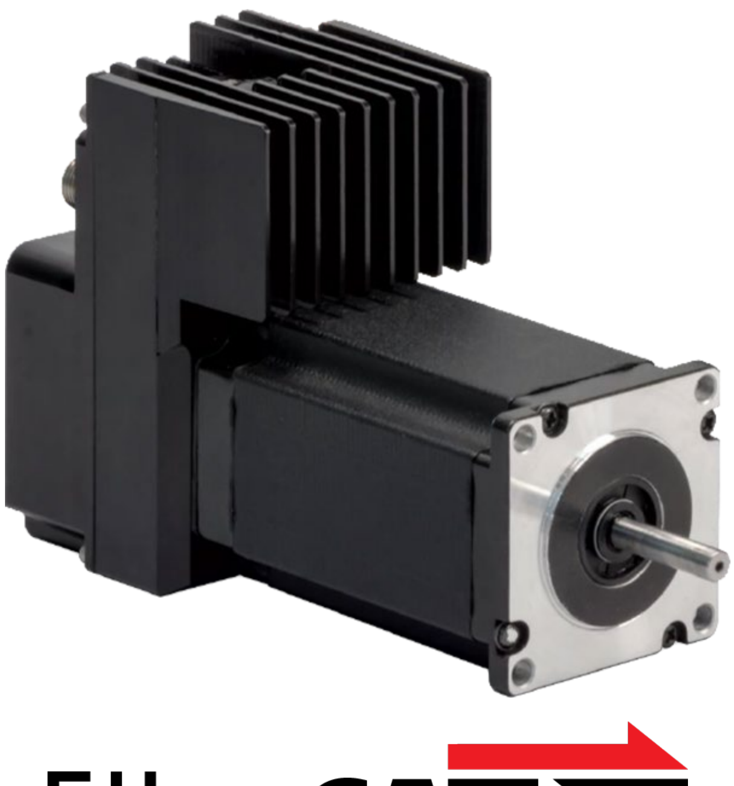
USER GUIDE

EtherCAT User's Guide

ACSI Integrated Servo Motor/Drive/Controller

ACSI Motor/Drive/Controllers with EtherCAT drive are DISCONTINUED Replacements are not available. Use this manual as reference only.

EtherNet/IP, Modbus and Basic ASCI Motor/Drive/Controllers continue with full Tolomatic Support



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Introduction

Device Information
Vendor ID: 0x00000986
Vendor Name: Tolomatic, Inc.
Product Code: 0x2362
Type: ACSI Drive & Controller
Name: ACSI Drive & Controller Interface

For use with 36043324_ACSI_ESI definitions file.

An ACSI to TwinCAT 3.1 Interface Library is available for reference, part number 3604-3325. Please contact Tolomatic Support for details.

Network Configuration

ACSI EtherCAT supports star or daisy chain topologies.

The ACS Servo drive supports a maximum communications cycle rate of 100 Hz. Setting the communications cycle rate faster than 10ms could cause a loss of communications to the drive.

Maximum Cycle Rate: 100Hz or 10ms

Ethernet Cabling

The ACSI uses circular M12 D-code 4-pin connectors. Please refer to the hardware manuals for further cable information (Hardware and Installation Guide; ACSI: 36044185). See appendix for network cable type and length specifications.

The following information regarding cable length is from commercial building telecommunications cabling standard ANSI/TIA/EIA-568-B.1. The maximum length of a cable segment is 100 meters (328 ft.). Category 5e cable is capable of transmitting data at speeds up to 1000 Mbps – 1 Gbps (ACSI has a maximum speed of 100 Mbps). The specifications for 10BASE-T networking specify a 100-meter length between active devices. This allows for 90 meters of fixed cabling, two connectors, and two patch leads of 5 meters, one at each end.

Tolomatic Motion Interface (TMI) Requirements

EtherCAT Ethernet configuration settings are controlled by the PLC setup. There are not Ethernet configuration settings established by Tolomatic Motion Interface (TMI) software. Application motor tuning, home settings, and other safety limits should be set in TMI before operation.

EtherCAT LED Indicators

EtherCAT LED Indicators

RUN LED	System Status
Off	**Initialization**
Blinking	**Pre-Operational**
Single Flash	**Safe-Operational**
Double Flash	**N/A**
On	**Operational**

ERR LED	System Status
Off	**No error**
Blinking	**Invalid Configuration**
Single Flash	**Local Error**
Double Flash	**Process Data Watchdog Timeout/EtherCAT Watchdog Timeout**
On	**Application Controller Failure**

L/A LED	Port Status
Off	**Port Closed**
Flickering	**Port Open**
On	**Port Open**

LS LED	Port Status
Flickering	**Communicating**

Table 1 - ACSI EtherCAT LED Indicators Blink Definitions

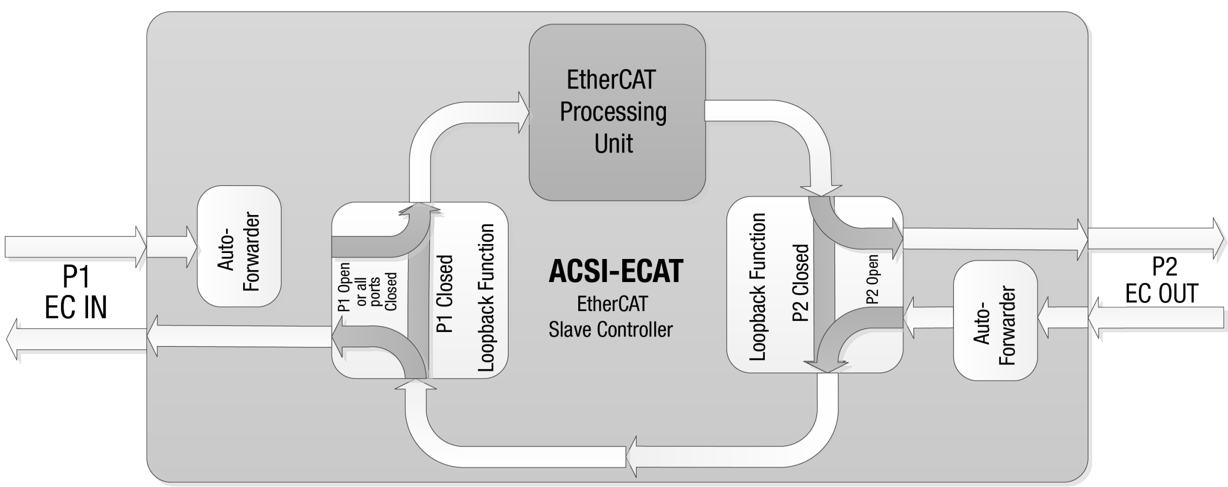

Figure 1 – ESC Port Assignment

Input Objects

The following are the input objects, as defined by the ESI file for use with the ACSI Integrated Drive & Controller.

Input Objects					
Direction (Perspective of PLC)	> Address	Type	Size	Description	Units
Input	39	REAL	4	Current Position	mm or rotary unit (as defined by TMI)
	43	BITARR32	4	Drive Status	bitmask (defined below)
	47	BITARR32	4	Drive Faults	bitmask (defined below)
	51	BITARR32	4	Digital Inputs	bitmask (first 4 bits represent 4 inputs)
	55	BITARR32	4	Digital Outputs	bitmask (first 2 bits represent 2 outputs)
	59	REAL	4	Analog Input (Remappable Register 1*)	v or mA (as defined by TMI)
	63	REAL	4	Analog Output (Remappable Register 2*)	v or mA (as defined by TMI)

*As pf ACSI Firmware Version 1.7

Table 2 - Input Object Definitions

Drive Status Definition	
BIT	Description
0	Drive Enable: 0 = Not Enabled; 1 = Enabled
1	Drive Homed: 0 = Not Homed; 1 = Homed
2	Drive In Motion: 0 = Not In Motion; 1 = In Motion
3	Software Stop: 0 = OFF; 1 = ON
4 - 19	(internal use)
20	Brake Not Active: (0 = Brake Active)
21 – 25	(internal use)
26	Drive In Position: 1 = In Commanded Position
27-30	(internal use)
31	Drive Control: 0 = off (I/O, CTROFF) 1 = on (Host, CTRON)

Table 3 - Drive Status Bitmask Definition

Drive Faults Definition	
BIT	Description
0	Positive Limit
1	Negative Limit
2	Software Stop
3	Position Error
4	Feedback Error
5	Overcurrent
6	Motor Over Temperature
7	Drive Over Temperature
8	Drive Over Voltage
9	Drive Under Voltage
10	Flash Error
11	I2T Limit
12	Short Circuit
13	Watchdog Reset
14	Velocity Error
15 to 21	Reserved

Table 4 - Drive Faults Bitmask Definition

ACS SERVO DRIVE / ACSI REMAPPABLE REGISTERS
Analog Input (Default Register 1)
Analog Output (Default Register 2)
Actual Position
Actual Position Error
Actual Velocity
Actual Velocity Error
Actual Current
Commanded Position
Commanded Velocity (Trajectory)
I2T Accumulation Value*
I2T Limit*
Bus Voltage (Volts)
Board Temperature (Drive)
Digital Inputs
Digital Outputs

* When I2T Accumulation value exceeds limit, I2T fault occurs. Accumulation happens any time motor is running

Table 5 - ACS Servo Drive / ACSI Remappable Registers

Output Objects

The following are output objects, as defined by the ESI file for use with the ACSI Integrated Drive & Controller.

Output Objects					
Direction (Perspective of PLC)	> Address	Type	Size	Description	Units
Output	39	USINT	1	Drive Command	Commands Defined below
	40	USINT	1	Move Select	profile index (0 - uses defined target 0 profile, 1-16 uses index profiles defined in TMI)
	41	REAL	4	Target0 Position	mm or rotary (as defined by TMI)
	45	REAL	4	Target0 Velocity	mm/s or rotary (as defined by TMI)
	49	REAL	4	Target0 Acceleration	mm/s² or rotary (as defined by TMI)
	53	REAL	4	Target0 Deceleration	mm/s² or rotary (as defined by TMI)
	57	REAL	4	Target0 Force	% of Peak Current of Motor (as defined by TMI)
	61	UDINT	4	Target0 Motion Type	enumeration (defined below)
	65	BITARR32	4	Digital Outputs	bitmask (first 2 bits represent 2 outputs)

Table 6 - Output Object Definitions

Drive Command Definition	
Command	Description
0 (0x00)	Disable
1 (0x01)	Enable/Clear Start Motion
3 (0x03)	Start Motion
5 (0x05)	Home
8 (0x08)	Software Stop
17 (0x11)	Stop Motion
21 (0x15)	Home Here

Table 7 - Drive Command Definitions

Note: Drive Command Processing

The drive processes commands issued over the network in an edge-triggered manner. The drive does not process new commands unless they differ from the previous command. For motion, this means the drive will not make a new move until it detects a new "Start Motion" command. To clear the previous Start Motion command, the PLC program must set the command to something other than Start Motion. "Enable" is typically used. This can be done while the drive is in motion, or in a time-based scheme as long as the drive has sufficient time to detect the transition from Start Motion to Enable (> 2x Scan Rate).

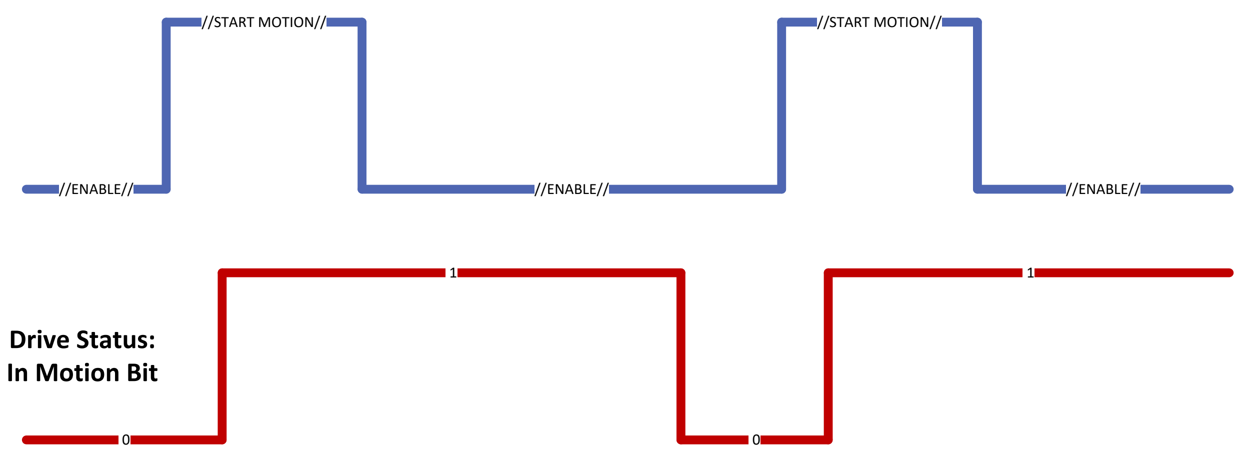

Figure 2 - Edge Triggered Commands

Motion Types Enumeration		
Name	Value	Description
Absolute	**0**	Moves to absolute position defined by Target0 Position using the defined motion profile
Incremental Positive	**1**	Moves in the positive direction the distance specified by Target0 Position using the defined motion profile
Incremental Negative	**2**	Moves in the negative direction the distance specified by Target0 Position using the defined motion profile
Home	**5**	Executes a home motion using the homing profile defined in TMI
No Action	**6**	Does not execute motion
Force	**9**	Press to Target0 Force % defined by motion profile (more complete description available in TMI manual)
Incremental Positive Rotary	**11**	Moves in the positive direction the distance specified by Target0 Position at the defined motion profile. If position is commanded past max distance, the current position is reset and the drive is un-homed
Incremental Negative Rotary	**12**	Moves in the negative direction the distance specified by Target0 Position using the defined motion profile. If position is commanded past max distance, the current position is reset and the drive is un-homed
Velocity Forward	**13**	Starts a velocity move in the positive direction at profile velocity and acceleration (Set Velocity Feed Forward Tuning to 100% in TMI)
Velocity Reverse	**14**	Starts a velocity move in the negative direction at the profile velocity and acceleration (Set Velocity Feed Forward Tuning to 100% in TMI)

Table 8 - Motion Types Definitions

A Note about EEPROM

The ACS Drive should be shipped from Tolomatic with the EEPROM already configured. In the event that the drive is not responding or the drive does not go into OP mode, the user may have to update the EEPROM using EtherCAT. In TwinCAT, this is done in the Advanced Settings under the device.

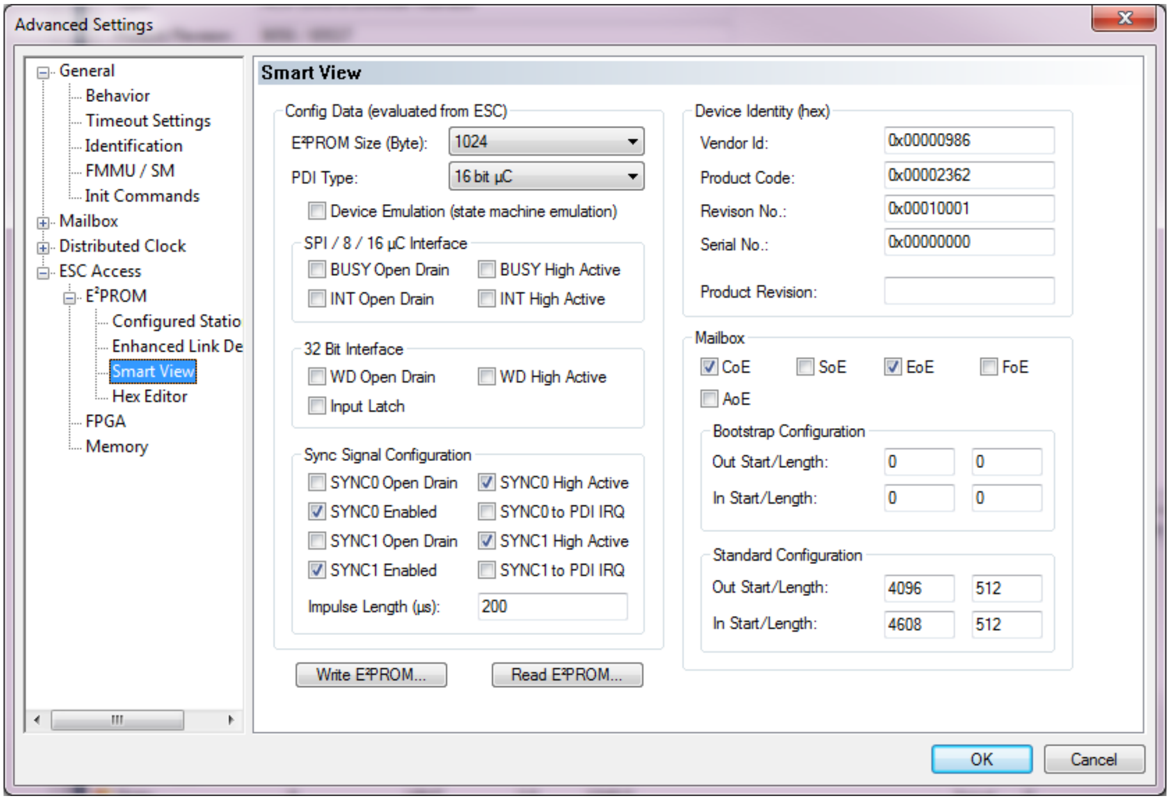

Figure 3 - Advanced Settings TwinCAT, Write EEPROM

Device Specific Serial Number

All ACSI EtherCAT MAC Addresses are with the CC2237B00000 – CC2237BFFFFF range. The reported serial number in the EtherCAT protocol is the portion of this address that is unique to each device. See below.

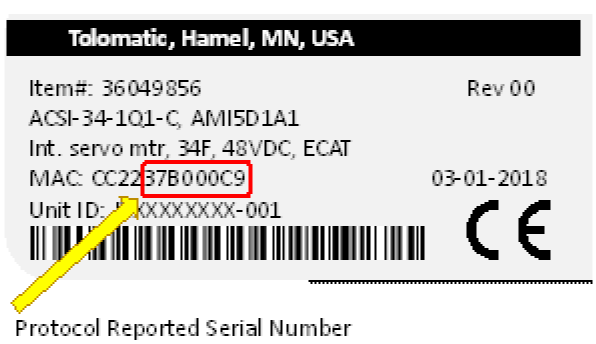

Figure 4 – Protocol Reported Serial Number

Getting Started – The Basics

The purpose of this guide is to present the ACS EtherCAT interface to the user and provide a starting point for implementation. It assumes that the user is familiar with the specific PLC and development environment that the device is being deployed to. This section will go over the generic aspects of implementing an ACS in any PLC.

Terminology: Inputs and Outputs

When looking at documentation, the user always looks at these terms from the PLC's perspective. Therefore, an Input is data that comes from a device to the PLC, and an Output is data that goes to a device from the PLC.

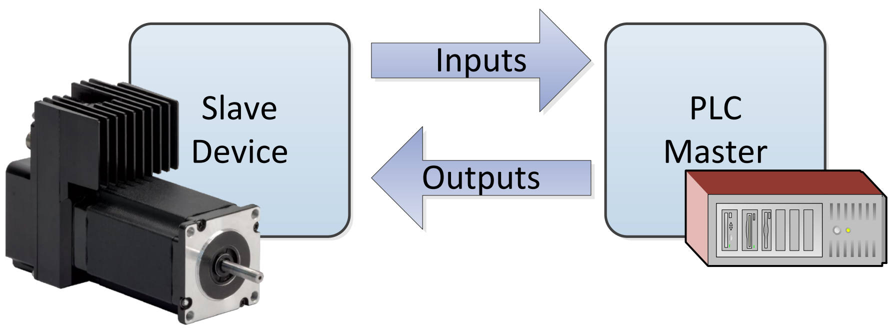

Figure 5 - PLC Data Direction

PLC Program Structure: Maintaining State

Writing a PLC program can be very complicated. Typically, PLC's are controlling multiple axes, receiving inputs from multiple sensors, and can even be controlling independent processes on different parts of a machine.

One of the goals for structuring a PLC program is to maintain state. By organizing processes in such a way as to create an effective state machine, the program will be easier to support and debug if problems arise.

The most common issue that occurs when commissioning a machine is something called a race condition. A race condition is a condition where the output is dependent on the sequence or timing of other uncontrollable events. When events do not happen in the order the programmer intended this becomes a bug.

To combat race conditions and provide a framework for the PLC program, the user can follow the ISPUO structure. Which is – Input Scan, Process, Update Outputs. Although many PLC's may internally follow this process, structuring the User Code in this fashion is recommended.

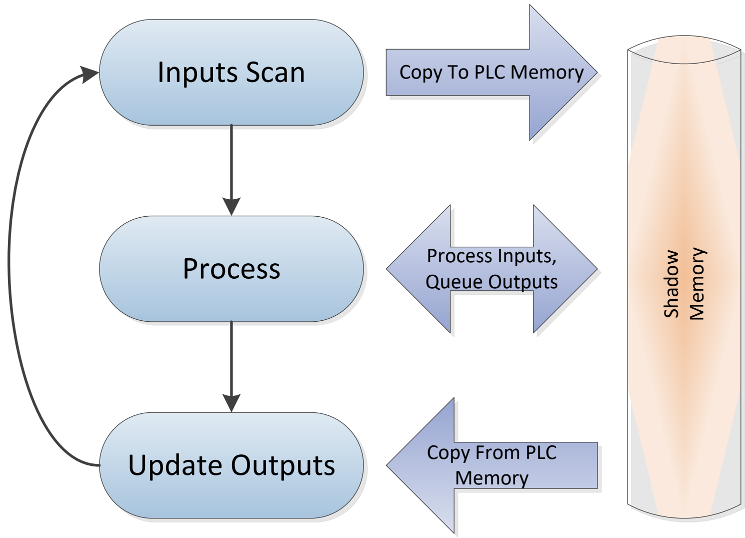

Figure 6 - Input Scan, Process, Update Outputs

PLC Program Structure: Shadow Memory

Shadow Memory is a term used to describe a block of memory set aside that tracks and stores the inputs and outputs of a device so that they are controlled and only change when the user changes them. This prevents an input from changing during the Process stage of the program structure.

Shadow memory can be defined as User Types, or as individual variables that are updated by the Input Scan, processed by the Process stage, and copied out during the Update Outputs stage.

In general, for the ACSI – a drive object is created. Inside of this object, one defines all of the Inputs and Outputs of the drive. Also, any additional state variables can be defined in this object.

A sample shadow memory drive object is described below.

```
//Synchronization Variables (Read/Write Routines)
_InputCurrentPosition AT %I*        : REAL;
_InputAnalogOutput AT %I*           : REAL;
_InputAnalogInput AT %I*            : REAL;

//User Current Position in mm or rotary units
UserInputCurrentPosition            : REAL;
//User Access to Analog Output
UserInputAnalogOutput               : REAL;
//User Access to Analog Input
UserInputAnalogInput                : REAL;
```

Figure 7 - Shadow Memory, REAL Inputs

During the Input Scan stage, the Current Position, Analog Input, and Analog Output values are copied from the _InputCurrent* mappings into the three UserInput values in the Shadow Memory object.

The Shadow Memory object can also abstract the Device Inputs so that the User PLC code does not have to worry about bit masking during the Process stage.

Next, we show that the Drive Status Input is a Bit Array of size 32. Each bit represents a state of the drive. By abstracting, or masking the bits during the scan, we allow the user code to simply reference the various drive statuses as a coil (or Boolean).

```
//Synchronization Variable (Read/Write Routines)
_InputStatus AT %I*                    : BITARR32;

//Status bits from drive
InputStatusDriveEnabled                : BOOL;
//Status bits from drive
InputStatusDriveHomed                  : BOOL;
//Status bits from drive
InputStatusDriveInMotion               : BOOL;
//Status bits from drive
InputStatusDriveSoftwareStop           : BOOL;
//Status bits from drive
InputStatusDriveBrakeNotActive         : BOOL;
//Status bits from drive
InputStatusDriveTMISoftwareControl     : BOOL;
```

In the Input Scan routine, we parse out the _InputStatus value into individual bits, then toggle the various Boolean values based on the bit status.

Further details outlining PLC programming can be found in the ACSI TwinCAT 3.1 Integration Guide 3600-4202 and the ACSI TwinCAT 3.1 Interface Library 3604-3325.

Additional information for the ACSI EtherCAT implementation can be found in:
3604-4185 ACSI Hardware User's Guide,
3604-4184 Tolomatic Motion Interface User's Guide.

See tolomatic.com for the most up-to-date technical information.

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