WEST

Technical Documentation

PAM-199-P-ETC

Universal power amplifier with EtherCAT interface

Electronics
Hydraulics meets
meets Hydraulics
Electronics

CONTENTS

1 General Information

1.1 Order Number

PAM-199-P-ETC - universal power amplifier for directional valves or two pressure or throttle valves with EtherCAT interface

Alternative products

PAM-199-P-PDP - universal power amplifier for directional valves or two pressure or throttle valves with ProfibusDP interface

PAM-199-P-PFN - universal power amplifier for directional valves or two pressure or throttle valves with ProfinetIO interface

PAM-199-P - universal power amplifier for directional valves or two pressure or throttle valves with analog interface

1.2 Scope of supply

The scope of supply includes the module plus the terminal blocks which are a part of the housing.
Interface cables and further parts which may be required should be ordered separately.
This documentation can be downloaded as a PDF file from www.w-e-st.de.

1.3 Accessories

WPC-300 - Start-Up-Tool (downloadable from our homepage – products/software)

1.4 Symbols used

General information

Safety-related information

1.5 Legal notice

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Date: 07.01.2025

1.6 Safety instructions

Please read this document and the safety instructions carefully. This document will help to define the product area of application and to put it into operation. Additional documents and knowledge of the application should be taken into account or be available.
General regulations and laws (depending on the country: e.g. accident prevention and environmental protection) must be complied with.

These modules are designed for hydraulic applications in open or closed loop control circuits. Uncontrolled movements can be caused by device defects (in the hydraulic module or the components), application errors and electrical faults. Work on the drive or the electronics must only be carried out whilst the equipment is switched off and not under pressure.

This handbook describes the functions and the electrical connections for this electronic assembly. All technical documents which pertain to the system must be complied with when commissioning.

This device may only be connected and put into operation by trained specialist staff. The instruction manual must be read with care. The installation instructions and the commissioning instructions must be followed. Guarantee and liability claims are invalid if the instructions are not complied with and/or in case of incorrect installation or inappropriate use.

CAUTION!
All electronic modules are manufactured to a high quality. Malfunctions due to the failure of components cannot, however, be excluded. Despite extensive testing the same also applies for the software. If these devices are deployed in safety-relevant applications, suitable external measures must be taken to guarantee the necessary safety. The same applies for faults which affect safety. No liability can be assumed for possible damage.

Further instructions

- The module may only be operated in compliance with the national EMC regulations. It is the user's responsibility to adhere to these regulations.
- The device is only intended for use in the commercial sector.
- When not in use the module must be protected from the effects of the weather, contamination and mechanical damage.
- The module may not be used in an explosive environment.
- To ensure adequate cooling the ventilation slots must not be covered.
- The device must be disposed of in accordance with national statutory provisions.

2 Characteristics

This module is used for controlling a directional valve with two solenoids or up to two pressure or throttle valves with one solenoid. Various adjustable parameters allow an optimal adaptation to the respective valve. This power amplifier is an inexpensive, robust and space-saving solution.

The control signals are transmitted by an EtherCAT interface. Furthermore, it is possible to change the parameterization via this bus or via the USB interface. Two control modes are implemented, channel 0 for one directional valve or channel 1/2 for two independent pressure or throttle valves.

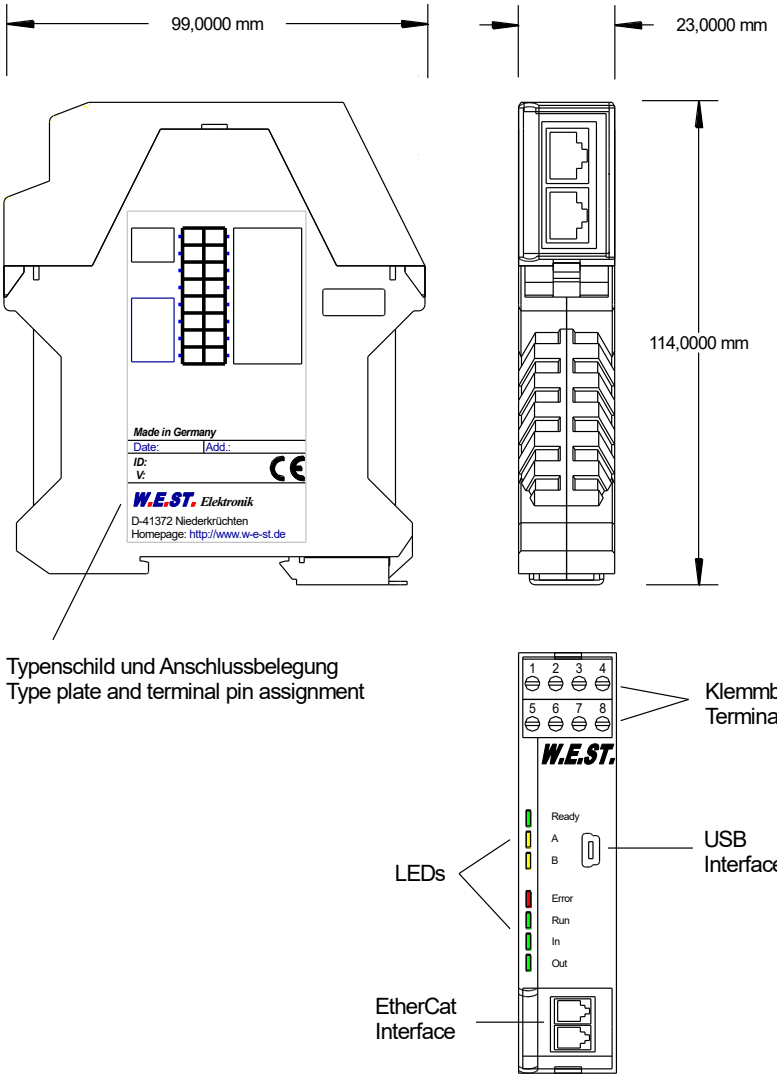
The output current is closed loop controlled and therefore independent from the power supply and the solenoid resistance. The output stage is monitored for cable breakdown and short circuit and disables the power stage in case of an error.

Typical applications: Control of directional, throttle and pressure valves, which need a flexible adaptation of the solenoid control. All typical proportional valves of the different manufactures (BOSCH REXROTH, BUCHER, DUPLOMATIC, PARKER...) can be controlled.

Features

- **Control of directional, pressure or throttle valves**
- **Compact housing**
- **Digital reproducible adjustments**
- **Controlling via EtherCAT**
- **Simple and application orientated parameter settings**
- **Characteristics linearization via 10 XY-points per direction**
- **Free parameterization of RAMPS, MIN / MAX, PWM, output current and DITHER**
- **Rated output current up to 3.0 A**
- **Failure monitoring and extended function check**

2.1 Device description



3 Use and application

3.1 Installation instruction

- This module is designed for installation in a shielded EMC housing (control cabinet). All cables which lead outside must be screened; complete screening is required. It is also a requirement that no strong electro-magnetic interference sources are installed nearby when using our open and closed loop control modules.

- **Typical installation location:** 24V control signal area (close to PLC)
  The devices must be arranged in the control cabinet so that the power section and the signal section are separate from each other.
  Experience shows that the installation space close to the PLC (24 V area) is most suitable. All digital and analogue inputs and outputs are fitted with filters and surge protection in the device.

- The module should be installed and wired in accordance with the documentation bearing in mind EMC principles. If other consumers are operated with the same power supply, a star-connected ground wiring scheme is recommended. The following points must be observed when wiring:
  - The signal cables must be laid separately from power cables.
  - Analogue signal cables **must be screened**.
  - All other cables must be screened if there are powerful interference sources (frequency converters, power contactors) and cable lengths > 3m. Inexpensive SMD ferrites can be used with high-frequency radiation.
  - The screening should be connected to PE (PE terminal) as close to the module as possible. The local requirements for screening must be taken into account in all cases. The screening should be connected to at both ends. Equipotential bonding must be provided where there are differences between the connected electrical components.
  - With longer lengths of cable (>10 m) the diameters and screening measures should be checked by specialists (e.g. for possible interference, noise sources and voltage drop). Particular care is required with cables of over 40 m in length – the manufacturer should be consulted if necessary.

- A low-resistance connection between PE and the mounting rail should be provided. Transient interference is transmitted from the module directly to the mounting rail and from there to the local earth.

- Power should be supplied by a regulated power supply unit (typically a PELV system complying with IEC364-4-4, secure low voltage). The low internal resistance of regulated power supplies gives better interference voltage dissipation, which improves the signal quality of high-resolution sensors in particular. Switched inductances (relays and valve coils connected to the same power supply) must always be provided with appropriate overvoltage protection directly at the coil.

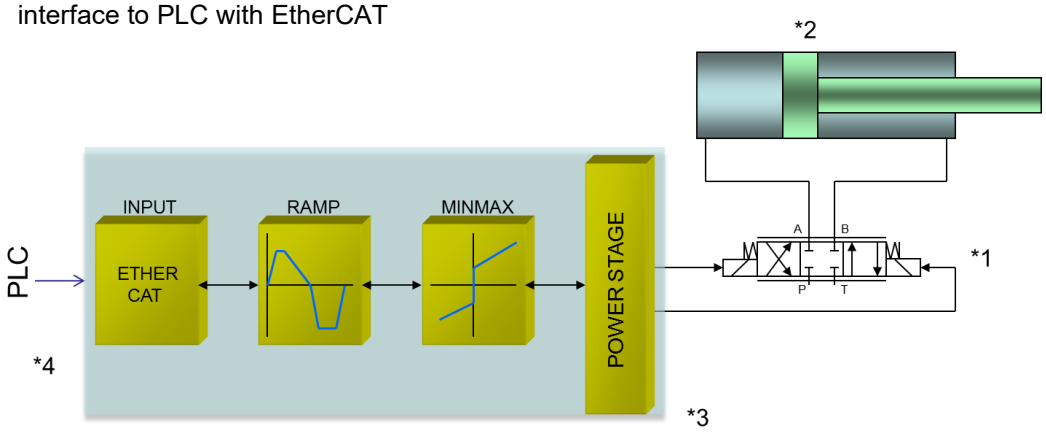
3.2 Typical system structure

The module can be set up for two different operating modes (for control of directional control valves = CHANNEL 0 or for two control of pressure / throttle valves = CHANNEL 1 and 2).

3.2.1 Function Directional

This minimal system consists of the following components:

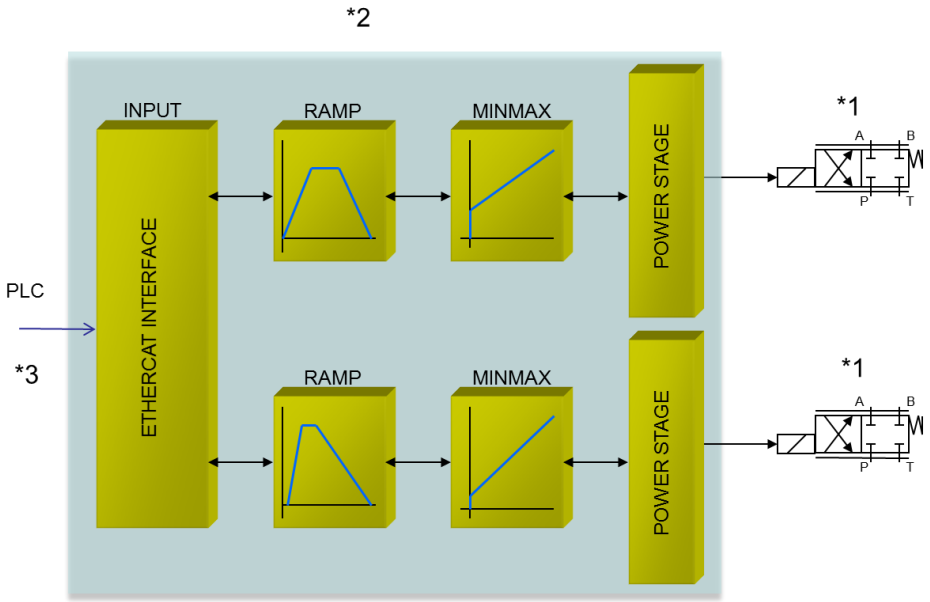
(*1) proportional directional valve
(*2) hydraulic cylinder
(*3) PAM-199-P-ETC
(*4) interface to PLC with EtherCAT



3.2.2 Function Independent

This minimal system consists of the following components:

(*1) proportional valve
(*2) PAM-199-P-ETC
(*3) interface to PLC with EtherCAT



3.3 Commissioning

3.3.1 Proceeding

Step	Task
Preparing of the communication	The ESI file which is provided by W.E.St. has to be supplied to the EtherCAT master. For that is has to be copied into the relating directory of the programming software. Using TwinCat the path is located below *version*/Config/IO and EtherCAT. Next the fieldbus communication can be established. The procedure has to be taken from the manual of the belonging master. The ESI file provides information about the available data objects. Alternatively there is an USB interface on board for the usage with our WPC program. This allows a start-up in case the PLC is not yet available at this time.
Switching on	Install the device in accordance with the circuit diagram. Ensure it is wired correctly and that the signals are well shielded. The device must be installed in a protective housing (control cabinet or similar). Ensure that no unwanted movement of the drive is possible (e.g. switch off the hydraulics). Connect an amp meter and check the current consumed by the device. If it is higher than specified, there is an error in the wiring. Switch off the device immediately and check the wiring.
Pre-parameterization	Now set up the following parameters (with reference to the system design and circuit diagrams): The basic setup **FUNCTION** for configuring the inputs and outputs of the device. There are predefined PDOs available which should be selected accordingly. **IO_BASE** for defining the scaling of the signals. The nominal output **CURRENT** and the typical valve parameters such as PWM frequency, DITHER and MIN/MAX. A **quick start guide** about this topic can be found in chapter 7 (quick start configuration and parameterization). Pre-parameterization is necessary to minimize the risk of uncontrolled movements.
Control signal	Check the control signal with an amp meter. (The current of the solenoid is within the range of 0... 3A). In the actual state, it should show approximately 0 A. **Hint:** You also can monitor the current of the solenoids via the fieldbus or in the WPC program.
Switching on the hydraulics	The hydraulics can now be switched on. The module is not yet generating a signal. Drives should be at a standstill or drift slightly (leave its position at a slow speed) if it is a proportional valve.
Activating ENABLE	**CAUTION!** The drive can now leave its position and move to an end position with full speed or the pressure can reach maximum. Take safety measures to prevent personal injury and damage. The ENABLE bit/signal releases the application. If the system is error-free this will be indicated by the READY bit/signal.
Giving demand value	The amplifier can now be controlled via the setpoint demand value.
Optimizing settings	Depending on the behavior of the system, the parameterization can now be improved and maybe extended by ramp and linearization functions. **ATTENTION!** The settings are not stored automatically. For keeping the parameterization permanently it has to be saved by the user.

4 Function modes and technical description

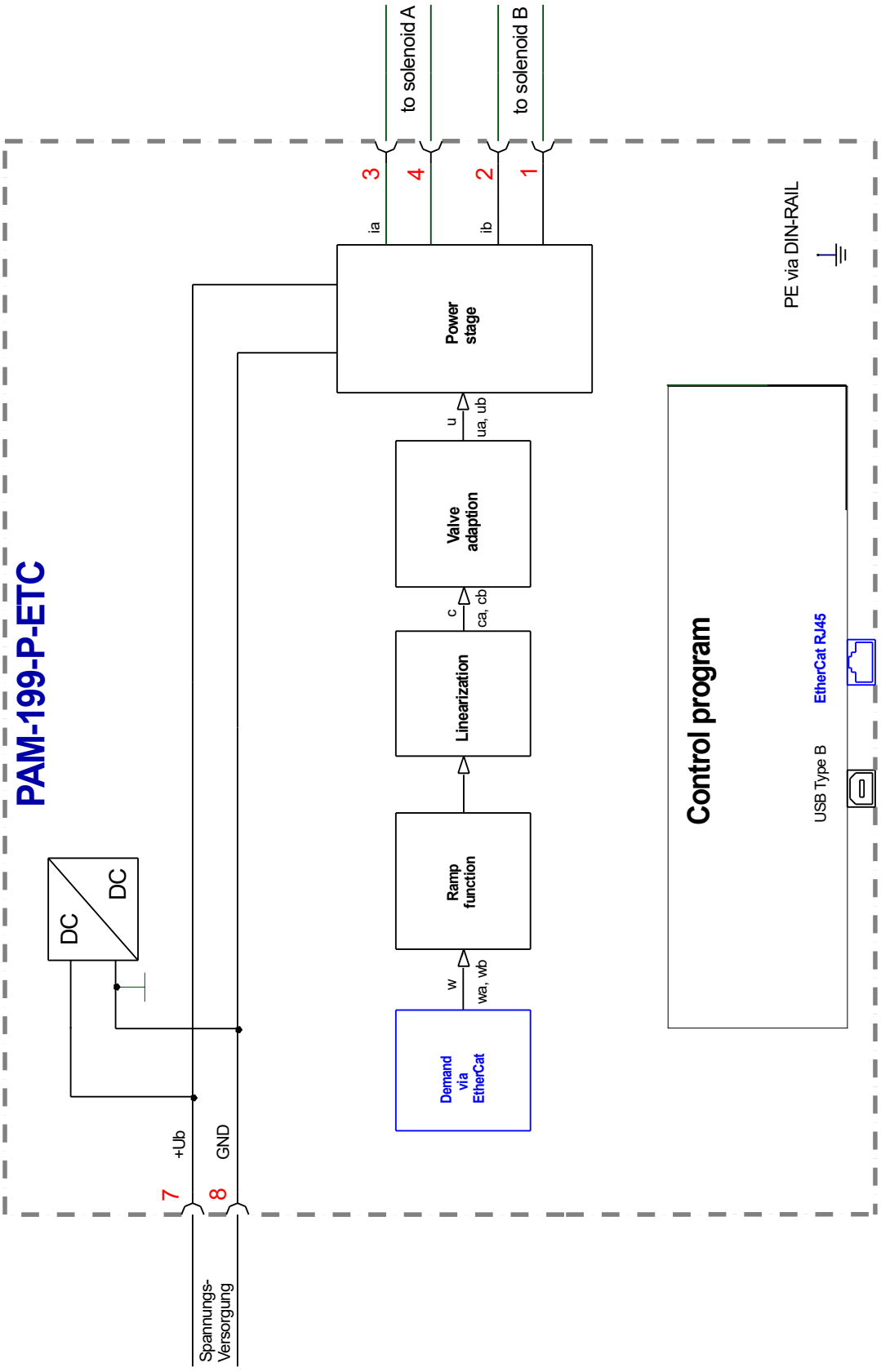
4.1 LED Indications

LEDs	Indication	Description of the function
GREEN	*READY*	Display of the operational state of the amplifier: **OFF:** Power supply or ENABLE is not available **ON:** Operational state **Flashing:** Error detected
YELLOW YELLOW	*A* *B*	Activity of channel A: Activity of channel B: The intensity depends on the solenoid current.
RED	*FB-**ERROR***	Error display of the fieldbus communication: **OFF:** No error **Blinking:** Invalid configuration **Single flash:** Unsolicited state change **Double flash:** Application watchdog timeout **Flickering:** Booting error **ON:** PDI watchdog timeout
GREEN	*FB-**RUN***	Actual state of the fieldbus state machine: **OFF:** Initialization **Blinking:** Pre-operational **Single flash:** Safe-operational **Flashing:** Bootstrap **ON:** Operational
GREEN GREEN	*LINK-ACT-**IN*** *LINK-ACT-**OUT***	Activity of the EtherCAT input: Activity of the EtherCAT output: **OFF:** No connection **ON:** Connection established **Flashing:** Communication is active

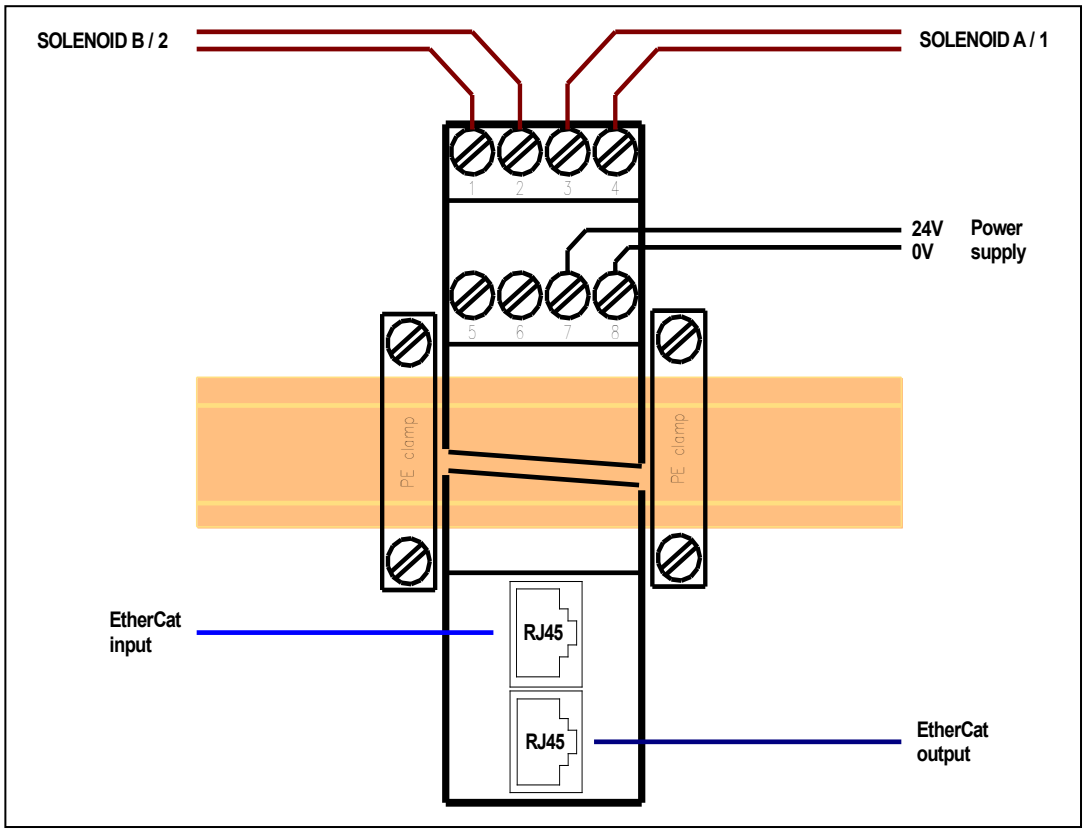
4.2 Input and output signals

Connection	Supply
PIN 7	Power supply (see technical data)
PIN 8	0 V (GND) Power supply.
Connection	**PWM output**
PIN 3 / 4	Current controlled PWM outputs for solenoid A / 1. PIN 4 optionally can be common return in the directional mode (see circuit diagram).
PIN 2 / 1	Current controlled PWM outputs for solenoid B / 2.

4.3 Circuit diagram



4.4 Typical wiring



4.5 Technical data

Power supply (U_b)	**[VDC]**	12… 30 (incl. ripple)
Current consumption in idle mode	**[mA]**	60
Power consumption max.	**[W]**	80 (depending on type of solenoid, two solenoids are active)
External fuse	**[A]**	4 medium time lag
Digital inputs	**[V]**	OFF: < 2
	[V]	ON : > 10
Input resistance	**[kΩ]**	25
Digital outputs	**[V]**	OFF: < 2
	[V]	ON: max. U_b
Maximum current	**[mA]**	50
Nominal PWM output current	**[mA]**	0… 3000; broken wire monitored and short circuit proof
PWM frequency	**[Hz]**	60...10000; adjustable in steps
Sample time (solenoid current control)	**[ms]**	0,053
Internal signal processing	**[ms]**	1
EtherCAT	**[Mbit/s]**	100; relating to IEE 802.3
Serial interface		USB Virtual COM port driver 9600… 115200 Baud 1 Stoppbit, No parity, No handshake
Housing		Snap-On Module EN 50022 Polyamide PA 6.6 Combustibility class V0 (UL94)
Weight	**[kg]**	0,310
Protection class		IP20
Temperature range	**[°C]**	-20… 60
Storage temperature	**[°C]**	-20 …70
Humidity	**[%]**	<95 (not condensing)
Vibration	**-**	IEC 60068-2-6 (category C)
Connections		USB type Mini 2 x RJ45 2 x 4pol. screw terminals PE: direct via DIN rail
EMC		EN 61000-6-2: 8/2005 EN 61000-6-4: 6/2007 ; A1:2011

5 EtherCAT IO interface

5.1 ETHERCAT CoE

EtherCAT is an Ethernet-based field bus system, developed by Beckhoff and the EtherCAT Technology Group (ETG). EtherCAT is an open technology standardized in the international standards IEC 61158 and IEC 61784 as well as in ISO 15745-4. EtherCAT can provide the same communication mechanisms as are known from CANopen: object directory, PDO (process data objects) and SDO (service data objects). Even network management is comparable. For example, EtherCAT can be implemented on devices that were previously equipped with CANopen with minimal effort; large parts of the CANopen firmware are reusable. The objects can optionally be expanded to take account of the larger bandwidth of EtherCAT.

In order to create a user-friendly interface for device operation, different organizations have created various standards in which the following are defined:

- The device classes that exist (e.g.: class ‘rotary encoder’, ‘analogue input module’).
- The parameters that each representative of such a class has (obligatory and optional elements).
- The place where these parameters can be found and the mechanism with which they can be changed.

EtherCAT follows the so-called CoE standard here: Can-application-protocol-over-EtherCAT.
The process data objects (PDO) are used for the fast and efficient exchange of real-time data (for example I / O data, setpoints or actual values). In the EtherCAT telegram, no objects are addressed but the contents of the process data is sent directly from previously mapped parameters.

5.2 EtherCAT installation

EtherCAT supports almost any topology, line, tree or star. The bus or line structure known from the fieldbuses thus also becomes available for Ethernet. Particularly useful for system wiring is the combination of lines and junctions or stubs. The required interfaces exist in the devices; no additional switches are required. Naturally, the classic switch-based Ethernet star topology can also be used.
The permissible cable length between two EtherCAT devices must not exceed 100 meters. This results from the Fast Ethernet technology, which mainly for reasons of signal attenuation over the Line length allows a maximum link length of 5 + 90 + 5 m if lines with appropriate properties.
To connect EtherCAT devices, use only Ethernet (cable + plug) connections at least of category 5 (CAT5) according to EN 50173 or ISO / IEC 11801. EtherCAT uses four wires of the cable for signal transmission. EtherCAT uses RJ45 connectors, for example. The contact assignment is compatible with the Ethernet standard (ISO / IEC 8802-3).

5.3 EtherCAT device profiles

For allocating the application based index range of the EtherCAT, there are particular device profiles. Some are allocated within additional sub profiles. Thus the EtherCAT automation protocol (1000), the EtherCAT device protocol (1100) and the AoE Router (9000) have their own sub profile numbers. Below these numbers the ports of devices which support the relating protocol have own object dictionaries. The device described in this document uses the *Modular device profile,* called MDP, defined in the specification 5001. It defines the range beginning with index 0x6000.

Localization of the CoE on the EtherCAT Slave:

The CoE directory as a parameter system must be administrated in the device in the firmware (FW) in the local controller. This is the so-called online directory, because it is only available for the user if the EtherCAT slave is in operation and, if applicable, can be manipulated via EtherCAT communication. So that the parameters can be viewed and changed in advance without the presence of a slave, a default copy of the entire directory is usually stored in the device description file ESI (XML). This is called the offline directory. Changes in this directory do not affect the later operation of the slave with the master.

The ESI description also defines the process image, the communication type between master and slave / device and the device functions, if applicable. The physical device (firmware, if available) has to support the communication queries / settings of the master. This is backward compatible, i.e. newer devices (higher revision) should be supported if the EtherCAT master addresses them as an older revision.

The ranges in the Slave CoE that are important for the application-oriented EtherCAT fieldbus user are:

0x1000: This is where fixed identity information for the device is stored, including name, manufacturer, serial number etc., plus information about the current and available process data configurations.
0x8000: This is where the operational and functional parameters for all channels are stored, such as filter settings or output frequency. The following ranges are also of interest:
0x4000: In some EtherCAT devices the channel parameters are stored here (as an alternative to the 0x8000 range).
0x6000: Input PDOs ("input" from the perspective of the EtherCAT master)
0x7000: Output PDOs ("output" from the perspective of the EtherCAT master)
0xA000: Diagnostic data
0xF000: Area of the modular device (ETG 5001.1)

5.4 Device description file (ESI)

The ‘ESI file (CoE directory) is provided by the manufacturer of an EtherCAT device.
It is created in the description language XML and has a standardized format for the description of devices. The ESI file contains information about:

- Description of the file (name, version, creation date, etc.)
- General device information (manufacturer name and code)
- Device name and type, versions
- Description of the supported objects by their attributes

This file describes the available functions and data of the device via the EtherCAT fieldbus. For providing them to the user, this file is required by the master’s engineering system. For that it has to be put into the relating directory on the computer.

5.5 Object dictionary

Devices with CoE interface, like the one described here, have an object dictionary. This contains all data, which can be transmitted via the EtherCAT fieldbus, independent of the direction. The object dictionary is included in the device description file.

5.6 SDO parameterization

SDO is the shortcut for *service data object*. Commonly those entries of the object dictionary are considered as SDOs which are located beginning with address 0x1000. They can be read out including its description by the SDO information service via the mailbox channel as soon as it is initialized. The description contains type, size, access rights and the PDO access.
The parameterization can be done via CoE. The application dependent parameters are located beginning with address 0x8000 or 0x8010/0x8020 depending on the channel.

5.7 Process data PDO

The input and output data of the EtherCAT slave are displayed as CANopen Process Data Objects (PDO). The process data (PDOs) cyclically transmitted by an EtherCAT slave are the user data. They are expected or sent to the slave in the application. For this purpose, the EtherCAT Master (e.g. Beckhoff TwinCAT) parameterizes each EtherCAT slave during the start-up phase. It specifies the process data (size in bits / bytes, source location, transmission type) from or to the slave.
With so-called "intelligent" EtherCAT devices, the process data information is also available in the CoE directory. However, any changes in this CoE directory which lead to deviating PDO settings prevent the slave from booting successfully. It is not recommended to configure other than the intended process data, since the device firmware (if available) is tuned to these PDO combinations.

Object list:

- Index object index PDO
- Subindex subindex PDO
- Name surname of PDO
- Flag RW read or write status of PDO
- Flag RO read only status, it is not possible to write data to the object
- Flag P an additional P characterizes the object as a process data object
- Value value of the object

5.8 PDO mapping

The PDO mapping determines which application objects out of the dictionary should be used as PDO. This mapping can be changed by the user. This device provides some predefined mappings, which depend on the selected basic function of the amplifier.

5.9 EtherCAT System behavior, state machine of slave devices

Overview of the states

State	Description
INIT	Initializing state after switching on. Mailbox communication is getting prepared.
BOOT	Only mailbox communication via ***F**ile-Access **o**ver **EtherCAT*** is active. In this state a firmware update can be done.
PRE-OP	Mailbox communication has been checked and is active now. Process data communication and mapping are being prepared.
SAFE-OP	Mailbox and process data communication have been checked and are active. The ***EtherCAT**-**S**lave **C**ontroller* is actualized cyclically now, but the outputs of the device are still in safe state (Watchdog).
OP	Operational state. Output data can now be transmitted. The device forwards the received data from the master to the outputs now.

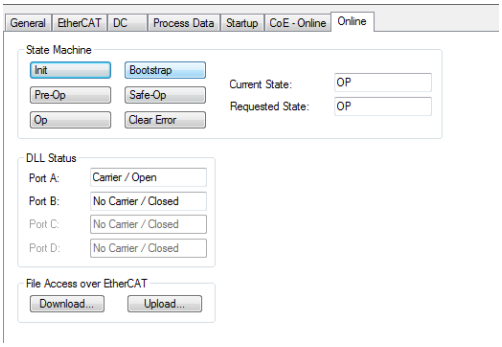
Possible transitions between the different states

State	Transition	Target state	Activity
INIT	IB IP	BOOT PRE-OP	Start mailbox communication for FoE protocol. Checking mailbox and starting the SDO-communication.
BOOT	BI	INIT	Stop mailbox communication.
PRE-OP	PI PS	INIT SAFE-OP	Stop SDO-communication. Start PDO-communication.
SAFE-OP	SI SP SO	INIT PRE-OP OP	Stop SDO- and PDO-communication. Stop PDO-communication. Start evaluating the master‘s demand.
OP	OI OP OS	INIT PRE-OP SAFE-OP	Stop SDO- and PDO-communication. Stop PDO-communication. Stop evaluating the master‘s demand.

5.10 Firmware update via FoE

When setting the EtherCAT state machine to the bootstrap (BOOT), it is possible to perform a firmware update via the File Access over EtherCAT protocol. For this a *.efw file is required. The file will be provided by W.E.St. if an update should be necessary.

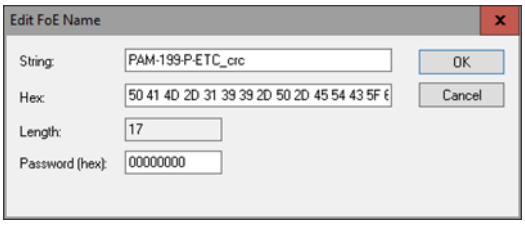
To start the firmware update first switch the slave (PAM-199-P-ETC) to bootstrap mode. Then the download can be initiated. In TwinCAT 3.1 this is accomplished by the following steps:



In this mask, click on „Bootstrap“ (upper part).

Then activate the button “Download …”.

After choosing the binary file (extension .efw) the following dialog appears:



The password is 00000000. After a confirmation (OK) the download begins, which is indicated by the progress bar in the lower right corner of the TwinCAT-window. After the transfer has been finished, the red LED of the module flashes shortly. Now change to the *Init* state. The bootloader will then start and copy the new software into the internal flash memory. During this the READY-LED on the module will flash rapidly. After this is finished, the module should be temporarily disconnected from the supply voltage. After restarting it, the newly loaded firmware is active.

5.11 Watchdog

Functionality

The watchdog is a monitoring function for the process data communication. If this gets disturbed, it sets the outputs to a safe state in a defined time. Normally this state is OFF, but it can vary in some devices depending on the settings.

There are two independent watchdogs provided:
SM (Sync Manager): Monitoring of the process data communication of the device via EtherCAT.
PDI (Process Data Interface): Monitoring of the process data communication to the local CPU of the device.

The response time is set separately for each function. A multiplier, valid for both functions, allows a big range of adjustment. Putting in “0” offers also a deactivation of the watchdog. If the communication is disturbed, the outputs will not be set to a safe state in this case.

Adjustment

The settings can be found at the EtherCAT tab of the relating device (box) below extended settings / behavior. So they are device specific and have to be done for each individual device. The parameterization is taken over when starting the device if the marker in the belonging check box was set. Otherwise the settings in the EtherCAT slave controller are not updated.

Function	Default	Range	Description
MULTIPLIER	2498	1… 65535	Setting watchdog basic time between 40 ns and ca 2,6 ms. Calculation: 1 / 25 MHz * (Multiplier + 2).
PDI WATCHDOG	1000	0… 65535	Response time PDI monitoring 40 ns up to ca 172 s. Calculation: t * Multiplier. („0“ deactivates the monitoring.)
SM WATCHDOG	1000	0… 65535	Response time SM monitoring 40 ns up to ca 172 s. Calculation: t * Multiplier. („0“ deactivates the monitoring)

5.12 Function channels

This device provides two different basic functionalities which can be selected by the user. This leads to changing process data depending on the chosen functionality. Therefore this amplifier is a so-called modular device which uses different channels for each function.

Channel 0

This is the channel for the *directional* mode. Here you can find all parameters and data of the whole device if a directional proportional valve with two solenoids should be controlled.

Channel 1/2

These channels are used for the *independent* mode. That means both outputs can be controlled independently from each other. So there are two separate applications. The parameters and data contained here are only valid in the *independent* mode and for the relating output one.

6 Parameter

6.1 CoE Parameter overview

6.1.1 Communication parameters

Index	Group	Name	Data type	Flags	Default	Units	Comment
Communication							
1000:00		**DEVICE TYPE**	UINT32	RO		-	
1001:00		**ERROR REGISTER**	UINT8	RO		-	
1008:00		**DEVICE NAME**		RO	PAM-199-P-ETC	-	
1009:00		**HARDWARE VERSION**		RO	10	-	
100A:00		**SOFTWARE VERSION**		RO	10	-	
1018:00	**IDENTITY**		UINT8	RO	0x04	-	Number of index entries.
1018:01		**VENDOR ID**	UINT32	RO	0x000005AE	-	
1018:02		**PRODDUCT CODE**	UINT32	RO	0x00C703F3	-	
1018:03		**REVISION**	UINT32	RO	0x00000007	-	Will eventually be increased
1018:04		**SERIAL NUMBER**	UINT32	RO	---	-	Not used
Rx PDO Mapping							
1600:00	**DIR**		UINT8	RO	0x03 (3_{dez})	-	Number of index entries.
1600:01		**ENABLE**		RO	0x70000101	-	General enabling of the device
1600:02						-	
1600:03		**COMMAND VALUE**		RO	0x70000320	-	Command value

Index	Group	Name	Data type	Flags	Default	Units	Comment
1601:00	**IND**		UINT8	RO	0x06 (6_{dez})	-	Number of index entries.
1601:01		**ENABLE 1**		RO	0x70100101	-	General enabling of channel 1
1601:02							
1601:03		**COMMAND VALUE 1**		RO	0x70100310	-	Command value for channel 1
1601:04		**ENABLE 2**		RO	0x70200101	-	General enabling of channel 2
1601:05							
1601:06		**COMMAND VALUE 2**		RO	0x70200310	-	Command value for channel 2
Tx PDO Mapping							
1A00:00	**DIR_IN**		UINT8	RO	0x0D (13_{dez})	-	Number of index entries.
1A00:01		**READY**	UINT32	RO	0x60000101	-	Common readiness of the device
1A00:02							
1A00:03		**MEMORY**	UINT32	RO	0xA0000101	-	No Memory Error
1A00:04		**UNDER-VOLTAGE**	UINT32	RO	0xA0000201	-	supply voltage not too low
1A00:05		**OVER VOLTAGE**	UINT32	RO	0xA0000301	-	supply voltage not too high
1A00:06		**OVER TEMPERATURE**	UINT32	RO	0xA0000401	-	Controller temperature not too high
1A00:07							
1A00:08		**SHORT SOLENOID A**	UINT32	RO	0xA0100101	-	No short circuit at solenoid A
1A00:09		**OPEN SOLENOID A**	UINT32	RO	0xA0100201	-	No open circuit at solenoid A

Index	Group	Name	Data type	Flags	Default	Units	Comment
1A00:0A							
1A00:0B		**SHORT SOLENOID B**	UINT32	RO	0xA0200101	-	No short circuit at solenoid B
1A00:0C		**OPEN SOLENOID B**	UINT32	RO	0xA0200201	-	No open circuit at solenoid B
1A00:0D							
1A01:00	**IND_IN**		UINT8	RO	0x03 (3_{dez})	-	Number of index entries.
1A01:01		**READY 1**	UINT32	RO	0x60100101	-	
1A01:02							Common readiness of channel 1
1A01:03		**READY 2**	UINT32	RO	0x60200101	-	Common readiness of channel 2
1A01:04							
1A01:05		**MEMORY**	UINT32	RO	0xA0000101	-	No memory (internal) error
1A01:06		**UNDER-VOLTAGE**	UINT32	RO	0xA0000201	-	Supply voltage not too low
1A01:07		**OVER VOLTAGE**	UINT32	RO	0xA0000301	-	Supply voltage not too high
1A01:08		**OVER TEMPERATURE**	UINT32	RO	0xA0000401	-	Controller temperature not too high
1A01:09							
1A01:0A		**SHORT SOLENOID A**	UINT32	RO	0xA0100101	-	No short circuit at solenoid 1
1A01:0B		**OPEN SOLENOID A**	UINT32	RO	0xA0100201	-	No open circuit at solenoid 1
1A01:0C							
1A01:0D		**SHORT SOLENOID B**	UINT32	RO	0xA0200101	-	No short circuit at solenoid 2
1A01:0E		**OPEN SOLENOID B**	UINT32	RO	0xA0200201	-	No open circuit at solenoid 2
1A01:0F							
1A02:00	**DIR_SIG**		UINT8	RO	0x05 (5_{dez})	-	Number of index entries.
1A02:01		**W**	UINT32	RO	0x60000310	-	Actual command value
1A02:02		**C**	UINT32	RO	0x60000410	-	Control signal after CC
1A02:03		**U**	UINT32	RO	0x60000510	-	Output signal
1A02:04		**IA**	UINT32	RO	0x60000610	-	Current at solenoid A
1A02:05		**IB**	UINT32	RO	0x60000710	-	Current at solenoid B
1A03:00	**IND_SIG**		UINT8	RO	0x06 (6_{dez})	-	Number of index entries.

Index	Group	Name	Data type	Flags	Default	Units	Comment
1A03:01		**W1**	UINT32	RO	0x60100310	-	Actual command value channel 1
1A03:02		**C1**	UINT32	RO	0x60100410	-	Control signal after CC channel 1
1A03:03		**U1**	UINT32	RO	0x60100510	-	Output signal channel 1
1A03:04		**I1**	UINT32	RO	0x60100610	-	Solenoid current at channel 1
1A03:05		**W2**	UINT32	RO	0x60200310	-	Actual command value channel 2
1A03:06		**C2**	UINT32	RO	0x60200410	-	Control signal after CC channel 2
1A03:07		**U2**	UINT32	RO	0x60200510	-	Output signal channel 2
1A03:08		**I2**	UINT32	RO	0x60200610	-	Solenoid current at channel 2

6.1.2 PDOs

Index	Group	Name	Data type	Flags	Default	Units	Comment
INPUT DATA							
6000:00	**DIR**		UINT8	RO	0x07 (7_{dez})	-	Number of index entries.
6000:01		**READY**	BOOL	RO	-	-	Common readiness of the device
6000:02							
6000:03		**W**	INT	RO	-	-	Actual command value
6000:04		**C**	INT	RO	-	-	Control signal after CC
6000:05		**U**	INT	RO	-	-	Output signal
6000:06		**IA**	UINT	RO	-	mA	Current at solenoid A
6000:07		**IB**	UINT	RO	-	mA	Current at solenoid B
6010:00	**IND1**		UINT8	RO	0x06 (6_{dez})	-	Number of index entries.
6010:01		**READY1**	BOOL	RO	-	-	Common readiness of channel 1
6010:02							
6010:03		**W1**	UINT	RO	-	-	Actual command value channel 1
6010:04		**C1**	UINT	RO	-	-	Control signal after CC channel 1
6010:05		**U1**	UINT	RO	-	-	Output signal channel 1
6010:06		**I1**	UINT	RO	-	mA	Solenoid current at channel 1
6020:00	**IND2**		UINT8	RO	0x06 (6_{dez})	-	Number of index entries.
6020:01		**READY2**	BOOL	RO	-	-	Common readiness of channel 2
6020:02							
6020:03		**W2**	UINT	RO	-	-	Actual command value channel 2
6020:04		**C2**	UINT	RO	-	-	Control signal after CC channel 2
6020:05		**U2**	UINT	RO	-	-	Output signal channel 2
6020:06		**I2**	UINT	RO	-	mA	Solenoid current at channel 2

Index	Group	Name	Data type	Flags	Default	Units	Comment
OUTPUT DATA							
7000:00	**DIR**		UINT8	RO	0x03 (3_{dez})	-	Number of index entries.
7000:01		**ENABLE**	BOOL	RW	-	-	General enabling of the device
7000:02							
7000:03		**COMMAND VALUE**	DINT	RW	-	-	Command value
7010:00	**IND1**		UINT8	RO	0x03 (3_{dez})	-	Number of index entries.
7010:01		**ENABLE1**	BOOL	RW	-	-	General enabling of channel 1
7010:02							
7010:03		**COMMAND VALUE 1**	UINT	RW	-	-	Command value of channel 1
7020:00	**IND2**		UINT8	RO	0x03 (3_{dez})	-	Number of index entries.
7020:01		**ENABLE2**	BOOL	RW	-	-	General enabling of channel 2
7020:02							
7020:03		**COMMAND VALUE 2**	UINT	RW	-	-	Command value of channel 2

6.1.3 Parameters channel 0 (DIRECTIONAL)

Index	Group	Name	Data type	Flags	Default	Units	Comment	WPC Group
Ramp function								
8002:00	**RAMP**		UINT8	RO	0x05 (5_{dez})	-	Number of index entries.	**CTRL**
8002:01								
8002:02		**RA:UP:A**	UDINT	RW	100	ms	Ramp time increasing solenoid current A	
8002:03		**RA:DOWN:A**	UDINT	RW	100	ms	Ramp time decreasing solenoid current A	
8002:04		**RA:UP:B**	UDINT	RW	100	ms	Ramp time increasing solenoid current B	
8002:05		**RA:DOWN:B**	UDINT	RW	100	ms	Ramp time decreasing solenoid current B	
Characteristics linearization								
8006:00	**CC**		UNIT8	RO	0x2A (42_{dez})	-	Number of index entries.	**CTRL + EXP**
8006:01		**CCB:10_X**	INT	RW	-10000	0,01%	X-coordinate point -10	
8006:02		**CCB:10_Y**	INT	RW	-10000	0,01 %	Y coordinate point -10	
8006:03		**CCB:9_X**	INT	RW	-9000	0,01 %	X coordinate point -9	
8006:04		**CCB:9_Y**	INT	RW	-9000	0,01 %	Y coordinate point -9	
8006:05		**CCB:8_X**	INT	RW	-8000	0,01 %	X coordinate point -8	
8006:06		**CCB:8_Y**	INT	RW	-8000	0,01 %	Y coordinate point -8	
8006:07		**CCB:7_X**	INT	RW	-7000	0,01 %	X coordinate point -7	
8006:08		**CCB:7_Y**	INT	RW	-7000	0,01 %	Y coordinate point -7	
8006:09		**CCB:6_X**	INT	RW	-6000	0,01 %	X coordinate point -6	
8006:0A		**CCB:6_Y**	INT	RW	-6000	0,01 %	Y coordinate point -6	
8006:0B		**CCB:5_X**	INT	RW	-5000	0,01 %	X coordinate point -5	
8006:0C		**CCB:5_Y**	INT	RW	-5000	0,01 %	Y coordinate point -5	
8006:0D		**CCB:4_X**	INT	RW	-4000	0,01 %	X coordinate point -4	
8006:0E		**CCB:4_Y**	INT	RW	-4000	0,01 %	Y coordinate point -4	
8006:0F		**CCB:3_X**	INT	RW	-3000	0,01 %	X coordinate point -3	

Index	Group	Name	Data type	Flags	Default	Units	Comment	WPC Group
8006:10		**CCB:3_Y**	INT	RW	-3000	0,01 %	Y coordinate point -3	
8006:11		**CCB:2_X**	INT	RW	-2000	0,01 %	X coordinate point -2	
8006:12		**CCB:2_Y**	INT	RW	-2000	0,01 %	Y coordinate point -2	
8006:13		**CCB:1_X**	INT	RW	-1000	0,01 %	X coordinate point -1	
8006:14		**CCB:1_Y**	INT	RW	-1000	0,01 %	Y coordinate point -1	
8006:15		**CCA:0_X**	INT	RW	0	0,01 %	X coordinate point 0	
8006:16		**CCA:0_Y**	INT	RW	0	0,01 %	Y coordinate point 0	
8006:17		**CCA:1_X**	INT	RW	1000	0,01 %	X coordinate point 1	
8006:18		**CCA:1_Y**	INT	RW	1000	0,01 %	Y coordinate point 1	
8006:19		**CCA:2_X**	INT	RW	2000	0,01 %	X coordinate point 2	
8006:1A		**CCA:2_Y**	INT	RW	2000	0,01 %	Y coordinate point 2	
8006:1B		**CCA:3_X**	INT	RW	3000	0,01 %	X coordinate point 3	
8006:1C		**CCA:3_Y**	INT	RW	3000	0,01 %	Y coordinate point 3	
8006:1D		**CCA:4_X**	INT	RW	4000	0,01 %	X coordinate point 4	
8006:1E		**CCA:4_Y**	INT	RW	4000	0,01 %	Y coordinate point 4	
8006:1F		**CCA:5_X**	INT	RW	5000	0,01 %	X coordinate point 5	
8006:20		**CCA:5_Y**	INT	RW	5000	0,01 %	Y coordinate point 5	
8006:21		**CCA:6_X**	INT	RW	6000	0,01 %	X coordinate point 6	
8006:22		**CCA:6_Y**	INT	RW	6000	0,01 %	Y coordinate point 6	
8006:23		**CCA:7_X**	INT	RW	7000	0,01 %	X coordinate point 7	
8006:24		**CCA:7_Y**	INT	RW	7000	0,01 %	Y coordinate point 7	
8006:25		**CCA:8_X**	INT	RW	8000	0,01 %	X coordinate point 8	
8006:26		**CCA:8_Y**	INT	RW	8000	0,01 %	Y coordinate point 8	
8006:27		**CCA:9_X**	INT	RW	9000	0,01 %	X coordinate point 9	
8006:28		**CCA:9_Y**	INT	RW	9000	0,01 %	Y coordinate point 9	
8006:29		**CCA:10_X**	INT	RW	10000	0,01 %	X coordinate point 10	
8006:2A		**CCA:10_Y**	INT	RW	10000	0,01 %	X coordinate point 10	

Index	Group	Name	Data type	Flags	Default	Units	Comment	WPC Group
Valve adaption								
800A:00	**MINMAX**		UINT8	RO	0x09 (9_{dez})	-	Number of index entries.	**CTRL +EXP**
800A:01		**CCMODE**	DT0802EN03	RW	0FF	-	Activation of the linearization function	
800A:02								
800A:03		**MMTYPE**	DT0805EN03	RW	JMP	-	Compensation type: jump or linear	
800A:04								
800A:05		**TRIGGER**	UINT	RW	200	0,01 %	Threshold of the compensation value	
800A:06		**MIN:A**	UINT	RW	0	0,01 %	Deadband compensation value solenoid A	
800A:07		**MAX:A**	UINT	RW	10000	0,01 %	Output scaling solenoid A	
800A:08		**MIN:B**	UINT	RW	0	0,01 %	Deadband compensation value solenoid B	
800A:09		**MAX:B**	UINT	RW	10000	0,01 %	Output scaling solenoid B	
Power stage								
800D:00	**POWER STAGE**		UINT8	RO	0x0A (10_{dez})	-	Number of index entries.	**IO_CONFIG**
800D:01							Reserved	
800D:02		**CURRENT**	UINT	RW	1000	mA	Nominal solenoid current	
800D:03		**DAMPL**	UINT	RW	500	0,01 %	Dither amplitude	
800D:04		**DFREQ**	UINT	RW	120	Hz	Dither frequency	
800D:05		**PWM**	DT0803EN05	RW	2604	Hz	PWM frequency	
800D:06								
800D:07		**ACC**	DT0802EN03	RW	ON	-	Automatic solenoid current controller adjustment	**IO_CONFIG + EXP**
800D:08								
800D:09		**PPWM**	UINT	RW	7	-	P gain solenoid current controller	
800D:0A		**IPWM**	UINT	RW	40	-	I gain solenoid current controller	

6.1.4 Channel 1 / 2 (INDEPENDENT)

Index	Group	Name	Data type	Flags	Default	Units	Comment	WPC Group
Ramp function								
8012:00	**RAMP CHANNEL 1**		UINT8	RO	0x03 (3_{dez})	-	Number of index entries.	**CTRL**
8012:01								
8012:02		**RA:UP:1**	UDINT	RW	100	ms	Ramp time increasing solenoid current	
8012:03		**RA:DOWN:1**	UDINT	RW	100	ms	Ramp time decreasing solenoid current	
8022:00	**RAMP CHANNEL 2**		UINT8	RO	0x03 (3_{dez})	-	Number of index entries.	
8022:01								
8022:02		**RA:UP:2**	UDINT	RW	100	ms	Ramp time increasing solenoid current	
8022:03		**RA:DOWN:2**	UDINT	RW	100	ms	Ramp time decreasing solenoid current	
Characteristics linearization								
8016:00	**CC CHANNEL 1**		UNIT8	RO	0x16(22_{dez})	-	Number of index entries Channel 1	**CTRL + EXP**
8016:01		**CC1:0_X**	INT	RW	0	0,01 %	X coordinate point 0	
8016:02		**CC1:0_Y**	INT	RW	0	0,01 %	Y coordinate point 0	
8016:03		**CC1:1_X**	INT	RW	1000	0,01 %	X coordinate point 1	
8016:04		**CC1:1_Y**	INT	RW	1000	0,01 %	Y coordinate point 1	
8016:05		**CC1:2_X**	INT	RW	2000	0,01 %	X coordinate point 2	
8016:06		**CC1:2_Y**	INT	RW	2000	0,01 %	Y coordinate point 2	
8016:07		**CC1:3_X**	INT	RW	3000	0,01 %	X coordinate point 3	
8016:08		**CC1:3_Y**	INT	RW	3000	0,01 %	Y coordinate point 3	
8016:09		**CC1:4_X**	INT	RW	4000	0,01 %	X coordinate point 4	
8016:0A		**CC1:4_Y**	INT	RW	4000	0,01 %	Y coordinate point 4	
8016:0B		**CC1:5_X**	INT	RW	5000	0,01 %	X coordinate point 5	
8016:0C		**CC1:5_Y**	INT	RW	5000	0,01 %	Y coordinate point 5	
8016:0D		**CC1:6_X**	INT	RW	6000	0,01 %	X coordinate point 6	

Index	Group	Name	Data type	Flags	Default	Units	Comment	WPC Group
8016:0E		**CC1:6_Y**	INT	RW	6000	0,01 %	Y coordinate point 6	
8016:0F		**CC1:7_X**	INT	RW	7000	0,01 %	X coordinate point 7	
8016:10		**CC1:7_Y**	INT	RW	7000	0,01 %	Y coordinate point 7	
8016:11		**CC1:8_X**	INT	RW	8000	0,01 %	X coordinate point 8	
8016:12		**CC1:8_Y**	INT	RW	8000	0,01 %	Y coordinate point 8	
8016:13		**CC1:9_X**	INT	RW	9000	0,01 %	X coordinate point 9	
8016:14		**CC1:9_Y**	INT	RW	9000	0,01 %	Y coordinate point 9	
8016:15		**CC1:10_X**	INT	RW	10000	0,01 %	X coordinate point 10	
8016:16		**CC1:10_Y**	INT	RW	10000	0,01 %	X coordinate point 10	
8026:00	**CC CHANNEL 2**		UNIT8	RO	0x16 (22_{dez})	-	Number of index entries Channel 2	
8026:01		**CC2:0_X**	INT	RW	0	0,01 %	X coordinate point 0	
8026:02		**CC2:0_Y**	INT	RW	0	0,01 %	Y coordinate point 0	
8026:03		**CC2:1_X**	INT	RW	1000	0,01 %	X coordinate point 1	
8026:04		**CC2:1_Y**	INT	RW	1000	0,01 %	Y coordinate point 1	
8026:05		**CC2:2_X**	INT	RW	2000	0,01 %	X coordinate point 2	
8026:06		**CC2:2_Y**	INT	RW	2000	0,01 %	Y coordinate point 2	
8026:07		**CC2:3_X**	INT	RW	3000	0,01 %	X coordinate point 3	
8026:08		**CC2:3_Y**	INT	RW	3000	0,01 %	Y coordinate point 3	
8026:09		**CC2:4_X**	INT	RW	4000	0,01 %	X coordinate point 4	
8026:0A		**CC2:4_Y**	INT	RW	4000	0,01 %	Y coordinate point 4	
8026:0B		**CC2:5_X**	INT	RW	5000	0,01 %	X coordinate point 5	
8026:0C		**CC2:5_Y**	INT	RW	5000	0,01 %	Y coordinate point 5	
8026:0D		**CC2:6_X**	INT	RW	6000	0,01 %	X coordinate point 6	
8026:0E		**CC2:6_Y**	INT	RW	6000	0,01 %	Y coordinate point 6	
8026:0F		**CC2:7_X**	INT	RW	7000	0,01 %	X coordinate point 7	
8026:10		**CC2:7_Y**	INT	RW	7000	0,01 %	Y coordinate point 7	
8026:11		**CC2:8_X**	INT	RW	8000	0,01 %	X coordinate point 8	
8026:12		**CC2:8_Y**	INT	RW	8000	0,01 %	Y coordinate point 8	

Index	Group	Name	Data type	Flags	Default	Units	Comment	WPC Group
8026:13		**CC2:9_X**	INT	RW	9000	0,01 %	X coordinate point 9	
8026:14		**CC2:9_Y**	INT	RW	9000	0,01 %	Y coordinate point 9	
8026:15		**CC2:10_X**	INT	RW	10000	0,01 %	X coordinate point 10	
8026:16		**CC2:10_Y**	INT	RW	10000	0,01 %	X coordinate point 10	
Valve adaption								
801A:00	**MINMAX CHANNEL 1**		UINT8	RO	0x07 (7_{dez})	-	Number of index entries Channel 1.	**CTRL + EXP**
801A:01		**CCMODE:1**	DT0802EN03	RW	OFF	-	Activation of the linearization function	
801A:02								
801A:03		**MMTYPE:1**	UINT	RW	JMP	-	Compensation type: jump or linear	
801A:04								
801A:05		**TRIGGER:1**	UINT	RW	200_{dez}	0,01 %	Threshold of the compensation value	
801A:06		**MIN:1**	UINT	RW	0_{dez}	0,01 %	Deadband compensation value solenoid 1	
801A:07		**MAX:1**	UINT	RW	10000_{dez}	0,01 %	Output scaling solenoid 1	
802A:00	**MINMAX CHANNEL 2**		UINT8	RO	0x07 (7_{dez})	-	Number of index entries Channel 2.	
802A:01		**CCMODE:2**	DT0802EN03	RW	OFF	-	Activation of the linearization function	
802A:02								
802A:03		**MMTYPE:2**	UINT	RW	JMP	-	Compensation type: jump or linear	
802A:04								
802A:05		**TRIGGER:2**	UINT	RW	200_{dez}	0,01 %	Threshold of the compensation value	
802A:06		**MIN:2**	UINT	RW	0_{dez}	0,01 %	Deadband compensation value solenoid 2	
802A:07		**MAX:2**	UINT	RW	10000_{dez}	0,01 %	Output scaling solenoid 2	
Power stage								
80xD:00	**POWER STAGE CHANNEL 1**		UINT8	RO	0x0A (10_{dez})	-	Number of index entries.	**IO_CONFIG**
801D:01								
801D:02		**CURRENT:1**	UINT	RW	1000	mA	Nominal solenoid current	

Index	Group	Name	Data type	Flags	Default	Units	Comment	WPC Group
801D:03		**DAMPL:1**	UINT	RW	500	0,01 %	Dither amplitude	
801D:04		**DFREQ:1**	UINT	RW	120	Hz	Dither frequency	
801D:05		**PWM:1**	DT0803EN05	RW	2604	Hz	PWM frequency	
801D:06								
801D:07		**ACC:1**	DT0802EN03	RW	ON	-	Automatic solenoid current controller adjustment	**IO_CONFIG + EXP**
801D:08								
801D:09		**PPWM:1**	UINT	RW	7	-	P gain solenoid current controller	
801D:0A		**IPWM:1**	UINT	RW	40	-	I gain solenoid current controller	
802D:00	**POWER STAGE CHANNEL 2**		UINT8	RO	0x0A (10_{dez})	-	Number of index entries.	**IO_CONFIG**
802D:01								
802D:02		**CURRENT:2**	UINT	RW	1000	mA	Nominal solenoid current	
802D:03		**DAMPL:2**	UINT	RW	500	0,01 %	Dither amplitude	
802D:04		**DFREQ:2**	UINT	RW	120	Hz	Dither frequency	
802D:05		**PWM:2**	DT0803EN05	RW	2604	Hz	PWM frequency	
802D:06								
802D:07		**ACC:2**	DT0802EN03	RW	ON	-	Automatic solenoid current controller adjustment	**IO_CONFIG + EXP**
802D:08								
802D:09		**PPWM:2**	UINT	RW	7	-	P gain solenoid current controller	
802D:0A		**IPWM:2**	UINT	RW	40	-	I gain solenoid current controller	

6.1.5 Diagnosis messages

Index	Group	Name	Data type	Flags	Default	Units	Comment
Diagnosis Messages							
A000:00	**DIAG**		UINT8	RO	0x04 (4_{dez})	-	Number of index entries.
A000:01		**MEMORY**	BOOL	RO	-	-	Operational readiness of the device
A000:02		**UNDERVOLTAGES**	BOOL	RO	-	-	Supply voltage is too low
A000:03		**OVERVOLTAGES**	BOOL	RO	-	-	Supply voltage is too high
A000:04		**TEMPERATURE**	BOOL	RO	-	-	Overtemperature
A010:00	**DIAG 1**		UINT8	RO	0x02 (2_{dez})	-	Number of index entries.
A010:01		**SHORT CIRCUIT**	BOOL	RO	-	-	Short circuit at output 1 (magnet A)
A010:02		**OPEN CIRCUIT**	BOOL		-	-	Cable break at output 1 (magnet A)
A020:00	**DIAG 2**		UINT8	RO	0x02 (2_{dez})	-	Number of index entries.
A020:01		**SHORT CIRCUIT**	BOOL	RO	-	-	Short circuit at output 2 (magnet B)
A020:02		**OPEN CIRCUIT**	BOOL		-	-	Cable break at output 2 (magnet B)

6.1.6 System

Index	Group	Name	Data type	Flags	Default	Units	Comment	WPC Group
Basic module settings								
F800:00	**BASIS**		UNIT8	RO	0x03 (3_{dez})	-	Number of index entries.	**SYSTEM**
F800:01		**IO_BASE**	UINT	RW	10000	-	Value base for command values, feedback values and parameter settings	
F800:02		**FUNCTION**	DT0800EN03	RW	DIR	-	Module function: IND for two independent channels (Channel 1 und 2) or DIR for one channel (Channel 0) for directional valves with two solenoids.	
F800:03		**SENS**	DT0801EN03	RW	ON	-		
General module functions								
F801:00	**FUNC**		UNIT8	RO	0x04 (4_{dez})	-	Number of index entries.	-
F801:01		**PASSWORD**		WO		-		
F801:02		**SAVE**		WO		-	Setting this parameter to „1“ will save all paramters in the internal EEPROM. This is acknowledged by the device by momentarily setting the return value to 0x11111111.	
F801:03		**DEFAULT**		WO		-	Setting this parameter to „1“ will restore the standard settings in the RAM. This is acknowledged by the device by momentarily setting the return valus to 0x11111111.	
F801:04		**LOADBACK**		WO		-	Setting this parameter to „1“ will restore all parameter values that have been saved previously in the EEPROM. This is acknowledged by the device by momentarily setting the return values to 0x11111111.	
Manufacturer settings								
F80F:00	**MANU**				0x02 (2_{dez})		Number of index entries.	**TERMINAL**
F80F:01			UINT	RW		-	Reserved	
F80F:02			UINT	RW		-	Reserved	

6.1.7 Data Types

Index	Group	Name	Data type	Flags	Default	Units	Comment	
Data Types								
0800:01		**DIRECTIONAL**	DT0800EN03	RO	1	-	Switching to the operating mode of the module	
0800:02		**INDEPENDENT**	DT0800EN03	RO	2	-		
0801:01		**OFF**	DT0801EN03	RO	1	-	Control function SENS	
0801:02		**ON**	DT0801EN03	RO	2	-		
0801:03		**AUTO**	DT0801EN03	RO	3	-		
0802:01		**OFF**	DT0802EN03	RO	0	-	Binäry Parameters	
0802:02		**ON**	DT0802EN03	RO	1	-		
0803:01		**60**	DT0803EN05	RO	0x11		Frequency table, value in 1/s	
0803:02		**70**	DT0803EN05	RO	0x0e			
0803:03		**80**	DT0803EN05	RO	0x0b			
0803:04		**100**	DT0803EN05	RO	0x08			
0803:05		**120**	DT0803EN05	RO	0x05			
0803:06		**150**	DT0803EN05	RO	0x02			
0803:07		**200**	DT0803EN05	RO	0x13			
0803:08		**250**	DT0803EN05	RO	0x10			
0803:09		**400**	DT0803EN05	RO	0x0d			
0803:0A		**500**	DT0803EN05	RO	0x0a			
0803:0B		**600**	DT0803EN05	RO	0x07			
0803:0C		**800**	DT0803EN05	RO	0x04			
0803:0D		**1000**	DT0803EN05	RO	0x01			

Index	Group	Name	Data type	Flags	Default	Units	Comment	
0803:0E		**1200**	DT0803EN05	RO	0x12			
0803:0F		**1500**	DT0803EN05	RO	0x0f			
0803:10		**2000**	DT0803EN05	RO	0x0c			
0803:11		**2500**	DT0803EN05	RO	0x09			
0803:12		**3000**	DT0803EN05	RO	0x06			
0803:13		**6000**	DT0803EN05	RO	0x03			
0803:14		**10000**	DT0803EN05	RO	0x14			
0804:01		**LIN**	DT0804EN03	RO	0			
0804:02		**SIN**	DT0804EN03	RO	1			
0805:01		**JMP**	DT0805EN03	RO	0		Coverage compensation	
0805:02		**LIN**	DT0805EN03	RO	1			

6.2 Parameter descriptions

6.2.1 IO_BASE (Scaling of the input and output signals)

The reference value for 100% command and feedback values can be defined here. So it can be adapted to the used number system. E.g. a value of 10000 can be chosen to use 0.01% units or 16383 to use 3FFF as maximum.

Adjustable range: 100… 32767

6.2.2 Data Storage

In order to parameterize the device for the required functionality the settings described in chapter 6.2 have to be made.

Using EtherCAT there are three possible ways in order to accomplish this:

1.) Usage of the EtherCAT master engineering system and setting of the relevant SDO in the online view of the slave. After all needed entries have been made, a transfer of these settings is performed by using F801:01 (*Function Parameters/Save Parameters*). So the parameters are stored permanently.

2.) Defining of tasks which will be automatically performed by the EtherCAT master during start-up. For this e.g. TwinCAT offers a tab “Startup” on the properties – mask of the slave device. There the needed parameters have to be set one after another. By this data is stored permanently in the master instead of the slave.

3.) There is also the possibility to write parameter values by system functions of the master PLC. This method is the most elaborate but it offers the possibility to change parameters during the operation by the PLC program. It is also possible to combine this method with the others. Attention: The “Save” command triggers write access to the internal EEPROM and therefore must not be called cyclically.

6.2.3 Loadback

Via this command (WPC or EtherCAT) the last saved data will be restored.

6.2.4 Default

Via this command (WPC or EtherCAT) the default parameters are reactivated.

6.2.5 SENS (Failure monitoring)

This command is used to activate / deactivate the monitoring functions (output current and internal failures) of the module.

ON: All monitoring functions are active. Detected failures can be reset by deactivating the ENABLE input.

OFF: No monitoring function is active.

AUTO: Auto reset mode. All monitoring functions are active. If the failure does not exist anymore, the module resumes to work automatically.

Normally the monitoring functions are always active because otherwise no errors are detectable via the READY output. The possibility of deactivation is provided especially for troubleshooting.

AUTO MODE: The module checks each second the actual failure status, which will (in case of a persistent error) trigger the LED and the READY output for a short time.

6.2.6 FUNCTION (Choosing operation mode)

This parameter allows adapting the amplifier to valves with one solenoid (IND, e.g. pressure valves) or to such with two solenoids (DIR, directional valves). The relating parameters for the directional mode are listed in channel 0. The channels 1 and 2 contain the parameters for the two separate channels in independent mode. This is the main basic adjustment of the device which should be done at first.

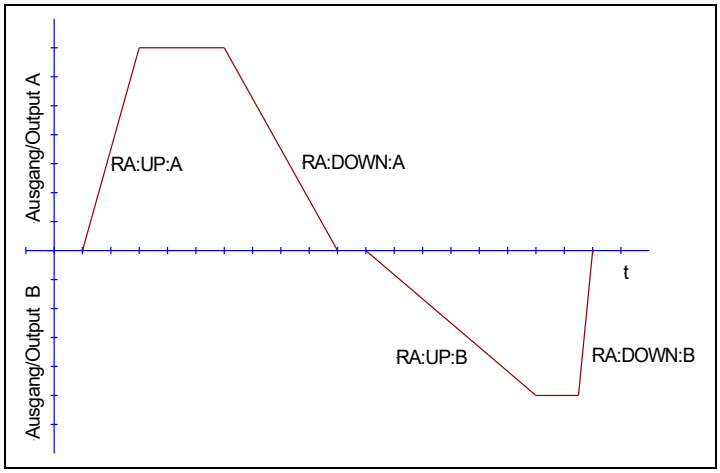
6.3 Function parameters

6.3.1 RA (Ramp time)

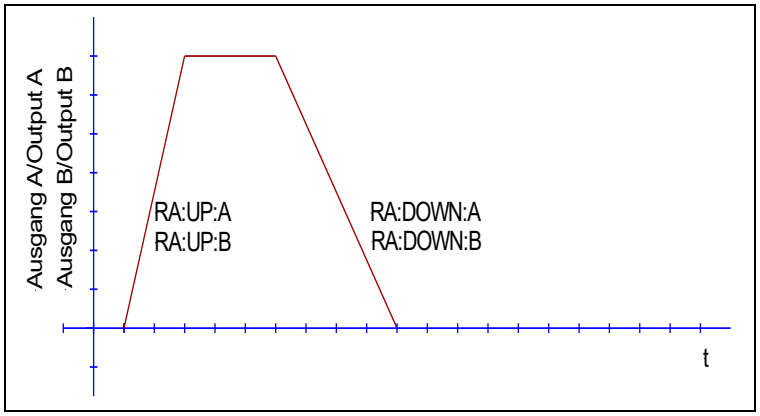
This amplifier provides a ramp function for the demand values. There are two time values for increasing demand and decreasing demand for each solenoid.

Adjustable range: 1… 120000 Milliseconds

When using the independent mode, the two channels are separated and so the ramp functions are independent, too.



In the directional mode, this ramp function is a four-quadrant-ramp. If the direction of control is altered (change of sign of the command value), first the deceleration ramp of the old direction is completed (RA:DOWN:A/B) before the acceleration in the new direction starts (RA:UP:A/B).



6.3.2 CCMODE (Activation of the linearization function)

This command is used for activating and deactivating the linearization function. By immediately deactivating the linearization an easy and fast evaluation of the linearization is possible.

ON: Linearization function CC is active (nevertheless, the default setting of the curve points will cause no effect on the output)

OFF: Linearization function CC is not active.

ATTENTION: When using the CC command, the parameters MIN, MAX and TRIGGER have to be considered. Those commands influence each other and so using both can complicate evaluating the result.

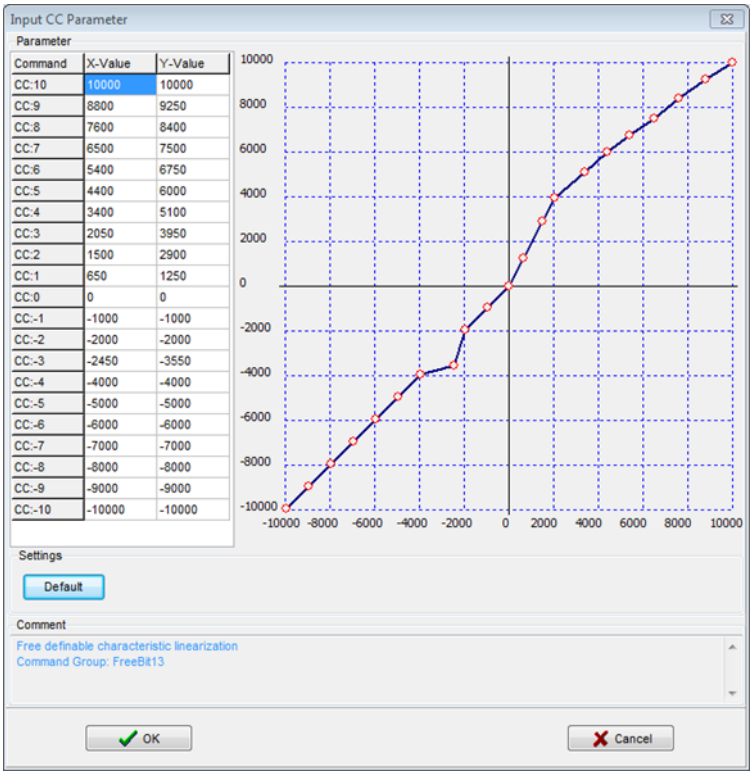
6.3.3 CC (Defining curve points)

A user defined signal characteristic can be set by this function. For activating the parameter CCMODE has to be switched ON first.

The curve is calculated according to the equation of a linear interpolation **y=(x-x1)*(y1-y0)/(x1-x0)+y1**.
The influence of the linearization can be estimated via the process data.

For each solenoid there are 10 points to define the curve. Those are determined by a X-value and a Y value. The input signal of the function is displayed by the X axis and the relating output value on the Y axis.

Adjustable range: 0… 10000(IND) respectively -10000… 10000(DIR)



6.3.4 MMTYPE (Type of compensation)

The overlap of a valve can be compensated in different ways. One solution is a jump of the output signal to the compensation value when reaching an activation threshold (JMP). Alternatively, the output current can be increased linearly to the compensation value at the activation threshold (LIN).

This setting can be recommended if the driven valve is part of a control loop.

6.3.5 TRIGGER (Threshold)

The trigger defines when the MIN value is activated. So a non-sensitive range around the zero-point[1] can be accomplished.

Adjustable range: 0… 3000

6.3.6 MIN (Deadband compensation)

With the MIN value the overlap (deadband) of the valve is compensated. If the control signal passes the trigger point, this value is the minimum starting value of the output.

Adjustable range: 0… 6000

ATTENTION: When setting the compensation value too high, maybe small movements or speeds are no more possible.

6.3.7 MAX (Output scaling)

With the MAX value the output signal (the maximum current) can be adapted if necessary.

Adjustable range: 5000… 10000

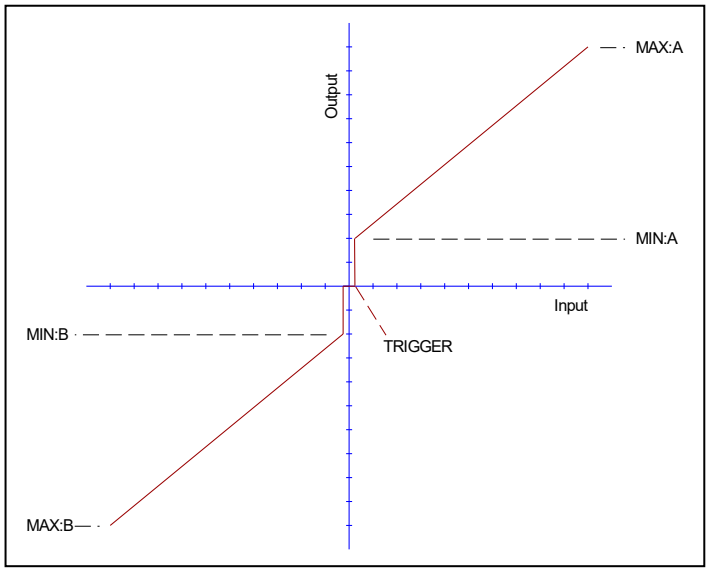


Fig.1: mode DIR, directional valve with 2 solenoids

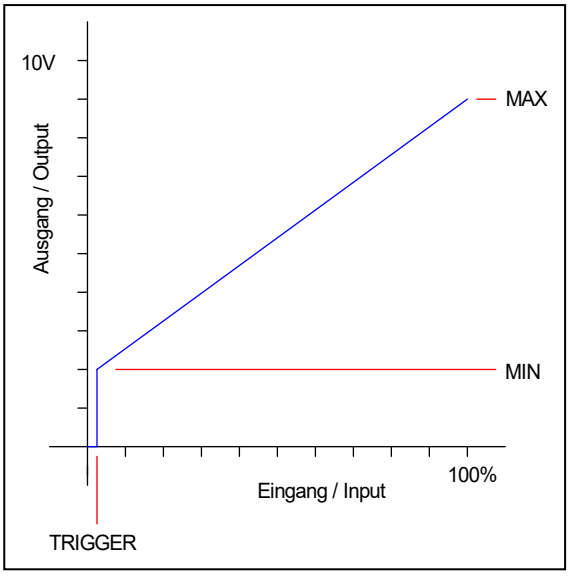


Fig.2: mode IND, one solenoid each channel

[1] This dead band is necessary, in order to avoid unrequested activations caused by small variations of the input signal. If this module is used in a position controls, the TRIGGER value should be reduced (typical: 1…10).

6.4 Power stage

6.4.1 CURRENT (nominal output current)

This parameter defines the nominal current of the solenoid. Dither amplitude and also MIN/MAX settings always refer to this value.

Adjustable range: 500… 3000

6.4.2 DAMPL (Dither amplitude)

Setting the amplitude of the dither signal referring to the nominal current.

Adjustable range: 0… 3000

***CAUTION**: If the PWM frequency is less than 500 Hz, the dither amplitude should be set to zero.*

6.4.3 DFREQ (Dither frequency)

Choosing the frequency of the dither signal.

Adjustable range: 50… 400

***CAUTION:** The PPWM and IPWM parameters influence the effect of the dither setting. These parameters should not be changed again after the dither has been optimized.*

If there are no adjustment data from the valve manufacturer, proceed as follows: First, the amplitude is adjusted based on the hysteresis of the valve. Then setting starts with a low dither frequency. The user should increase it step by step. The aim is that no oscillation (often observed as humming of the valve) is noticeable at the end of the tuning procedure.
Alternatively, the PWM frequency can also be used as a dither. In this case, the dither amplitude must be set to zero and a relatively low PWM frequency is set (typically: 60 ... 250 Hz). Again, no humming on the drive should be detectable after the adjustment.

6.4.4 PWM (PWM frequency)

The frequency can be changed in the defined steps. The best working frequency depends on the valve.

Selectable values: 60 / 70 / 80 / 100 / 120 / 150 / 200 / 250 / 400 / 500 / 600 / 800 / 1000 / 1200 / 1500 / 2000 / 2500 / 3000 / 6000 / 10000

***Attention:** The PPWM and IPWM parameters should be adapted when using low PWM frequencies because of the longer dead times which forces a reduced stability of the closed loop control.*

6.4.5 ACC (Auto adaptation of the closed loop current controller)

This parameter activates or deactivates the automatic adjustment of the solenoid current controller.

ON: PPWM and IPWM are adapted depending on the pre-set PWM-frequency.
The parameters PPWM and IPWM cannot be altered by the user in this case.

OFF: Manual adjustment of PPWM and IPWM, no automatic adaption is done.

6.4.6 PPWM (Solenoid current controller P gain)

Adjustable range: 0… 300

6.4.7 IPWM (Solenoid current controller I gain)

Adjustable range: 0… 100

The PI current controller for the solenoids is parameterized with these commands.

CAUTION: These parameters should not be changed without adequate measurement facilities and experiences. If the parameter ACC is set to ON, these adjustments are done automatically.

6.5 Process data (Monitoring)

Command	Description	Unit	Function
W	Command value after input scaling	%	**DIR**
C	Command value after ramp function	%	
U	Command value to current controller	%	
IA	Output current of solenoid A	mA	
IB	Output current of solenoid B	mA	
W1	Command value after input scaling channel 1	%	**IND**
C1	Command value after ramp function channel 1	%	
U1	Command value to current controller channel 1	%	
I1	Solenoid current channel 1	mA	
W2	Command value after input scaling channel 2	%	
C2	Command value after ramp function channel 2	%	
U2	Command value to current controller channel 2	%	
I2	Solenoid current channel 2	mA	

The process data are the variable values which can be continuously observed.

7 Quick Start Configuration and Parameterization

In the following the basic steps are exemplified on the basis of the engineering system “TwinCAT 3.1” from the manufacturer Beckhoff.

For other EtherCAT master and their belonging engineering environment the procedure is basically similar.

The steps are:

After the initial configuration of the device, during which the EtherCAT connection will be established and the process data objects are activated, the parameterization of the unit’s functionality follows. Here are two alternative ways explained. The first is the exclusive use of EtherCAT SDO (parameterization without WPC). The second is an approach using the program WPC-300.

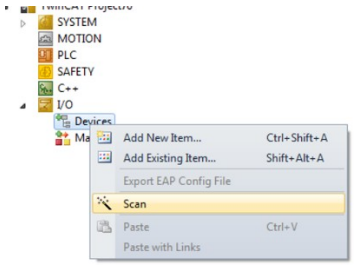
7.1 Configuration

First the device description “PAM-199-P-ETC.xml”, the so-called ESI-file has to be copied into the local folder containing these descriptions for the programming software.

If a standard-installation of TwinCAT is used, this will be the path „C:\TwinCAT\3.1\Config\Io\EtherCAT“.

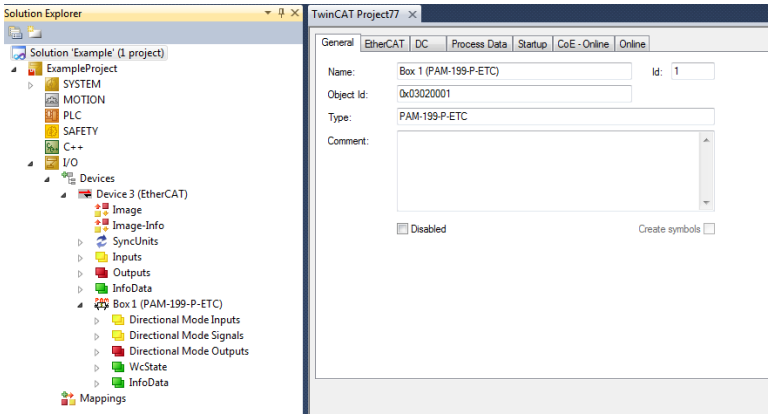
For the following steps the device has to be powered on and the EtherCAT “In” interface (the upper RJ-45 jack of the PAM) must be linked to an EtherCAT-compatible network adapter of the computer.

Scan for devices:



After the right network adapter has been chosen the connected amplifier will be found automatically. Confirm the request to activate *Free Run*.

Double-clicking on the found box will yield the following mask:



In the tab *Process Data* it is now possible to define the PDOs to be transferred.

The decision has to be made if the unit will be used to control a directional valve (function *Directional Mode*) or up to two independent single solenoids (function *Independent Mode*).

Therefore the belonging PDOs from the list have to be assigned to the *Sync Managers*.

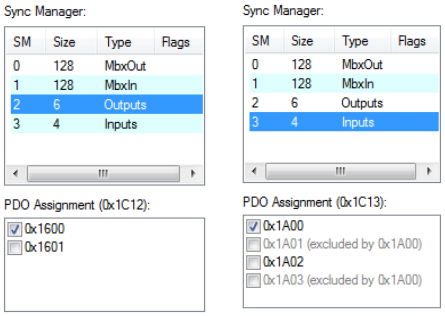
In order to accomplish this, activate the Sync Managers for the *Outputs* (= control signals to the amplifier) and for the *Inputs* (= feedback about internal values of the amplifier) and assign the following:

To the *Outputs* the group 0x1600 if *directional mode* should be used. Or group 0x1601 for the *independent mode*.

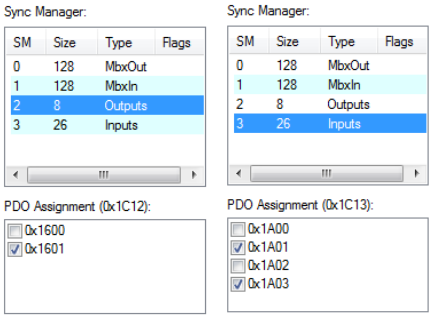
To the *Inputs* the group 0x1A00 if *directional mode* should be used. Or group 0xA002 for the *independent mode*. If additional information about internal signals should be received, the groups 0x1A02 (*Directional*) or 0x1A03 (*Independent*) have to be activated additionally.

In order to facilitate these settings for TwinCAT a preselection has been created that can be fetched by the menu “Predefined PDO Assignment”. By using it the settings for in- and outputs can be made automatically. The result looks as follows:

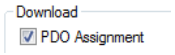
Case 1: *Directional Mode (Extended)*



Case 2: *Independent Mode (Extended)*

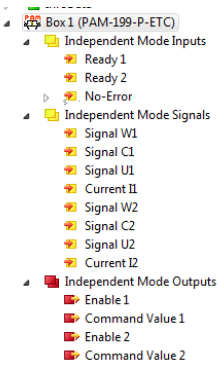


Subsequently verify if the following box is checked:



Push  in order to transfer the information into the device.

The signals of the module now are displayed in the project tree:



It is possible to set values here in *online* mode (*Outputs*) and to monitor the reaction of the amplifier using the other signals.

Example: Setting the bit “Enable” -> Feedback of the ready-state of the belonging channel if no error is present and the suitable mode (*directional / independent*) has been parameterized.

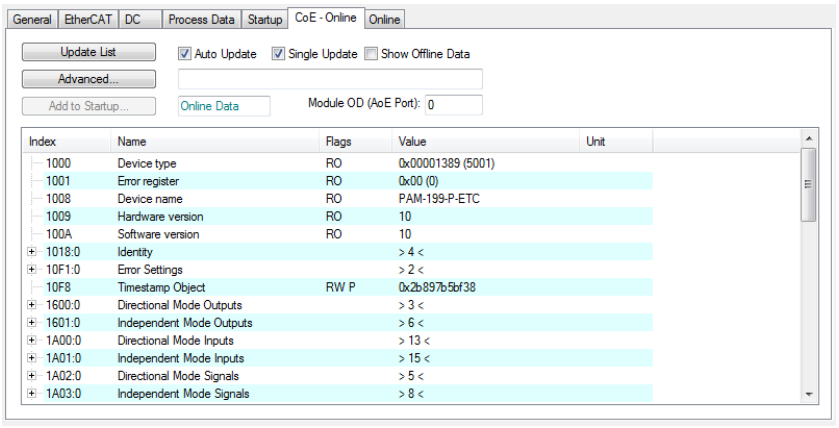
For the later use of these signals within the PLC program they have to be connected to the belonging I/O of the program blocks.

Note:

If the transmission of the signals is not operating properly, the state of the EtherCAT-state machine in the *Online* tab of the device should be checked. The state has to be “OP” = normal operation. Also the LEDs on the front of the PAM serve as aid for diagnosis: FB-RUN should be turned on and LINK-ACT-IN should flash.

7.2 Parameterization w/o WPC

The tab “CoE-Online” offers the possibility to see the SDO of the unit and to adjust their values.



It can be recommended to activate *Auto Update* because this will give the possibility to check during the adjustment of the parameters whether they are taken over correctly. In this view the entry 10F8 *Timestamp Object* should change continuously, otherwise the online-connection is not operational.

In the following these indices are edited:

Open F800:0, choose the FUNCTION (F800:02) and eventually also change SENS or IOBASE. The description of these parameters can be found in chapter 6.2.

Further necessary settings depend upon the choice of the FUNCTION – parameter:

Directional:
First the adjustments for the power stage should be made in the group 800D:0 (*Directional Power Stage*).
Essential: CURRENT
Advisable: DAMPL / DFREQ / PWM according to the information of the valve manufacturer.
For experts, only if required: ACC / PPWM / IPWM

Then the group 800A:0 should be treated:
Overlap compensation, output scaling, if necessary the activation of the characteristics linearization by the parameter CCMODE. Only if this has been activated the values in group 8006:0 will have an impact and have to be set accordingly.

If a ramp is desired this can be set by the parameters in group 8002:0. If none should be active (e.g. because the unit is part of a control loop) the ramp times have to be minimized.

The remaining parameters, especially those related to the *Independent* mode, don’t have to be changed.

Independent:
If only one channel is used, it is sufficient to set its belonging parameters. The second output remains inactive if its *Enable*-bit is not set, see preceding chapter.

First the adjustments for the power stage should be made in the groups 801D:0 (*Channel 1 Power Stage*) and 802D:0 (*Channel 2 Power Stage*).
Essential: CURRENT
Advisable: DAMPL / DFREQ / PWM according to the information of the valve manufacturer.
For experts, only if required: ACC / PPWM / IPWM

Then the groups 801A:0 (*Channel 1 Output Characteristic*) und 802A:0 (*Channel 2 Output Characteristic*) should be treated:

Overlap compensation, output scaling, if necessary the activation of the characteristics linearization by the parameter CCMODE. Only if this has been activated the values in group 8016:0 or 8026:0 will have an impact and have to be set accordingly.

If a ramp is desired this can be set by the parameters in group 8012:0 for channel 1 or 8022:0 for channel 2. If none should be active (e.g. because the unit is part of a control loop) the ramp times have to be minimised.

The remaining parameters, especially those related to the *Directional* mode, don't have to be changed.

Important for both functions:

After the adjustment of the parameters and tests, if the system behaves as intended, in any case the parameter F801:02 should be set to "1":

F801:0	Function Parameters		> 4 <
F801:01	Vendor Settings Password	RW	0x00000000 (0)
F801:02	Save Parameters	RW	0x00000000 (0)
F801:03	Set Parameters to Default	RW	0x00000000 (0)
F801:04	Loadback Parameters	RW	0x00000000 (0)

The successful execution of this command is signaled by a short feedback of the value „0x11111111".

By this step the settings are permanently stored in the internal EEPROM. If this is omitted the settings are lost if the amplifier is powered off.

7.3 Parameterization with WPC

This device can also be connected with WPC.

The advantages are the structured display of parameters and therefore a better user guidance. Furthermore, characteristic curves are displayed graphically thus enabling a plausibility check.

The groups can be switched by the parameter "Mode". The sequence System -> IO_CONFIG -> CONTROL can be recommended.

In the group *System* first the function (DIR/IND) is chosen.

As a result in the other groups only the parameters are displayed which belong to the chosen function.

If only a simple parameterization of the basic functionality is intended the parameter "USER" should remain in the STD setting, meaning standard view. Then extended functions like the curve input or the tuning of the solenoid current controller are not displayed.

After the parameter entry using WPC also a manual "SAVE" command is required, initiated by the button beside the parameter table.

An operation completely without EtherCAT is possible in "Remote Control" mode (see monitor window). This can be interesting for functional tests without PLC.

8 Appendix

8.1 Failure monitoring

Following possible error sources are monitored continuously when SENS = ON / AUTO:

Source	Fault	Characteristics
Solenoid A PIN 3 / 4 Solenoid B PIN 1 / 2	Broken wire Short circuit	The power stage is deactivated.
EEPROM (monitored during power on procedure)	Data error	The power stage is deactivated. The module can only be activated by saving the parameters.
EtherCAT communication	Interrupt	The power stage is deactivated.

8.2 Troubleshooting

With the flashing READY LED and the deactivated READY signal an occurred error will be reported by the module. Possible errors are for example:

- Broken wire or wrong wiring of the solenoids
- Internal data error. For restarting please execute command SAVE for starting with DEFAULT values.

Possible errors can be read out via the fieldbus (see Tx PDOs) or the monitor of the WPC program. Additionally there are some status messages and warnings provided for evaluating the situation.

9 Notes