	RO	0x02
10F1:01	Local error reaction	Not implemented	UINT32	RW	0x00000001
10F1:02	Sync error counter limit	For DC mode only: The Sync Error Counter is incremented with every missing Sync Management Event by three and decremented by one if an event is	UINT16	RW	0x0004

		received. If the Sync Error Counter exceeds this limit the system changes into the SAFEOP state with the 'Synchronization Lost' error. The Sync Error Counter is reset when the error was acknowledged.			

10.2 TxPDO Mapping Objects

Index 0x1An0 ENC StatusCh.n (TxPDO-Map)

Index (hex)	Name	Description	Data type	Flags	Default
1An0:0	ENC Status	Encoder Status	UINT8	RO	0x0B
1An0:01	Status__BiSS Warning bit (nWarning)	BiSS Warning bit data (1 Bit)	UINT32	RO	0x60n00101
1An0:02	Status__BiSS Error bit (nError)	BiSS Error bit data (1 Bit)	UINT32	RO	0x00000201
1An0:03	Status__Ready	Whether the data is ready to read or not (1 Bit)	UINT32	RO	0x60n00301
1An0:04	Status__CRC Error	CRC check error (1 Bit)	UINT32	RO	0x60n00401
1An0:05	Status__Gap1	empty (4 Bit)	UINT32	RO	0x00000004
1An0:06	Status__Input cycle counter	Position data counter, when there is correct reading data, this number will increase by 1 (8 Bit)	UINT32	RO	0x60n00908
1An0:07	Status__Multiturn Position	Encoder multiturn position data (32 Bit)	UINT32	RO	0x60n01120
1An0:08	Status__Singleturn Position	Encoder singleturn position data (32 Bit)	UINT32	RO	0x60n01220

"n" represents the channel number

10.3 Sync Manager Objects

Index 0x1C00 Sync manager type

Index (hex)	Name	Description	Data type	Flags	Default
1C00:0	Sync manager type	Using the sync managers	UINT8	RO	0x04
1C00:01	SubIndex 001	Sync-Manager Type Channel 1: Mailbox Write	UINT8	RO	0x01
1C00:02	SubIndex 002	Sync-Manager Type Channel	UINT8	RO	0x02

		2: Mailbox Read			
1C00:03	SubIndex 003	Sync-Manager Type Channel 3: Process Data Write (Outputs)	UINT8	RO	0x03
1C00:04	SubIndex 004	Sync-Manager Type Channel 4: Process Data Read (Inputs)	UINT8	RO	0x04

Index 0x1C13 TxPDO assign

Index (hex)	Name	Description	Data type	Flags	Default
1C13:0	TxPDO assign	SyncManager 3 assignment: PDO Assign Inputs	UINT8	RO	0x20
1C13:01	SubIndex 001	Default assignment: ENC Status Channel 0	UINT16	RW	0x1A00
1C13:02	SubIndex 002	Default assignment: ENC Status Channel 1	UINT16	RW	0x1A10
1C13:03	SubIndex 003	Default assignment: ENC Status Channel 2	UINT16	RW	0x1A20
1C13:04	SubIndex 004	Default assignment: ENC Status Channel 4	UINT16	RW	0x1A30

Index 0x1C33 Sync Manager (SM) input parameter

Index (hex)	Name	Description	Data type	Flags	Default
1C33:0	SM input parameter	Synchronization parameters for the inputs	UINT8	RO	0x20
1C33:01	Synchronization Type	Current synchronization mode: • 0: Free Run • 1: Synchron with SM 3 Event (no outputs available) • 2: DC - Synchron with SYNC0 Event • 3: DC - Synchron with SYNC1 Event • 34: Synchron with SM 2 Event (outputs available)	UINT8	RO	0x0022
1C33:02	Cycle Time	Cycle time (in ns): • Free Run: Cycle time of the local timer • Synchronous with SM 2 event: Master cycle time • DC mode: SYNC0/SYNC1 Cycle Time	UINT8	RO	0x00000000
1C33:04	Synchronization Types supported	Supported synchronization modes: • Bit 0 = 1: free run is supported	UINT8	RO	0x8007

		• Bit 1 = 1: Synchron with SM 2 event is supported • Bit 2-3 = 01: DC mode is supported • Bit 4-5 = 10: Output shift with SYNC1 event (only DC mode)			
1C33:05	Minimum Cycle Time	Minimum cycle time (in ns)		RO	0x00000000
1C33:06	Calc and Copy Time	Time between reading of the inputs and availability of the Inputs data for the master (in ns, only DC mode)		RO	0x00000000
1C33:08	Get Cycle Time	• 0: Measurement of the local cycle time is stopped • 1: Measurement of the local cycle time is started Set parameter to 1 in order to update the Cycle Time (1C32:02, 1C33:02) parameter with the maximum measured value		RW	0x0000
1C33:09	Delay Time	Time between SYNC1 event and reading of the inputs (in ns, only DC mode)		RO	0x00000000
1C33:0A	Sync0 Cycle Time			RW	0x00000000
1C33:0B	SM-Event Missed	Number of missed SM events in OPERATIONAL (DC mode only)		RO	0x0000
1C33:0C	Cycle Time Too Small	Cycle was not completed in time or the next cycle began too early		RO	0x0000
1C33:20	Sync Error	The synchronization was not correct in the last cycle (outputs were output too late; DC mode only)		RO	FALSE

10.4 Input Data

Index 0x60n0 ENC Inputs Ch.n

Index (hex)	Name	Description	Data type	Flags	Default
60n0:0	Get encoder input status	Encoder input status	UINT8	RO	0x13
60n0:01	BiSS Warning bit (nWarning)	The Warning bit transmitted by the the Biss protocol encoder when transmitting data, This state is active low.	BOOLEAN	RO	

60n0:02	BiSS Error bit (nError)	The Error bit transmitted by the the Biss protocol encoder when transmitting data, This state is active low.	BOOLEAN	RO	
60n0:03	Ready	TRUE when data preparation is complete, otherwise keep FALSE	BOOLEAN	RO	
60n0:04	CRC Error	Use the data received by the Biss protocol to perform CRC check, Remains FALSE if successful, TRUE if failed.	BOOLEAN	RO	
60n0:09	Input cycle counter	Whenever the PDO data is read, it will first check whether the data is wrong, if the data is read correctly, this number will increase by 1	UINT8	RO	
60n0:11	Multiturn Position	For the multiturn position data of the encoder, the number of bits to be transmitted can be set through the object (80n0:07)	UINT32	RO	
60n0:12	Singleturn Position	For the singleturn position data of the encoder, the number of bits to be transmitted can be set through the object (80n0:07)	UINT32	RO	

"n" represents the channel number

10.5 Configuration Data

Index 0x80n0 ENC Settings Ch.n

Index (hex)	Name	Description	Data type	Flags	Default
80n0:0	ENC Settings	Encoder Settings	UINT8	RO	0x0B
80n0:01	CRC Invert	Invert CRC code bit	BOOLEAN	RW	0x01
80n0:03	CRC Polynomial	CRC generator polynomial	UINT16	RW	0x43
80n0:04	Clock Frequency	Transmission pulse frequency 0:10MHz 1:5MHz 2:2.5MHz 3:1.25MHz 4:625KHz 5:312.5KHz 6:156.25kHz	DT0801EN08	RW	0x00 (10MHz)
80n0:05	Coding	data encoding mode 0:Binary code 1:Gray code	DT0802EN08	RW	0x00 (Binary code)
80n0:06	Multiturn [Bit]	The number of bits of the multiturn position data of the encoder, the maximum setting is 32	UINT8	RW	0x00
80n0:07	Singleturn [Bit]	The number of bits of the singleturn position data of the encoder, the maximum setting is 32	UINT8	RW	0x20
80n0:08	Mode	The transmission protocol used by the encoder, or disable channel 0:BISS 1:SSI 2:Disable	DT0803EN08	RW	0x00 (BISS)
80n0:09	Measured Delay Time	Measure the delay time caused by the length of the line	UINT8	RO	0x00
80n0:0A	Latch Delay Time	The module automatically compensates the data delay time	UINT8	RO	0x00

"n" represents the channel number

10.6 Information and Diagnostic Data

Index 0xA0n0 STM Diag data

Index (hex)	Name	Description	Data type	Flags	Default
A0n0:0	STM Diag data	Encoder diagnostic status	UINT8	RO	0x06
A0n0:1	Error	Encoder error	BOOLEAN	RO	0x00
A0n0:2	SCD Error	DC sync error	BOOLEAN	RO	0x00

A0n0:3	Channel Status	channel enabled status 0: Disable 1: Enable	BOOLEAN	RO	0x00

"n" represents the channel number

10.7 Configuration Parameters Storage

Index 0xF008 Internal EEPROM

Index (hex)	Name	Description	Data type	Flags	Default
F008:0	Internal EEPROM	Storing CoE parameters to the internal EEPROM.	UINT8	RO	0x05
F008:01	Code Word	Password for saving CoE configuration data to the EEPROM Password: 0x12345678	UINT32	RW	0x00000000
F008:02	Save Counter	Total number of save sequence	UINT16	RO	0x0000
F008:03	Load factory default	Load factory default configuration immediately after power on. • By setting this parameter to FALSE the user set configuration data (0x8000 to 0x8020) will be loaded after power on	BOOLEAN	RW	TRUE
F008:04	Save configuration data	Save all configuration setting to local non-volatile memory. • Set to TRUE in order to save the configuration data (0x8000 to 0x8020) to the memory of the ECAT-2072A	BOOLEAN	RW	FALSE
F008:05	Save error encountered	Indicates whether data has been successfully written to memory	BOOLEAN	RO	FALSE
F008:06	Initialization error	Internal EEPROM access failed	BOOLEAN	RO	FALSE

10.8 Station alias Configuration

Index F009 Station Alias

Index (hex)	Name	Description	Data type	Flags	Default
F009:0	Station Alias		UINT8	RO	0x02
F009:01	Rotary switch value	Display rotary switch value	UINT16	RO	0x00
F009:02	Reserve	Reserve	BOOLEAN	RO	0x0