



APPLICATION NOTE

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Subject

Introduction to EtherCAT Communication

Purpose

This application note is intended to provide a basic overview of EtherCAT communication.

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2-17-2025

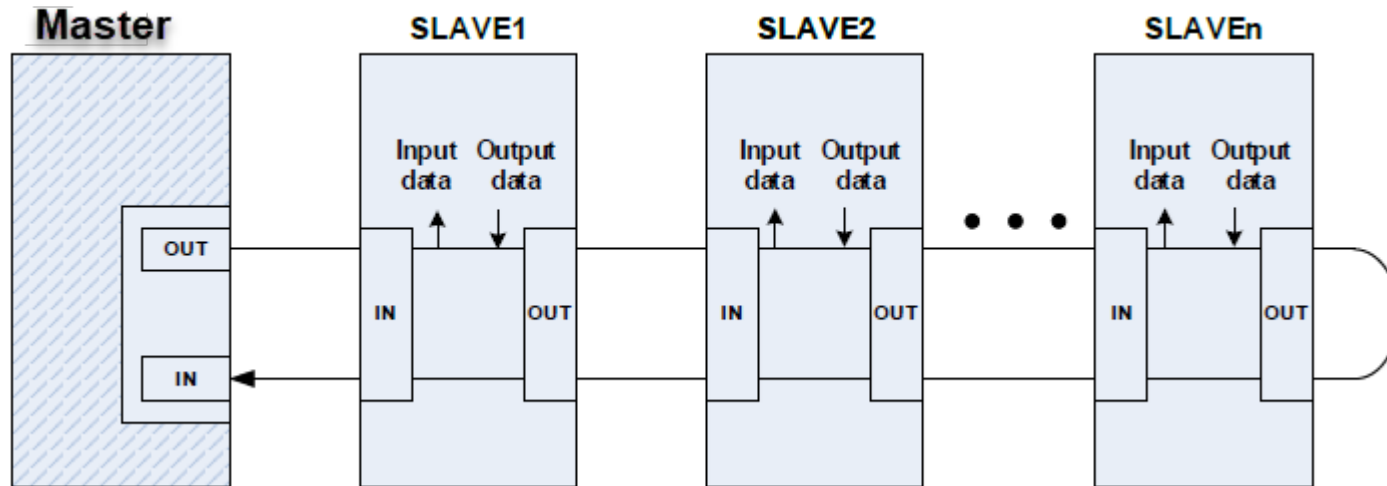
EtherCAT Communication

- EtherCAT stands for Ethernet for Control Automation Technology.
- The main organization overseeing the protocol is called the EtherCAT Technology Group (ETG).
- EtherCAT is a linear network topology that doesn't use standard or managed switches.
- Category 5 Shielded Twisted Pair Ethernet cables are required. (Doesn't matter if cross-over or straight through)
- EtherCAT devices are separated into Master devices and Slave devices.
- Protocols that use EtherCAT communication.
 - CANopen over EtherCAT (CoE): Automationdirect will be primarily using master and slave devices that support this protocol.
 - Sercos over EtherCAT (SoE).
 - Ethernet over EtherCAT (EoE): Ethernet communication is tunneled through an EtherCAT connection. Typically used for access to web servers on some slave devices.
 - File over EtherCAT (FoE): Used for sending firmware files to slave devices.



Section 1 - What is EtherCAT

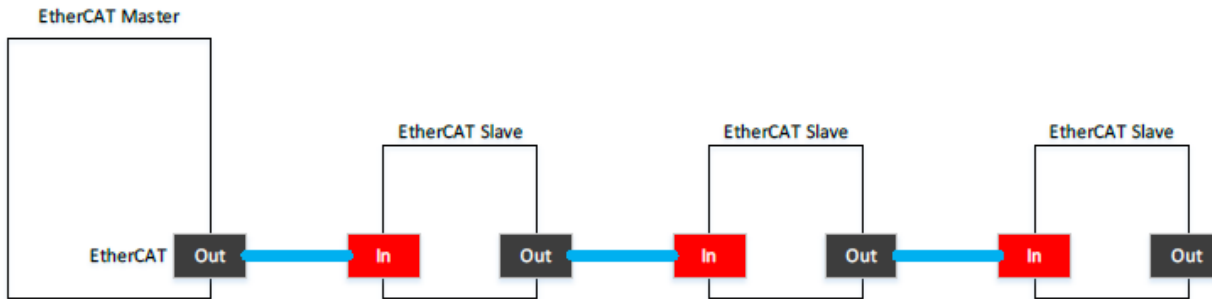
- EtherCAT is a high-performance industrial network system which uses Real-Time Ethernet.
- EtherCAT provides short communication cycle time between the master and slaves by transmitting Ethernet frames at a high speed.
- EtherCAT communication uses one frame to all slaves without transmitting data to each slave node in the network.
- Each slave reads and writes data to its own area in the frame when a communication frame passes through.
- The communication frame goes through the last slave and returns to the master through all the slaves.



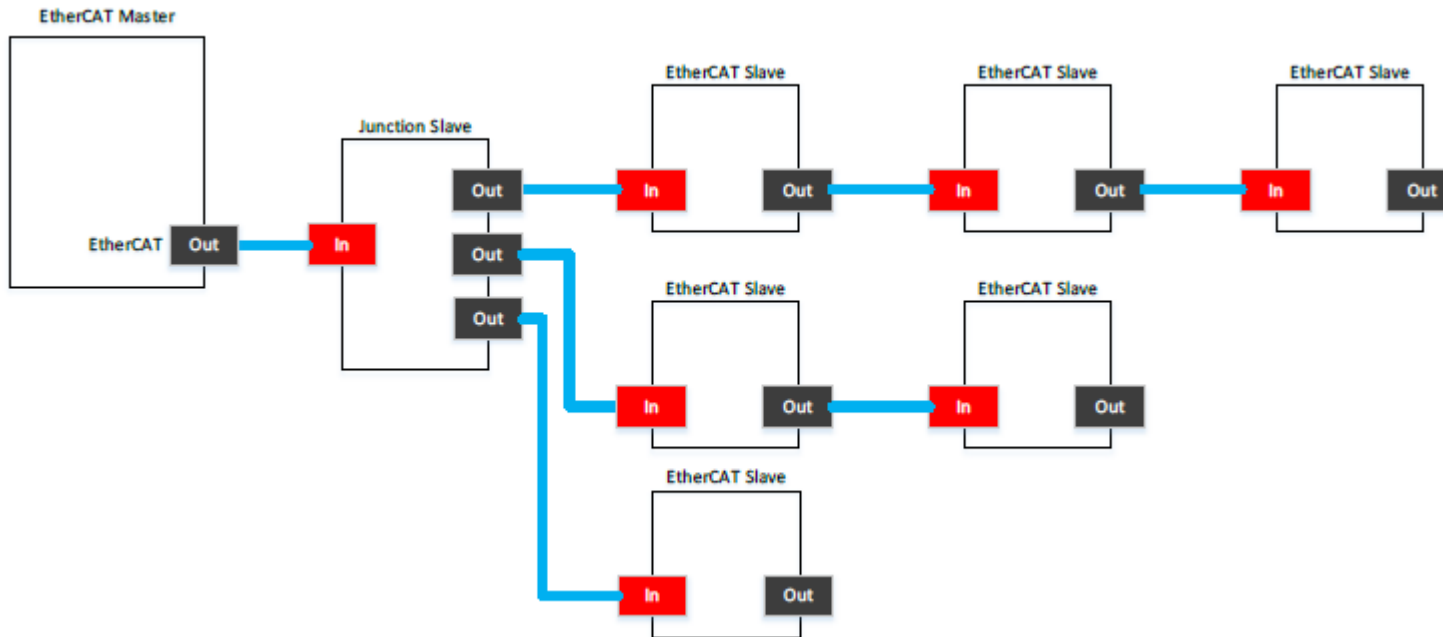
Section 2 - Supported EtherCAT Network Topologies

- Masters will support a couple different EtherCAT network topologies.
- For instance, the LS Electric XMC supports daisy chain and ring connection topologies.
- Branches and ring connection can be added using a junction slave.
- Only one junction slave may be used in the EtherCAT network.

Daisy Chain Topology with No Branches

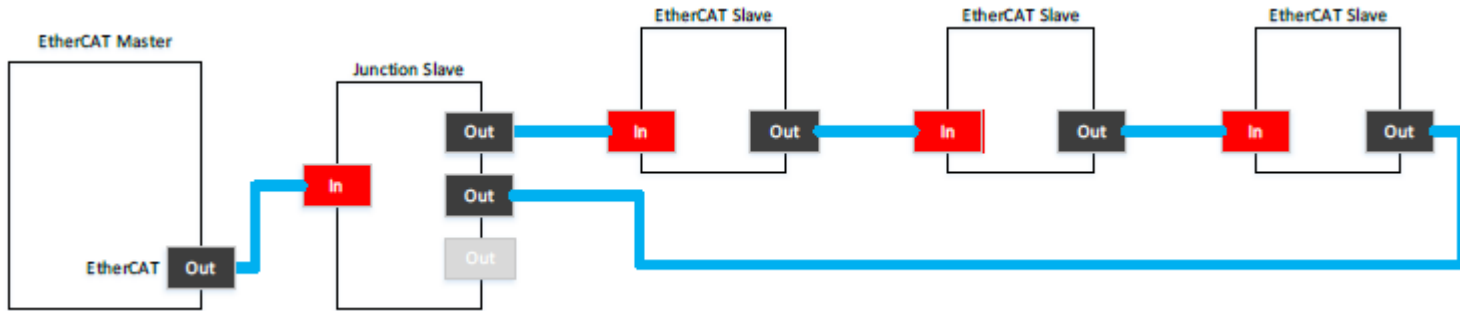


Daisy Chain Topology using Branches



Ring Topology

Note: When using ring topology, do not use the open ports on the junction slave.



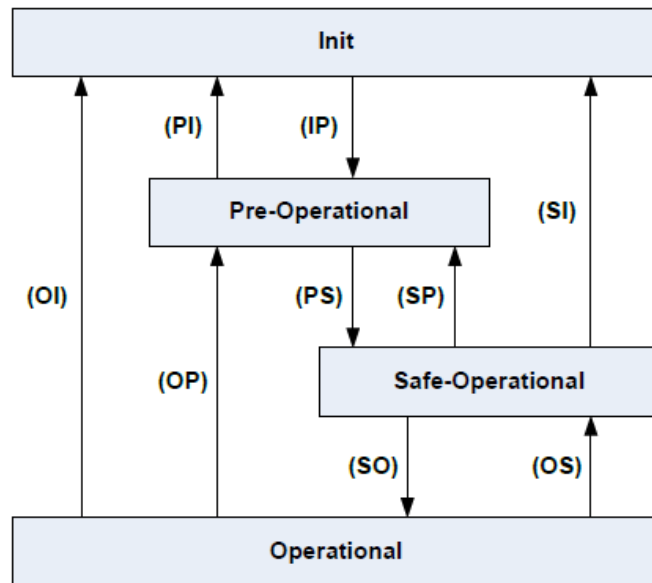
Section 3 - CANopen over EtherCAT (CoE) and CiA 402 Support

- Automationdirect will be launching masters and slaves that use the CANopen over EtherCAT (CoE) protocol.
- A CoE slave's parameter and data information is stored in an object dictionary described by an EtherCAT Slave Information (ESI) file .
- The object dictionary contains information used in the configuration of the device and communication to the device.
- A Process Data Object (PDO) is used for synchronous transmission of data between the master and slave nodes.
- The master performs synchronous process data communication to handle input/output signals and to control the EtherCAT slaves.
- A Service Data Object (SDO) is used for asynchronous transmission of data between the master and slaves.
- The master performs asynchronous service data communication for error information in the slave and parameter reading/writing.
- CiA 402 is an application profile used to standardize the control of VFDs and servo drives.
- CiA 402 describes all functional behavior including the finite state automation (FSA), all process data and configuration parameters.
- FSA defines the internal and external device behavior for each state.

Type	Communication Time	Content of Communication
Process Data Communication (PDO)	Synchronous with main task period	Servo drive position control data, input/output data, etc.
Service Data Communication (SDO)	Asynchronous only when requested	Servo parameter reading/writing, servo error information reading/acknowledgement, etc.



Section 4 - EtherCAT State Machine

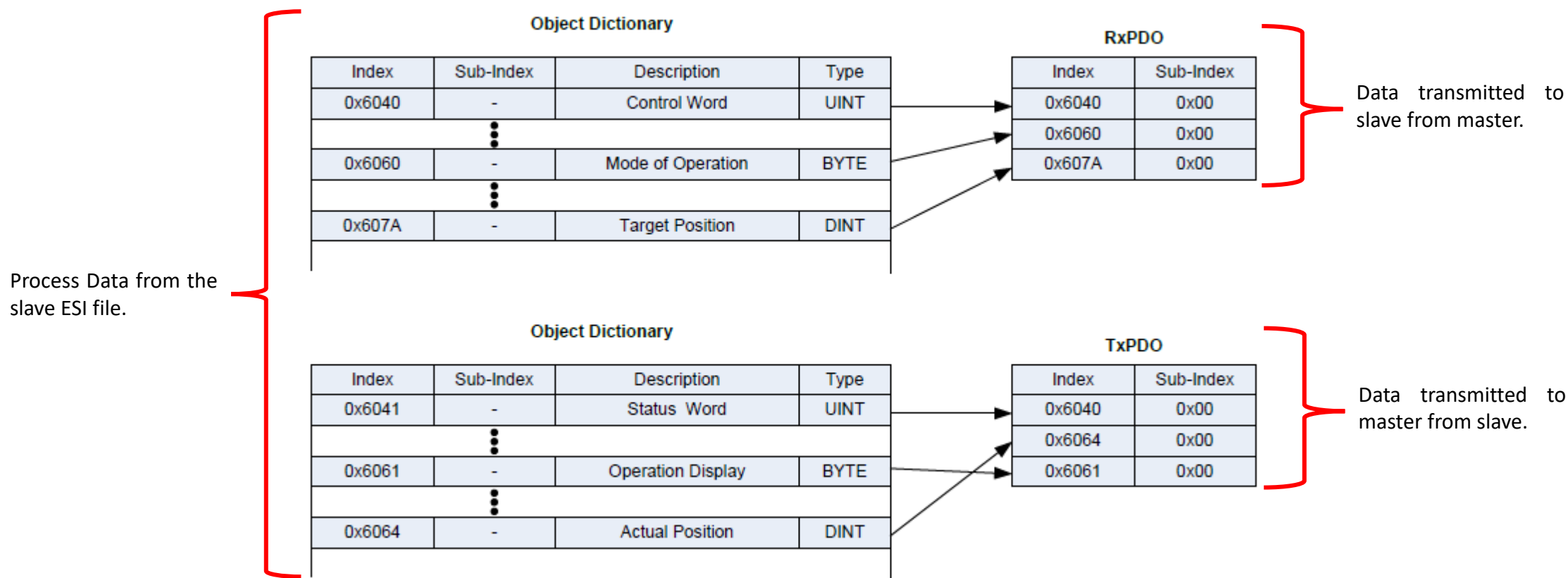


1. Communication between master and slave begins in the Init state.
2. Master configures the synchronous communication and proceeds to the Pre-operational state.
3. Master configures slave parameters to enter the Safe-Operational state.
4. Master starts sending valid outputs and the system enters Operational state.

Section 5 - Process Data Object

- The synchronous data communication in EtherCAT communication of the master occurs through process data object (PDO).
- TxPDO is configured for data that is transmitted from the slave to the master.
- RxPDO is configured for data that is transmitted from the master to the slave.
- The manufacturer of the slave node will have an EtherCAT Slave Information (ESI) file which contains the PDO data that the slave supports.
- This file must be imported into the master's programming software to be able to control the slave device.

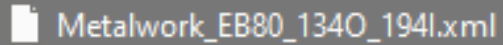
Section 4.1 - Example Configuration of RxPDO and TxPDO



Section 6 - EtherCAT Slave Information (ESI) File

- The EtherCAT Slave Information (ESI) file is an XML file that is used by EtherCAT masters to configure the slaves and generate network description files.
- The main purpose is to describe how data is shared with the slave.
- The master can often modify configuration data after importing the ESI file into the programming software.
- The new configuration can then be written to the slave from the EtherCAT master (This can be done in programming code or programming software).

Example ESI File

[illegible]

Example EtherCAT Slave in XG5000 Programming Software

TxPDO is input data from Slave to Master

PDO Type Filter: TxPDO
PDOs to Map:

Index	Name	Data type	Size(Bytes)
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PDO Selection: 0:0x1A00

Mapped Objects:

Index	Name	Data type	Size(Bytes)
0x3000:A	8 Digital Input 65-72	USINT	1
0x3000:B	8 Digital Input 73-80	USINT	1
0x3000:C	8 Digital Input 81-88	USINT	1
0x3000:D	8 Digital Input 89-96	USINT	1
0x3000:E	8 Digital Input 97-104	USINT	1
0x3000:F	8 Digital Input 105-112	USINT	1
0x3000:10	8 Digital Input 113-120	USINT	1
0x3000:11	8 Digital Input 121-128	USINT	1
0x3000:12	Analogue Input Channel 1 (Byte1)	USINT	1
0x3000:13	Analogue Input Channel 1 (Byte2)	USINT	1
0x3000:14	Analogue Input Channel 2 (Byte1)	USINT	1
0x3000:15	Analogue Input Channel 2 (Byte2)	USINT	1

RxPDO is output data from Master to Slave

PDO Type Filter: RxPDO
PDOs to Map:

Index	Name	Data type	Size(Bytes)
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PDO Selection: 0:0x1600

Mapped Objects:

Index	Name	Data type	Size(Bytes)
0x2000:A	Valve coils 73-80	USINT	1
0x2000:B	Valve coils 81-88	USINT	1
0x2000:C	Valve coils 89-96	USINT	1
0x2000:D	Valve coils 97-104	USINT	1
0x2000:E	Valve coils 105-112	USINT	1
0x2000:F	Valve coils 113-120	USINT	1
0x2000:10	Valve coils 121-128	USINT	1
0x2000:11	8 Digital Output 1-8	USINT	1
0x2000:12	8 Digital Output 9-16	USINT	1
0x2000:13	8 Digital Output 17-24	USINT	1
0x2000:14	8 Digital Output 25-32	USINT	1
0x2000:15	8 Digital Output 33-40	USINT	1

Example EtherCAT Slave in XG5000 Programming Software

SDO contains the setup parameters and information for a slave device.

General Information

PDO Setting

SDO Parameter

Init Command

Online Service

Set Timeout

Parameter type

All

Copy Settings

Parameter change during operation

☐ Allow parameter(individual) change during operation

Parameter Save

Note) * Applied when power is turned on again

<input checked="" type="checkbox"/>	Index	Name	Set Value	Initial Value	Access
<input checked="" type="checkbox"/>	1000:00	Device Type	0		ro
<input checked="" type="checkbox"/>	100A:00	Software Version	1.47		ro
<input checked="" type="checkbox"/>	1018:00	Identity Object	4		ro
<input checked="" type="checkbox"/>	1018:01	Vendor ID	750		ro
<input checked="" type="checkbox"/>	1018:02	Product Code	16		ro
<input checked="" type="checkbox"/>	1018:03	Revision Number	11		ro
<input checked="" type="checkbox"/>	1018:04	Serial Number	305419896		ro
<input checked="" type="checkbox"/>	8000:00	Params_Enabled	0		rw
<input checked="" type="checkbox"/>	8001:00	Params_Head_NetX	5		ro
<input checked="" type="checkbox"/>	8001:01	Not used	0		rw
<input checked="" type="checkbox"/>	8001:02	Fail safe output	0		rw
<input checked="" type="checkbox"/>	8001:03	System start	0		rw
<input checked="" type="checkbox"/>	8001:04	Visualization of analogue values	0		rw
<input checked="" type="checkbox"/>	8001:05	Analog input data format	0		rw
<input checked="" type="checkbox"/>	8002:00	Start/stop download parameters	1		ro
<input checked="" type="checkbox"/>	8002:01	Start/stop download	0		rw
<input checked="" type="checkbox"/>	8010:00	Params_PN_Fail_Safe	32		ro
<input checked="" type="checkbox"/>	8010:01	Fail safe coils 1-4	0		rw
<input checked="" type="checkbox"/>	8010:02	Fail safe coils 5-8	0		rw
<input checked="" type="checkbox"/>	8010:03	Fail safe coils 9-12	0		rw
<input checked="" type="checkbox"/>	8010:04	Fail safe coils 13-16	0		rw
<input checked="" type="checkbox"/>	8010:05	Fail safe coils 17-20	0		rw
<input checked="" type="checkbox"/>	8010:06	Fail safe coils 21-24	0		rw
<input checked="" type="checkbox"/>	8010:07	Fail safe coils 25-28	0		rw
<input checked="" type="checkbox"/>	8010:08	Fail safe coils 29-32	0		rw
<input checked="" type="checkbox"/>	8010:09	Fail safe coils 33-36	0		rw
<input checked="" type="checkbox"/>	8010:0A	Fail safe coils 37-40	0		rw
<input checked="" type="checkbox"/>	8010:0B	Fail safe coils 41-44	0		rw
<input checked="" type="checkbox"/>	8010:0C	Fail safe coils 45-48	0		rw
<input checked="" type="checkbox"/>	8010:0D	Fail safe coils 49-52	0		rw
<input checked="" type="checkbox"/>	8010:0E	Fail safe coils 53-56	0		rw
<input checked="" type="checkbox"/>	8010:0F	Fail safe coils 57-60	0		rw
<input checked="" type="checkbox"/>	8010:10	Fail safe coils 61-64	0		rw
<input checked="" type="checkbox"/>	8010:11	Fail safe coils 65-68	0		rw
<input checked="" type="checkbox"/>	8010:12	Fail safe coils 69-72	0		rw
<input checked="" type="checkbox"/>	8010:13	Fail safe coils 73-76	0		rw
<input checked="" type="checkbox"/>	8010:14	Fail safe coils 77-80	0		rw
<input checked="" type="checkbox"/>	8010:15	Fail safe coils 81-84	0		rw
<input checked="" type="checkbox"/>	8010:16	Fail safe coils 85-88	0		rw
<input checked="" type="checkbox"/>	8010:17	Fail safe coils 89-92	0		rw
<input checked="" type="checkbox"/>	8010:18	Fail safe coils 93-96	0		rw