JetWeb

JX2-PID1

Operator's Manual

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Edition 1.1

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This Operating Instruction belongs to the JX2-PID1 module:

Type: ______________________________

Serial #: ______________________________

Year of construction: ______________________________

Order #: ______________________________

To be entered by the customer:

Inventory #: ______________________________

Place of operation: ______________________________

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1 Safety instructions

The JX2-PID1 module reflects the present state of the art. This JX2-PID1 module complies with the safety regulations and standards in force. Special emphasis was given to the safety of the users.

Of course, the following regulations apply to the user:

- relevant accident prevention regulations;
- accepted safety rules;
- EC guidelines and other country-specific regulations.

Significance of this user's manual

This manual forms part of the JX2-PID1 module

- and must be kept in a way that it is always at hand until the JX2-PID1 module will be disposed;
- If the module is sold, transferred or lent, this manual must be handed over.

In any case you encounter difficulties to clearly understand the manual, please contact the manufacturer.
We would appreciate any kind of suggestion and contributions on your part and would ask you to inform us or the write us. This will help us to produce manuals that are more user-friendly and to address your wishes and requirements.

From this JX2-PID1 module may result inherent residual risks to persons and physical assets. For this reason, any person who has to deal with the operation, transport, installation, maintenance and repair of the JX2-PID1 module must have been familiarised with it and must be aware of these dangers.
Therefore, this person must carefully read, understand and observe this manual, and especially the safety instructions.

Missing or inadequate knowledge of the manual results in the loss of any claim of liability on part of Jetter AG. Therefore, the operating company is recommended to have the instruction of the persons concerned confirmed in writing.

Usage as agreed upon includes operation in accordance with the User's Manual.
The JX2-PID1 module is used to control machinery, such as conveyors, production machines, and handling machines.
The JX2-PID1 module can logically be operated and controlled only with the basic modules of the control system.
Power supply of the JX2-PID1 module must be made through the SELV module exclusively.
The use of other power supply modules is not admissible.

Usage other than agreed upon

The JX2-PID1 module must not be used in technical systems which to a high degree have to be fail-save, e.g. ropeways and aeroplanes.l

If the JX2-PID1 module is to be run under surrounding conditions, which differ from the conditions mentioned in chapter 2: "Operating conditions, page 13", the manufacturer is to be contacted beforehand.

Who is permitted to operate the JX2-PID1 module?

Only instructed, trained and authorised persons are permitted to operate the JX2-PID1 module.
Mounting and backfitting may only be carried out by specially trained personnel, as specific know-how will be required.

Maintenance of the JX2-PID1 module

The JX2-PID1 module is maintenance-free. Therefore, for the operation of the module no inspection or maintenance are required.

Decommissioning and disposal of the JX2-PID1 module

Decommissioning and disposal of the JX2-PID1 module are subject to the environmental legislation of the respective country in effect for the operator's premises.

Descriptions of symbols

Danger

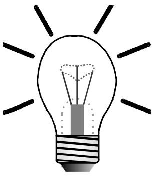
This sign is to indicate a possible impending danger of serious physical damage or death.

Caution

This sign is to indicate a possible impending danger of light physical damage. This sign is also to warn you of material damage.

Important!

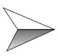
This sign is to indicate a possible impending situation which might bring damage to the product or to its surroundings.



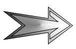
Note!

You will be informed of various possible applications and will receive further useful suggestions.

· / - Enumerations are marked by full stops, strokes or scores.



Operating instructions are marked by this arrow.



Automatically running processes or results to be achieved are marked by this arrow.

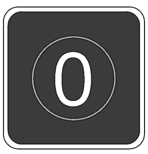


Illustration of PC and user interface keys.

Ensure your own safety

Isolate the JX2-PID1 module from the mains, if maintenance works have to be carried out. By doing so, you will prevent accidents resulting from electric voltage and moving parts.

Instructions on EMI

The noise immunity of a system corresponds to the weakest component of the system. For this reason, correct wiring and shielding of the cables is important.

Important!

Measures for increasing immunity to interfering:

- Shielding must be done on both ends of the applicable cables.
- The entire shield must be drawn behind the isolation, and then be extensively clamped under a strain relief.
- When the signal is connected to terminal screws: The strain relief must be connected with a grounded surface directly and extensively.
- When male connectors are used: Only use metallised connectors, e.g. SUB-D with metallised housing. Please take care of direct connection here as well.
- On principle, separate signal and voltage connections spatially.

Male/female SUB-D connectors (9, 15 or 25 pins) with metallised housing.

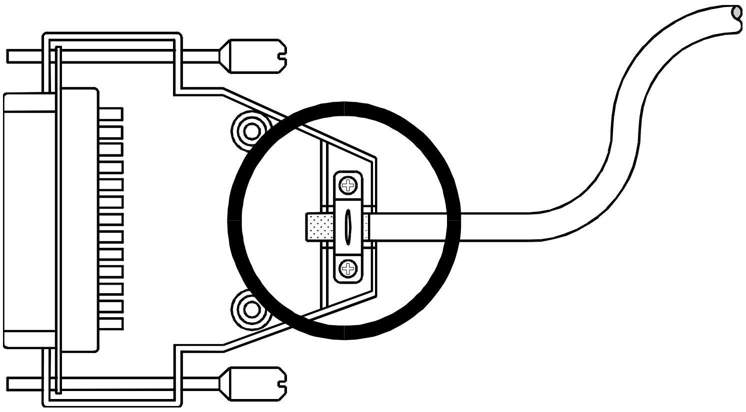


Fig. 1: Shielding in conformity with the EMC standards

Important!

To avoid malfunctions the following must be ensured:

- The shielding must be extensively clamped under a strain relief.
- The connection between the housing and the shielding must be electrically conducting.
- The distance between unshielded conductor ends must be as short as possible.

Modifications and alterations to the module

Due to safety reasons, no modifications and alterations to the JX2-PID1 module and its functions are allowed. Any modifications to the module not expressly authorised by the manufacturer will result in a loss of any liability claims to Jetter AG.

The original parts are specifically designed for the JX2-PID1 module. Parts and equipment of other manufacturers are not tested on our part, and are, therefore, not released by us. The installation of such parts may impair the safety and the proper functioning of the JX2-PID1 module.

For any damages resulting from the use of non original parts and equipment any claims with respect to liability of Jetter AG are excluded.

Malfunctions

Malfunctions or other damages are to be reported to an authorised person at once. The JX2-PID1 module must be protected from improper or inadvertent use. Only qualified experts are allowed to carry out repairs.
Safety and protective devices, e.g. the barrier and cover of the terminal box must not in any case be shunted or by-passed.
Dismantled protective equipment must be reattached prior to commissioning and checked for proper functioning.

Information signs and labels

Writings, information signs, and labels always have to be observed and kept readable.

Damaged or unreadable information signs and labels are to be exchanged.

Residual dangers

Danger resulting from electric shock!

If the JX2-PID1 module is not isolated from the mains, for example during maintenance and repair works, you can suffer from an electric shock.
Please, observe the following measure in order to avoid injuries, muscle cramps, burns, as well as possibly unconsciousness and respiratory standstill:

- Isolate the JX2-PID1 module from the mains (pull out the mains plug) when working on the control system.
- Have works on the electric and electronic system performed by qualified personnel only.

2 Operating Parameters

Environmental Operating Parameters		
Parameter	**Value**	**Reference**
Operating Temperature Range	0 °C through 50 °C	
Storage Temperature Range	-25 °C through +70 °C	DIN EN 61131-2 DIN EN 60068-2-1 DIN EN 60068-2-2
Air Humidity / Humidity Rating	5 % to 95 % No condensing	DIN EN 61131-2
Pollution Degree	2	DIN EN 61131-2
Corrosion Immunity/ Chemical Resistance	No special protection against corrosion. Ambient air must be free from higher concentrations of acids, alcaline solutions, corrosive agents, salts, metal vapours, or other corrosive or electroconductive contaminants.	
Operating Altitude	Up to 2000 m above sea level	DIN EN 61131-2

Mechanical Operating Parameters		
Parameter	**Value**	**Reference**
Free Falls Withstanding Test	Height of fall (units within packing): 1 m	DIN EN 61131-2 DIN EN 60068-2-32
Vibration Resistance	10 Hz - 57 Hz: with an amplitude of 0.0375 mm for continuous operation (peak amplitude of 0.075 mm) 57 Hz -150 Hz: 0.5 g constant acceleration for continuous operation (1 g constant acceleration as peak value), 1 octave per minute, 10 frequency sweeps (sinusoidal), all spatial axes	DIN EN 61131-2 IEC 68-2-6
Shock Resistance	15 g occasionally, 11 ms, sinusoidal half-wave, 2 shocks in all three spatial axes	DIN EN 61131-2 IEC 68-2-27
Degree of Protection	IP20, rear: IP10	DIN EN 60529
Mounting Position	Any position, snapped on DIN Rail	

Operating Parameters - Electrical Safety		
Parameter	**Value**	**Reference**
Class of Protection	III	DIN EN 61131-2
Dielectric Test Voltage	Functional ground is connected to chassis ground internally.	DIN EN 61131-2
Overvoltage Category	II	DIN EN 61131-2

Operating Parameters (EMC) - Emitted Interference		
Parameter	**Value**	**Reference**
Enclosure	Frequency 30 -230 MHz, limit 30 dB (µV/m) at 10 m distance frequency band 230-1000 MHz, limit 37 dB (µV/m) at 10 m distance (class B)	DIN EN 50081-1 DIN EN 55011 DIN EN 50081-2

Operating Parameters (EMC) - Immunity to Interference of Housing		
Parameter	**Value**	**Reference**
Magnetic Field with Mains Frequency	50 Hz, 60 Hz 30 A/m	DIN EN 61000-6-2 DIN EN 61000-4-8
RF Field, amplitude-modulated	Frequency band 27 - 1000 MHz Test field strength 10 V/m AM 80 % with 1 kHz Criterion A	DIN EN 61131-2 DIN EN 61000-6-2 DIN EN 61000-4-3
ESD	Discharge through air: Test peak voltage 15 kV (Humidity Rating RH-2 / ESD-4) Contact Discharge: Test peak voltage 4 kV (severity level 2) Criterion A	DIN EN 61000-6-2 DIN EN 61131-2 DIN EN 61000-4-2

Operating Parameters (EMC) - Immunity to Interference of Signal Ports		
Parameter	**Value**	**Reference**
Asymmetric RF, amplitude-modulated	Frequency band 0.15 -80 MHz Test voltage 10 V AM 80 % with 1 kHz Source impedance 150 Ohm Criterion A	DIN EN 61000-6-2 DIN EN 61000-4-6
Burst	Test voltage 1 kV tr/tn 5/50 ns Repetition rate 5 kHz Criterion A	DIN EN 61131-2 DIN EN 61000-6-2 DIN EN 61000-4-4

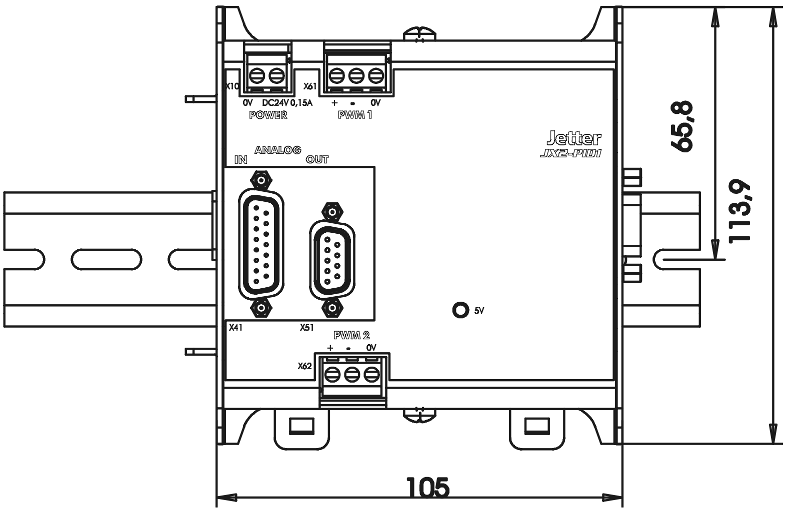
Operating Parameters (EMC) - Immunity to Interference of DC Power Supply In- and Outputs		
Parameter	**Value**	**Reference**
Asymmetric RF, amplitude-modulated	Frequency band 0.15 -80 MHz Test voltage 10 V AM 80 % with 1 kHz Source impedance 150 Ohm Criterion A	DIN EN 61000-6-2 DIN EN 61000-4-6
Burst	Test voltage 2 kV tr/tn 5/50 ns Repetition rate 5 kHz Criterion A	DIN EN 61131-2 DIN EN 61000-6-2 DIN EN 61000-4-4

3 JX2-PID1 Module

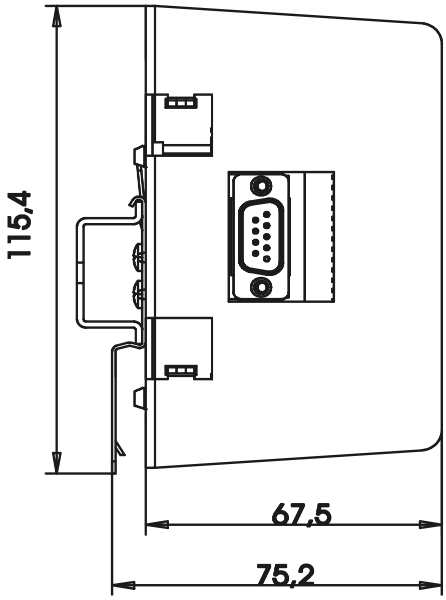
The JX2-PID1 is equipped with 8 analogue inputs (4 voltage inputs and 4 current inputs) and 4 analogue inputs. Furthermore, there are 2 bidirectional, resp. 4 unidirectional pulse-width modulation outputs (PWM outputs). The four integrated controllers are configured via software.

3.1 Mounting Dimensions of the JX2-PID1 Module

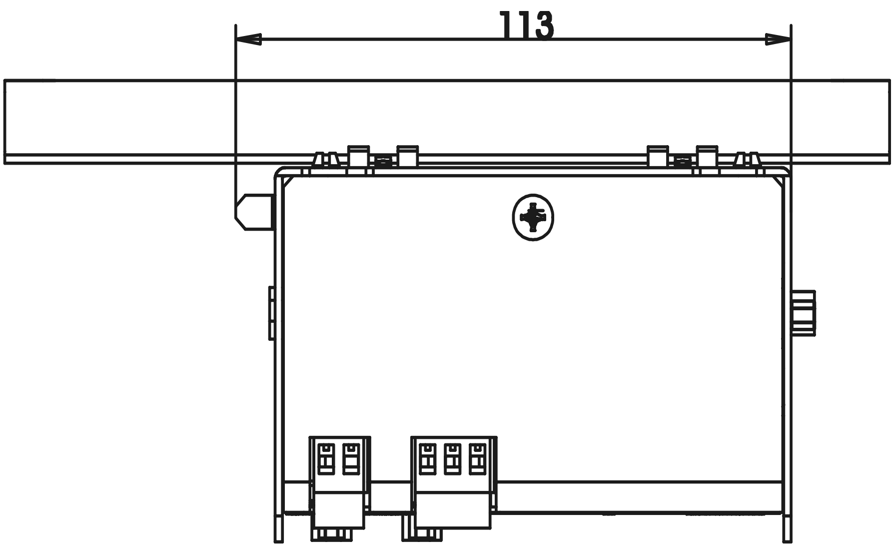
3.1.1 Front View



3.1.2 Side View



3.1.3 Top View



3.2 Technical Data

Technical Data of the JX2-PID1 Module		
Power supply		20-30 V DC at the X1 terminals
Connections to the basic unit via system bus		Male connector SUB-D, 9 pins
Dimensions (H x W x D in mm)		114 x 105 x 68
Power consumption		140 mA /+24 V
Ground		393 g
Mounting		DIN rail
Sampling time:		Minimum 2 ms per controller. When 4 controllers are activated the total sampling interval is 8ms
A/D converter	Voltage:	unipolar or bipolar: 12 bit resolution with 100 kSamples/s
	Current:	unipolar: 12 bit resolution with 100 kSamples/s
D/A converter		12 bit resolution, bipolar
Input ports:		Male connector SUB-D, 15 pins
Input quantity:		8 single ended: • 4 voltage inputs • 4 current inputs
Voltage range		• 0 V ... + 10 V • -10 V ... + 10 V
Current range		0 .... 20 mA
Heat loss of CPU logic circuit		3,5 Watt
Input resistance	Voltage:	20 kΩ
	Current:	100 Ω
Output ports:		• DAC: Male connector SUB-D, 9 pins • PWM: Screw terminal
Quantity of outputs:		• 4 analogue outputs • 4 PWM outputs
Voltage range DAC		-10 V ... + 10 V
Load current carrying capability	DAC:	10 mA
	PWM:	300 mA

Technical Data of the N-PID 1 Module	
PWM outputs (X61, X62)	Open Collector • 2 output channels per PWM+, PWM- or • 4 output channels per PWM+
Housing	Metal

The entire control performance of the four integrated controllers is controlled by a coprocessor. This coprocessor is integrated in the JX2-PID1 module.
The coprocessor controls the process, thus relieving the local intelligence of the main CPU implemented in the control system. The P, I and D parameters can be modified and combined from the control system. To the four PID controllers to be found on the module can be assigned any input and output channel combination.

The sampling rate is set to a multiple of 2 ms. The present actual values of the 8 ADC can be queried via the control system at any time. In the same way, present manipulated variables for the 4 DAC can be preset. That is why the JX2-PID1 module can also be used as analogue Input/Output module or as a mixed PID controller with additional inputs or outputs or as a sheer controller module.

3.3 Functional description

Communication with the JX2-PID1 module is made by means of read, resp. write accesses to a register set. The address of the same is made up of 3 figures.

The structure of the JX2-PID1 module is shown in Kapitel Fig. 2: "Block diagram of the JX2-PID1 module, Seite 21".

To the 8 single ended inputs is assigned a register set, in which the registers are specified functionally referring to the analogue inputs.

In theses registers individual inputs are allocated to one of the four PID controllers in order to perform actual-value acqisition.

Now, 4 PID controllers follow which are independent of each other, and which can be parameterised at will. The registers necessary for this purpose are exemplary shown for the first PID controller. Above the controllers is given a description of the algorithm according to which the controllers calculate a manipulated variable on the basis of the present actual value dependent on a preset setpoint value.

Finally, in the output register set are given all relevant registers for the analogue outputs, resp. PWM outputs. The allocation between the outputs and the 4 PID controllers is made in one of these registers in order to output a manipulated variable.

Below the 4 PID controllers are given the registers for global configuration and control of the JX2-PID1 module.

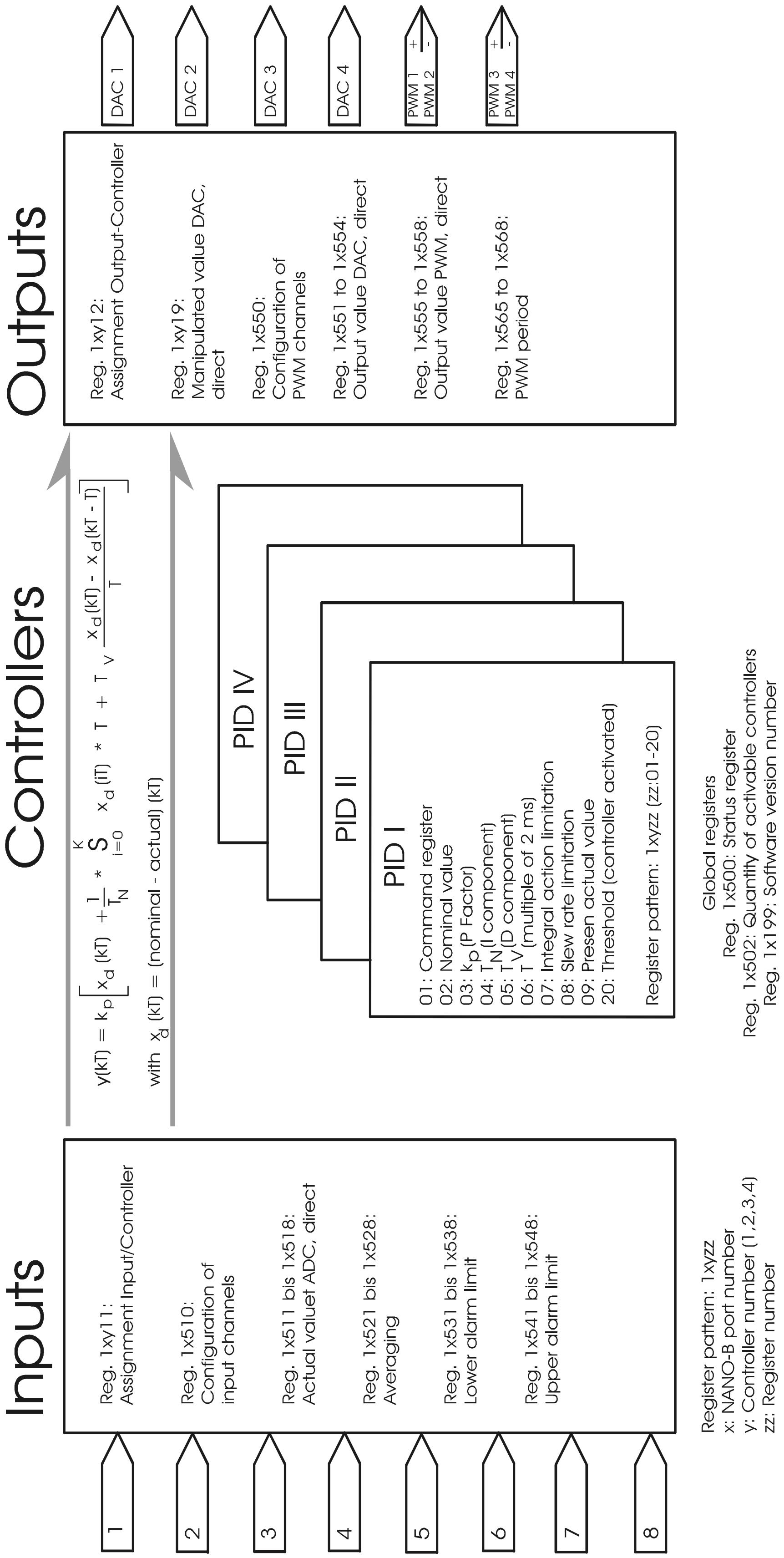


Fig. 2: Block diagram of the JX2-PID1 module

3.4 Hardware description

Functional description

The central chip of the JX2-PID1 module is the 16-bit microcontroller 80C196. This microcontroller controls the other ICs of the board and the data communication with the control system via system bus.

The analogue section of the board consists of 8 analogue inputs, 4 analogue outputs and 2 bipolar PWM switching outputs.

All possible input and output combinations can be assigned to any of the controllers. All parameters of a controller (P, I or D) can be combined and modified at will. The registers dedicated to the global control of the JX2-PID1 module enable a global configuration of the hardware.

The analogue voltages of the 8 input channels are switched to the 12-bit A/D converter via an 8 channel multiplexer. The ADC converts analogue voltages into digital numerical values.

Input circuit

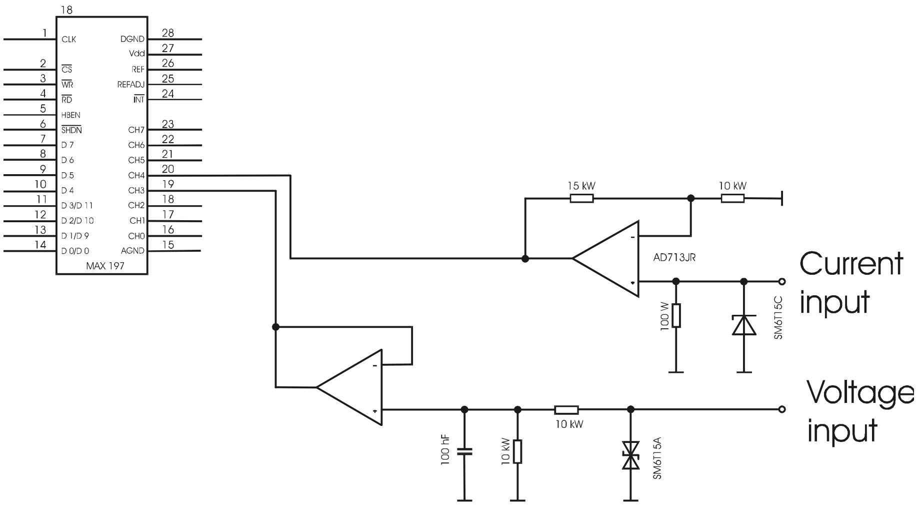


Fig. 3: Input circuit

Output circuit The analogue outputs of the JX2-PID1 module consist of 2 serial 12 bit D/A converters (DAC) with 2 channels each. These DACs convert the numerical values coming from the microcontroller into analogue voltages in the range from -10V to +10V.

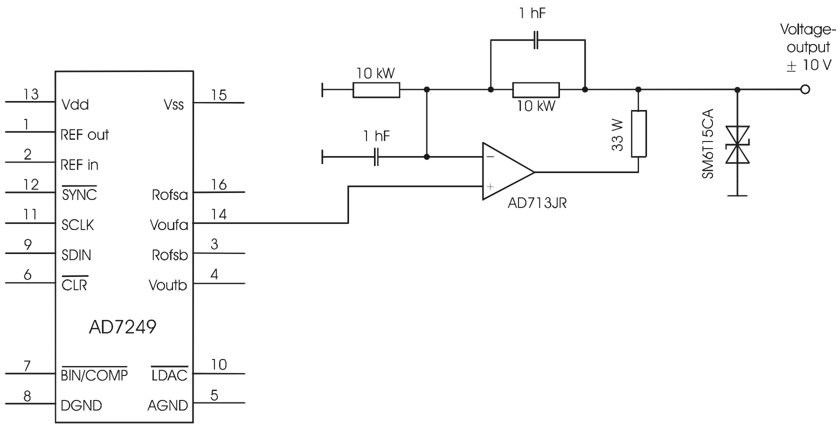


Fig. 4: Output circuit

The 2 PWM switching outputs X61 and X62 provide the manipulated variable via a PWM+ and PWM- channel each. While doing so, the open collector output must be connected to a signal voltage via a pull-up resistor. The pulse control factor of each channel corresponds to the value of the manipulated variable. Which of the channels is active depends on whether the manipulated variable is larger or smaller than zero. The PWM output circuit is as follows:

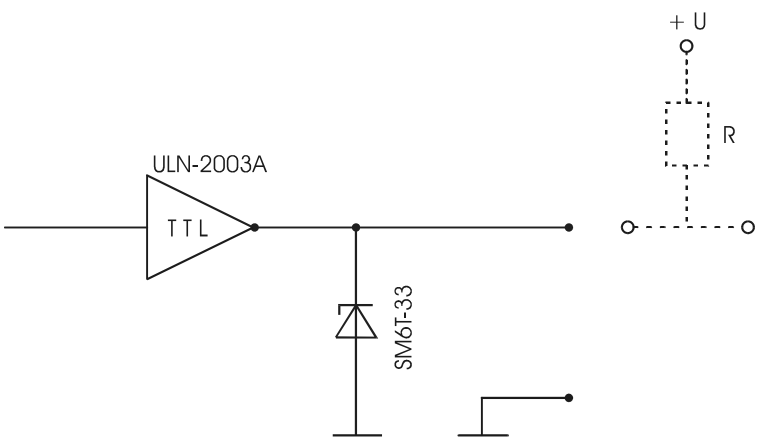


Fig. 5: Output circuit of the PWM outputs

Male SUB-D connector of the JX2-PID1 module - Assignment of output and input pins	
Input - Male SUB-D connector, 15 pins X41	
PIN	Comment
1	Voltage input 1
2	Voltage input 2
3	Voltage input 3
4	Voltage input 4
5	Current input 1
6	Current input 2
7	Current input 3
8	Current input 4
9 to 15	Ground
Output - Female connector SUB-D, 9 pins X51	
PIN	Comment
1	Voltage output 1
2	Voltage output 2
3	Voltage output 3
4	Voltage output 4
5	not assigned
6 to 9	Ground

3.5 Software description

3.5.1 Theory of the digital sampling controller

A controller serves the following basic purposes:

- The value of the manipulated variable shall follow the reference variable as accurately and instantaneously as possible (follow-up control, servo control).
- The value of the manipulated value shall correspond with the constant value of the reference variable irrespective of any external interferences (immunity to interferences).

The mathematical model of the control loop is as follows:

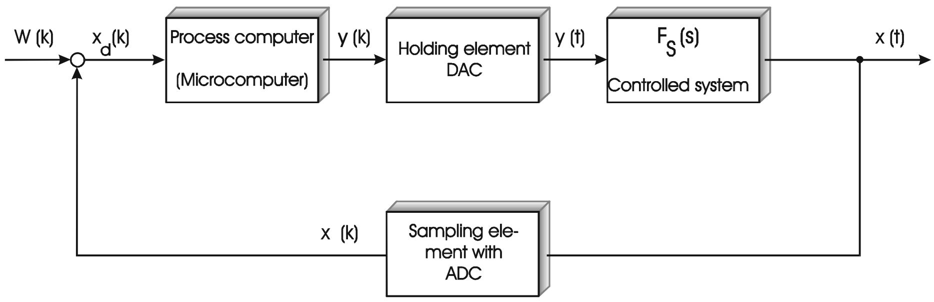


Fig. 6: JX2-PID1 module - Mathematical model of the control loop

- The time continuous signal x(t) is collected by the sampling element in fixed intervals and converted into a sequence of digitally coded numerical values x(k) by means of an ADC.
- The system deviation x_d(k) is determined by subtracting the present actual value x(k) from the setpoint value w(k).
- The processor accesses to these xd(k) values and calculates with the help of a programmed control algorithm on the basis of these values a sequence of manipulated values y(k) which are read out in regular intervals.
- The holding element stores the latest received numerical value until it is up-dated. This element converts the numerical values with the help of a DAC into a time continuous manipulated variable y(t). Therefore, the curve of the manipulated value y(t) has a stepped characteristic.

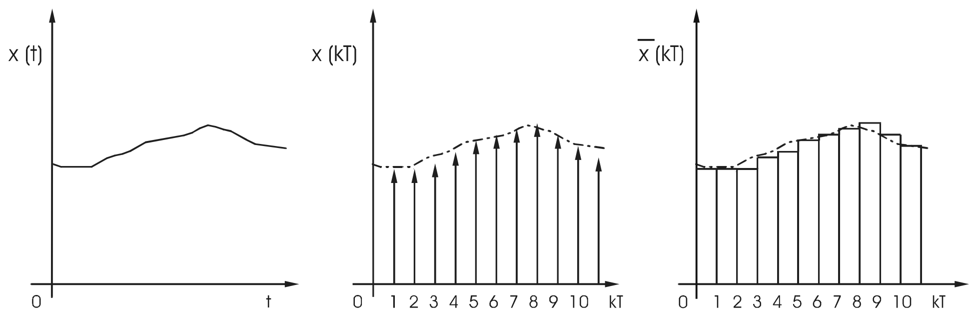


Fig. 7: Diagrams of digital sampling controllers

3.5.2 The algorithm of PID controllers

The manipulated variable is calculated on the basis of a so called manipulating algorithm. This is a discrete PID algorithm, which is presented in the following equation:

$$y(kT) = k_p\left(x_d(kT) + \sum_{i=0}^{K} x_d\left((iT) \cdot T + T_V + \frac{x_d(kT) - x_d(kT - T)}{T}\right)\right)$$

with: $x_d(kT) = (\text{nominal} - \text{actual}) \cdot (kT)$

The parameters K_p, T_n, T_v and T can be configured at will. These four parameters have the following meaning:

K_p:	Proportionality factor of the P-coefficient
T_n:	Integral-action time TN (I-component)
T_v:	Derivative action time TV(D-component)
T:	Sampling interval (period)

The other values are:

y(kT):	Manipulated variable
$x_d(kT)$:	Present system deviation
$x_d(kT-T)$:	System deviation of the last sample

As well as there is a proportionality factor for the proportional component, there are corresponding proportionality factors for integral-action and derivative components, too:

$$K_T = \frac{K_p}{T_N}$$

$$K_D = T_V \cdot K_P$$

The complete formulas for the three components of the PID algorithm are presented below. From these three equations and the manipulating algorithm result that the mathematical term is additively made up ot the P, I and D components.

Special settings of the P, I and D components of the PID controller are as follows:

- If the P component by means of the factor K_p is set to zero, no control action will take place.
- Increasing T_n the I-component will become zero.
- With the D component the factor T_v is set to zero in order to set the complete D component to zero.

$$P - \text{component} = K_P \cdot x_d$$

$$I - \text{component} = \frac{(K_p \cdot T)\sum_{i=o}^{K} x_d(iT)}{T_n}$$

$$D - \text{component} = \frac{K_p \cdot T_v}{T} \cdot (x_d(kT) - x_d(kT - T))$$

3.5.3 Register description

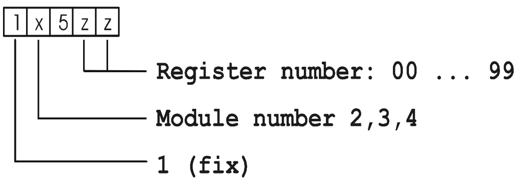
The registers are numbered from 12100 to 14599, and are physically located on the smart JX2-PID1 module. The numbers are defined as follows:

- the first digit is defined with "1";
- the second digit indicates the port number within the JX2-PID1 module;
- the third digit is the controller number of the module;
- the remaining two digits of this five-digit number define the assigned registers.

In principle, there are two different kinds of addressing registers.

- Global registers. The functions of these registers refer to the complete controller module.

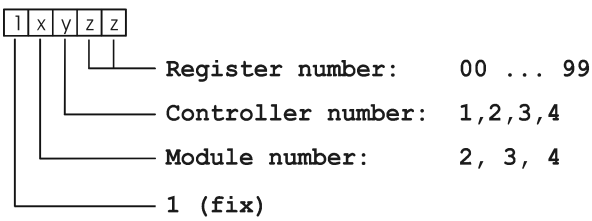
Register pattern:



Register 1x199 and all registers 1x5yy are global registers. All other registers are controller specific registers.

- Controller specific registers. The functions of these registers refer to one of the four PID controllers.

Register pattern:



3.5.4 Register table of the JX2-PID1 Module

Reg. #	Type of register	
1xy01	Command register y = 1 - 4	
1xy02	Setpoint value of the controller	unipolar: 0 ... + 4095 bipolar: - 2048 ... + 2047
1xy03	P gain (P, I, D component)	- 524288 ... + 524288
1xy04	Integral-action time T_n (I-comp.)	1 ... 131072 or 1000000
1xy05	Derivative-action time T_V (D-comp.)	- 8388608 ... + 8388607
1xy06	Sampling interval (min. 2 ms)	1 - 1000
1xy07	Integral action limitation	0 - 4095
1xy08	Slew rate limitation T (min 2 ms)	0 - 4095
1xy09	Actual value of the control algorithm	unipolar: 0 ... + 4095 bipolar: - 2048 ... + 2047
1xy10	Setpoint selection	- 2048 ... + 2047
1xy11	Assignment Input-Controller	0 - 8
1xy12	Assignment Output-Controller	0 - 8
1xy13	Controller limitation	unipolar: 1 ... + 4095 bipolar: 1 ... + 2047
1xy18	I-component	± Integral action limitation of reg. 1xy07
1xy19	Manipulated value	- 2048 ... + 2047
1xy20	Threshold activation of the controller	unipolar: 0 ... + 4095 bipolar: - 2048 ... + 2047
1x199	Software version	
1x500	Status register	bitcoded
1x501	Command register	
1x502	Quantity of activable controllers	1 - 4
1x510	Configuration of the input channels	bitcoded
1x511 - 1x518	Actual value ADC	unipolar: 0 ... + 4095 bipolar: - 2048 ... + 2047
1x521 - 1x528	Averaging	0 ... 255
1x531 - 1x538	Lower alarm limit: Input:	unipolar: 0 ... + 4095 bipolar: - 2048 ... + 2047

Reg. #	Type of register	
1x541 - 1x548	Upper alarm limit: Input:	unipolar: 0 ... + 4095 bipolar: - 2048 ... + 2047
1x550	Configuration of analogue outputs and PWM channels	bitcoded
1x551 - 1x554	Output value DAC	- 2048 ... + 2047
1x555 - 1x558	Output value PWM	- 2048 ... + 2047
1x565 - 1x568	PWM period	0 ... 10000

Note!

The structure of the above mentioned registers is presented in the Kapitel 3.6 "JX2-PID1 Structogram, Seite 54". Following the familiarisation with the mode of operation of the JX2-PID1 module this chart serves as a quick reference to the registers, and their relevant functions.

3.5.5 The registers of the JX2-PID1 module

Register 1xy01: Command register y = 1 - 4	
Function	**Description**
Read	Number of the previous command. Value following a reset: 0
Write	Transfer of a new command
Value range	-8388608 ... + 8388607

Command 1: Controller ON:
Controller y is switched on. Y indicates the controller identification digit of the register number xy01 (y = 1,2,3,4).

Command 2: Controller OFF:
Controller y is switched off. Y indicates the controller identification digit of the register number 1xy01.

Command 3: CLEAR I-component:
The I-component of the controller is cleared (I=0).

Command 4: Set I-component to registers 1x551 - 1x558:
Controller y is switched on. The values for the I-component indicated in the registers 1x551 - 1x558 are output to the manipulated variable output.

Register 1xy02: Setpoint value of the controller	
Function	**Description**
Read	If the controller is activated the present reference variable is read out by controller y. Value following a reset: 0
Write	If the controller is activated a new reference variable is transferred to the controller y.
Value range	unipolar: 0 ... + 4095 bipolar: - 2048 ... + 2047

Register 1xy03: P gain (P, I, D component)	
Function	**Description**
Read	Present gain of controller y. Value following a reset: 1000 (corresponds to a gain of 1)
Write	Specification of a new gain for controller y.
Value range	-524288 ... +524288 *)

*) K_p must not be larger than 524288.

The P gain corresponds to the proportionality factor K_p of the P controller. The P component of the PID controller results from the multiplication of the P gain by the deviation.
Within the controller the value stored in the register is divided by 1 000, i.e., to realise a gain of 1 the content of register 3 must be 1 000.

Register 1xy04: Integral action time T_n (I-component)	
Function	**Description**
Read	Present time constant T_N of controller y. Value following a reset: 1.000.000 (D-component deactivated)
Write	Specification of a new integral-action time for controller y
Value range	1 .... 1000000 *)

*) K_p / T_N must not be larger than 524.
*) K_p must not be larger than 131072.

The unit of the register value is milliseconds, i.e. a register value of 1 000 specifies an integral-action time of 1 second.

Register 1xy05: Derivative action time T_V (D-component)	
Function	**Description**
Read	Present derivative action time T_v of controller y. Value following a reset: 0 (D-component deactivated)
Write	New derivative action time T_v of controller y.
Value range	-8388608 ... +8388607 *)

*) K_p / T_N must not be larger than 524288.

The proportionality factor K_D of the D component results from the derivative action time multiplied by the gain. The unit of the register value is milliseconds.

Register 1xy06: Sampling interval T (min. 2ms)	
Function	**Description**
Read	Present sampling interval T of controller y. Value following a reset: 1
Write	New sampling interval T of controller y.
Value range	1 -1000

Register 1xy06 specifies the sampling interval of the A/D conversion for the control algorithm. The sampling interval results from the following formula:

Sampling interval T = Reg. 1xy06 • Reg. 1x502 (number of active controllers) • 2 ms

Register 1xy07: Integral action limitation	
Function	**Description**
Read	Present limitation of the I-component of controller y *) Value following a reset: 1000
Write	New limitation of the I-component of controller y
Value range	0 - 4095

*) In this register a limit for the integral action component can be specified which applies to the positive range, as well as to the negative range.

Register 1xy08: Slew Rate limitation	
Function	**Description**
Read	Present slew rate limitation of controller y. Value following a reset: 1000
Write	New slew rate limitation of controller y.
Value range	0 - 4095

The slew rate limitation specifies the maximum change of the manipulated variable per sampling interval.

Register 1xy09: Present actual value	
Function	**Description**
Read	Present actual value of the control algorithm. Value following a reset: 0
Write	Writing makes sense only if 1xy11 = 0
Value range	unipolar: 0 ... + 4095 bipolar: - 2048 ... + 2047

Register 1xy10: New precontrol setpoint value	
Function	**Description**
Read	New precontrol setpoint value Value following a reset: 0
Write	New precontrol setpoint value.
Value range	-2048 ... + 2047

*) For special applications the setpoint value is extended by the product of Reg. 1xy02 * Reg. 1xy10.

Register 1xy11: Assignment Input-Controller	
Function	**Description**
Read	Present input channel of controller y. Value following a reset: – Controller I: 1 – Controller II: 2 – Controller III: 3 – Controller IV: 4
Write	New input channel of controller y.
Value range	0 - 8 *)

*) 0 corresponds to reg. 1xy09; 1 - 8 corresponds to channel 1 - 8.
With 0 the user has to copy the present actual value into register 1xy09.

Register 1xy12: Assignment Output-Controller	
Function	**Description**
Read	Present output channel of controller y. Value following a reset: – Controller I: 1 – Controller II: 2 – Controller III: 3 – Controller IV: 4
Write	New output channel of controller y.
Value range	0 - 8 *)

*) 0 corresponds to reg. 1xy19; 1 - 8 corresponds to channel 1 - 8.
With 0 the user program has to pick up the present manipulated variable from register 1xy19.

Channel # 1 - 4: Assigment to one of the four analogue outputs.
Channel # 5 -8: Assigment to one of the four PWM outputs.

It is not possible to assign several controllers to one output channel.

Register 1xy13: Error Signal Limitation	
Function	**Description**
Read	Error signal limitation*). Value following a reset: 4095
Write	Setting of a new limit.
Value range	unipolar: 1 ... + 4095 bipolar: 1 ... + 2047

*) Error signal: Result (nominal - actual) of the present sampling cycle.

Register 1xy18: I-component	
Function	**Description**
Read	Present I-component of controller y. Value following a reset: 0
Write	Illegal
Value range	± Integral action limitation of reg. 1xy07

Register 1xy19: Manipulated value	
Function	**Description**
Read	Present manipulated value of controller y. *) Value following a reset: 0
Write	Illegal
Value range	- 2048 ... + 2047

*) The manipulated variable is computed by the controller according to the control algorithm when the controller is activated.

Register 1xy20: Threshold activation of the controller	
Function	**Description**
Read	Present threshold of controller y. Value following a reset: - 2048
Write	Present threshold of controller y.
Value range	unipolar: 0 ... + 4095 bipolar: - 2048 ... + 2047

First of all the controller is to be activated with command 1 or command 4. If the actual value (ADC) of the controller exceeds the threshold the corresponding controller starts to perform its control action. The default setting of the value -2048 guarantees that, on principle, the controller is active, except the user did specify a threshold. The registers 1x551 to 1x558 define the output value before the threshold is reached.

Register 1x199: Software version	
Function	**Description**
Read	Software version Value following a reset: Version number
Write	Illegal
Value range	23-bit-signed integer

Register 1x500: Status register	
Function	**Description**
Read	Present state of the JX2-PID1 Module. The bitcoded status register represents the states of the JX2-PID1 module. Value following a reset: 0
Write	Resetting the alarm bits.
Value range	23 bit-signed integer, bitcoded

Meaning of the individual bits

Bit 0:	Controller 1:	0 = OFF
		1 = ON
Bit 1:	Controller 2:	0 = OFF
		1 = ON
Bit 2:	Controller 3:	0 = OFF
		1 = ON
Bit 3:	Controller 4:	0 = OFF
		1 = ON
Bit 4 to 7:	not assigned	
Bit 8:	Alarm limit	Input 1
Bit 9:	Alarm limit	Input 2
Bit 10:	Alarm limit	Input 3
Bit 11:	Alarm limit	Input 4
Bit 12:	Alarm limit	Input 5
Bit 13:	Alarm limit	Input 6
Bit 14:	Alarm limit	Input 7
Bit 15:	Alarm limit	Input 8

Register 1x501: Command register	
Function	**Description**
Read	Number of the latest processed command. Value following a reset: 0
Write	Execution of a new command
Value range	- 8388608 ... + 8388607

Meaning of the individual commands

Command 1:	PWM 1 + ON: The PWM 1+ output is switched on. Only in case the controller is switched off.
Command 2:	PWM 1 + OFF: The PWM 1 + output is switched off. Only in case the controller is switched off.
Command 3:	PWM 1 - ON: The PWM 1 + output is switched on. Only in case the controller is switched off.
Command 4:	PWM 1 - OFF: The PWM 1 - output is switched off. Only in case the controller is switched off.
Command 5:	PWM 2 + ON: The PWM 2 + output is switched on. Only in case the controller is switched off.
Command 6:	PWM 2 + OFF: The PWM 2 + output is switched off. Only in case the controller is switched off.
Command 7:	PWM 2 - ON: The PWM 2 + output is switched on. Only in case the controller is switched off.
Command 8:	PWM 2 - OFF: The PWM 2 - output is switched off. Only in case the controller is switched off.

Register 1x502: Quantity of activable controllers	
Function	**Description**
Read	Present quantity of activable controllers Value following a reset: 4
Write	New quantity of activable controllers
Value range	1 - 4

By means of register 1x052 the number of activated controllers is specified.
The digit in the register defines the last activated controller. The counting direction starts from controller I.
Therefore, it is not possible to operate, for instance, only the controllers III and IV, because controller I is always active and cannot be deactivated.

The difference between controller activation by means of controller specific registers and the global activation registers lies in the fact that overall cycle time of all controllers is influenced.
If controllers are deactivated by means of their internal command registers the overall cycle time of all four controllers remain the same.
Irrespective of the register value all input and output channels are handled.

Example:

Each controller has a cycle time of 2 ms. Thus 4 controllers have a total cycle time of 8 ms. If 3 of the 4 controllers are switched off by means of the corresponding command registers the total cycle time remains 8 ms. This means: The only remaining active controller has an effective cycle time of 8 ms although the individual cycle time is 2 ms.
Using the global deactivation of individual controllers the effective cycle time of each controller is reduced. I.e., in the event that only one controller is activated its effective cycle time is 2 ms. (Reg. 1x502 = 1 for controller I).

Register 1x510: Configuration of the input channels	
Function	**Description**
Read	Configuration of the input channels
	Value following a reset: 0
	Bit 0: Input channel 1
	Bit 1: Input channel 2
	Bit 2: Input channel 3
	Bit 3: Input channel 4
Write	New configuration values
Value range	23 bit-signed integer, bitcoded*)

*) - A reset bit specifies that the input is read-in in unipolar mode.

Register 1x511 - 1x518: Actual ADC value	
Function	**Description**
Read	Present analogue input value Value following a reset: 0
Write	Illegal
Value range	unipolar: 0 ... + 4095 bipolar: - 2048 ... + 2047 (cf. Reg. 1x510)

Register and input channel assignment - Actual ADC values:

Register 1x511: Input channel 1

Register 1x512: Input channel 2

...

Register 1x518: Input channel 8

Register 1x521 - 1x528: Averaging	
Function	**Description**
Read	Present number of input values to be averaged. Value following a reset: 1
Write	New number of input values to be averaged.
Value range	0 ... 255*)

*) 0 specifies that averaging is deactivated.

Register and input channel assignment - Averaging:

Register 1x521: Input channel 1

Register 1x522: Input channel 2

...

Register 1x528: Input channel 8

Register 1x531 - 1x538: Lower alarm limit - Input	
Function	**Description**
Read	Present lower alarm limit for the input signal. Value following a reset: -2048
Write	New lower alarm limit for the input signal.
Value range	unipolar: 0 ... + 4095 bipolar: - 2048 ... + 2047

The moment the registers fall below the alarm limit the corresponding bit in register 1x500 is set.

Register and input channel assignment - Lower alarm limit:

Register 1xy06: Input channel # 1 Reg. 1x500: Bit 8)

Register 1x532: Input channel # 2 Reg. 1x500: Bit 9)

...

Register 1x538: Input channel # 8 Reg. 1x500: Bit 15)

Register 1x541 - 1x548: Upper alarm limit - Input	
Function	**Description**
Read	Present upper alarm limit for the input signal. Value following a reset: 4095
Write	New upper alarm limit for the input signal.
Value range	unipolar: 0 ... + 4095 bipolar: - 2048 ... + 2047

The moment the registers exceed the alarm limit the corresponding bit in register 1x500 is set.

Register and input channel assignment - Upper alarm limit:

Register 1x541: Input channel # 1 Reg. 1x500: Bit 8)

Register 1x542: Input channel # 2 Reg. 1x500: Bit 9)

...

Register 1x548: Input channel # 8 Reg. 1x500: Bit 15)

Register 1x550: Configuration of analogue outputs and PWM channels	
Function	**Description**
Read	Configuration of PWM channels: Bit 0: PWM 1 + and PWM 1 - Bit 1: PWM 2 + and PWM 2 - Bit 2: Analogue output # 1 Bit 3: Analogue output # 2 Bit 4: Analogue output # 3 Bit 5: Analogue output # 4 Value following a reset: 0
Write	Transfer of new configuration.
Value range	23 bit-signed integer, bitcoded*)

*) A reset bit specifies that the PWM + and PWM - channels are output in **unipolar** mode, and a set bit specifies that the PWM+ and PWM- channels are output in **bipolar** mode.
A reset bit specifies that the analogue output channels are output in **unipolar** mode, and a set bit specifies that the controlled output channels are output in **unipolar** mode.

Register 1x551 - 1x554: Analogue output value	
Function	**Description**
Read	Present analogue output value. Value following a reset: 0
Write	Transfer of a new output value for the parameter "Output value".
Value range	- 2048 .... + 2047

If a controller is activated the manipulated variable is copied into the assigned analogue output value.

Register and output channel assignment - Analogue output value:

Register 1x551: Output channel # 1

Register 1x552: Output channel # 2

Register 1x553: Output channel # 3

Register 1x554: Output channel # 4

Register 1x555 - 1x558: PWM output value	
Function	**Description**
Read	Output value PWM Value following a reset: 0
Write	Transfer of a new output value for the parameter "Output value direct".
Value range	-2048 .... +2047 *)

*) negative values make sense only with bipolar PWM outputs.

If a controller is activated the manipulated variable is copied into the assigned PWM output value register.

Register and output channel assignment - PWM output value:

Register 1x555: PWM1 +

Register 1x556: PWM1 -

Register 1x557: PWM2 +

Register 1x558: PWM2 -

Register 1x565 - 1x568: PWM period	
Function	**Description**
Read	Period Value following a reset: 100 corresponds 200 ms
Write	New PWM period
Value range	0 - 10000

The period is calculated by the following formula:

Register value • 2 ms = Period in ms

Register and output channel assignment - PWM period output value:

Register 1x565: PWM1 +

Register 1x566: PWM1 -

Register 1x567: PWM2 +

Register 1x568: PWM2 -

3.5.6 Examples of use

Example 1: Voltage measurement

In the following example a voltage is read-in via the analogue input 1 of the JX2-PID1 module.
The direct voltage value of the ADC is stored in register 12511 (value range 0 .. 4095). This value is converted into a voltage ranging from 0 V to 10V. The resulting value can be displayed on the SYMPAS set-up screen.

Note!

The following program requires that the configuration registers or other settings of the JX2-PID1 module have not been changed. The default settings following a reset have to be valid.

- Measuring input: Input 1 (Pin 1 of male SUB-D connector, 15 pins)
- Measuring range: 0 to 10V
- Read register: 12511 (actual value: 0 to 4095)
- Prerequisite: following a reset no changes have been made to the basic setting of the JX2-PID1 module; module # 2.

```
TASK 0 -----------------------------------
     REGISTER_LOAD [2810 with 2]       ;2 decimal positions
     REGISTER_LOAD [2812 with 6]       ;Characters
     DISPLAY_TEXT [#0, cp=1; "_INPUT 1:        V"]
LABEL 32
     REG 200
     =
     REG 12511                         ;Voltage input 1
     *
     1000                              ;Conversion to a range
     /                                 ;from 0 to 10.00 V
     4095
     DISPLAY_REG [#0, cp=12, Reg=200]
     GOTO 32
End of programm
```

Now register 200 can be inserted into the set-up screen where the present voltage value can be displayed.

Example 2: Voltage output

The following example program provides an analogue voltage via analogue output 1:

- Analogue output: Output 1 (Pin 1 of female SUB-D connector, 9 pins)
- Voltage range: -10V to +10V
- Output register: 12551 (output value: -2048 to +2047)
- Prerequisite: following a reset no changes have been made to the basic setting of the JX2-PID1 module.
- Module # 2

```
TASK 0 -----------------------------------
     REGISTER_LOAD [2810 with 2]       ;2 decimal positions
     REGISTER_LOAD [2812 with 6]       ;Characters
     DISPLAY_TEXT [#0, cp=1; "_Output 1:        V"]
LABEL 32
     LOAD_REGISTER [2815 with R(201)]  ;Recommended value
     USER_INPUT [#0, cp=12, Reg=200]
     REG 201                           ;Scaling from
     =                                 ;0 to 1000 (0-10.00 V)
     REG 200
```

```
10:     *
11:     100
12:     /
13:     REG 2807                    ;Entered decimal
                                    ;positions
14:     REG 12551                   ;Voltage output 1
15:     =
16:     REG 201                     ;Scaled from 0 to 1000
17:     *
18:     2047                        ;Conversion to output
19:     /                           ;range -2048 to +2047
20:     1000
21:     GOTO 32
End of programm
```

Now, different nominal values ranging from -10.00 V to +10.00 V can be entered via the LCD-display and accepted hitting the ENTER key. The resulting voltage is picked up at the analogue output 1 (pin 1 fot the male SUB-D connector, 9 pins).

Example 3: Control loop with a controlled system of 2nd order

In practice, the characteristics of many controlled systems correspond to a controlled system of 2. order. Therefore, in the following example a controlled loop was chosen, which is not ideal, and which, at best, has a transfer function of 2. order.
It is a damped oscillating circuit with the following values:

Time constant: $T_1 = \sqrt{L \cdot C}$

Damping: $d = \dfrac{R}{2 \cdot \sqrt{L/C}}$

Gain: $K = 1$

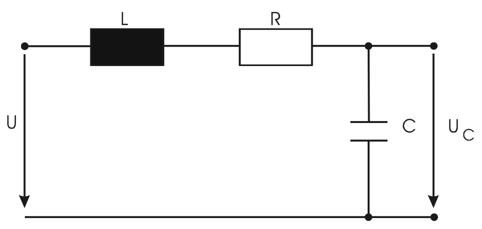


Fig. 8: Oscillating circuit

The values of the oscillating circuit elements are as follows:

R = 8,8Ω	(T = 36,9 ms)
L = 100 mH	(d = 1,6)
C = 13.6 mF	(K = 1)

The electrical arrangement corresponds to the mechanical arrangement shown below with the following values:

R = 0,623 Ns/mm
m = 36,9 kg
c = 1 mm/N

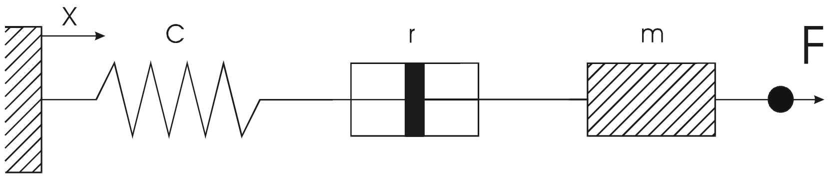


Fig. 9: Mechanical model

In general, the exact parameters of the controlled system are not known. Therefore, two approximation methods for the adjustment of a PID controller described in literature are briefly presented below.

The following program is used to initialise the JX2-PID1 module and to set the parameters. In the following program the JX2-PID1 module has the module # 2.

```
 0:  TASK 0 -----------------------------------
 1:       CLEAR_FLAGS [1 to 3]
 2:       REGISTER_LOAD [12502 with 1]      ;only one controller
                                            ;is activated
 3:       REGISTER_LOAD [12106 with 1]      ;sampling
                                            ;interval=2ms
 4:       REGISTER_LOAD [12111 with 1]      ;Input 1 assigned to
                                            ;Controller 1
 5:       REGISTER_LOAD [12112 with 1]      ;Output 1 assigned to
                                            ;Controller 1
 6:       REGISTER_LOAD [12101 with 1]      ;switch controller 1
                                            ;ON
 7:  LABEL lSelection
 8:       -FLAG 3
 9:    WHEN
10:       FLAG 1                            ;go to
11:       OR
```

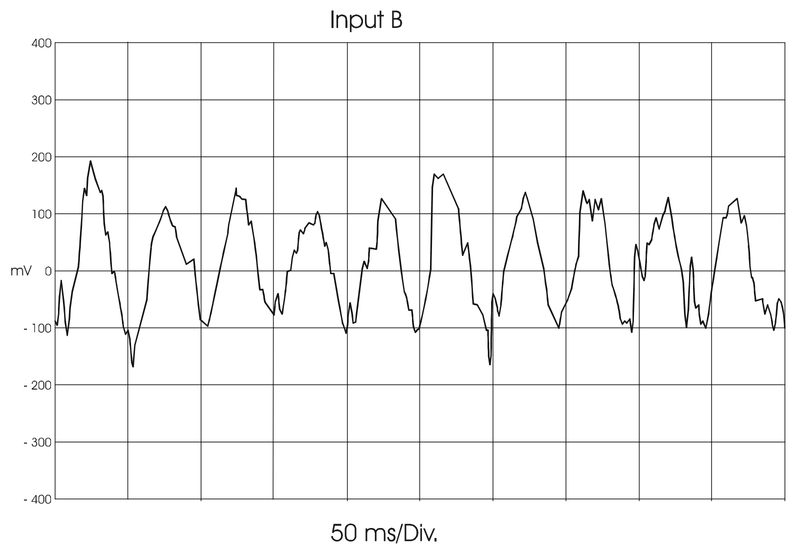
```
      FLAG 2                             ;determination of
                                         ;parameters
    THEN
  IF
      FLAG 2
    THEN
      GOTO sParameter
    THEN
LABEL lControlled system
      REGISTER_LOAD [12101 with 2]       ;Switch controller 1
                                         ;OFF
      REGNULL 12551                      ;and output set-
                                         ;point value "zero"
      DELAY R(511)
LABEL lGoto_Input
      -FLAG 1
      LOAD_REGISTER [12551 with R(510)]  ;input step
                                         ;-positive
      DELAY R(511)                       ;settling time
      REGISTER_LOAD [12551 with 0]       ;input step
                                         ;-negative
      DELAY R(511)                       ;settling time
  WHEN
      FLAG 1                             ;once again
                                         ;input step
      OR
      FLAG 3                             ;return
    THEN
  IF
      FLAG 3
    THEN
      REGISTER_LOAD [12101 with 1]
      GOTO lSelection
    THEN
      LABEL lGoto_Input
      ;
LABEL lParameter                         ;output impulse with
                                         ;given parameters
```

```
43:       -FLAG 2
44:       LOAD_REGISTER [12103 with R(503)]  ;preset Kp
45:       LOAD_REGISTER [12104 with R(504)]  ;preset Tn
46:       LOAD_REGISTER [12105 with R(505)]  ;preset Tv
47:       LOAD_REGISTER [12102 with R(502)]  ;upper nominal value
48:       DELAY R(500)                       ;settling time
49:       LOAD_REGISTER [12102 with R(501)]  ;lower nominal value
50:       DELAY R(500)
51:    WHEN
52:       FLAG 2                             ;repeat para-
                                             ;meterisation
53:       OR
54:       FLAG 3                             ;return
55:     THEN
56:    IF
57:       FLAG 2
58:     THEN
59:       GOTO sParameter
60:     THEN
61:       GOTO lSelection
End of programm
```

In line 2 of the initialising sequence (line 2-6) only one controller is activated. From this global configuration instruction results that, on the whole, only one controller can be activated. But it is not activated, yet. The only reason why register 12502 is set to 1 is to achieve an adjustable sampling interval of 2 ms in register 212106. Since the time constant of the controlled system should always be greater than the sampling interval, the shortest possible sampling interval is to be selected here.
The other initialisation values correspond to the electrical arrangement of the controlled system.

a) Adjustment criteria according to Ziegler and Nichols

The controller is switched on, and the I as well as the D components are deactivated (in the given case register 12104 = 1000000, register 12105 = 0). With this method the P gain (register 12103) is increased until the control loop produces continuous oscillations.
This function is realised in Abb. 10 with a setpoint value of 3.33 V(register 12102 = 333) of the SYMPAS set-up mode.



Y = 100mV/cm (AC), TB = 50ms/cm

Fig. 10: Continuous oscillation according to Ziegler and Nichols

This continuous oscillations appears at a P gain of 55 (register 12103 = 55000). This P gain is called critical controller gain (K_{pkr}), the period of oscillation is called critical period time (T_{kr}). In the given example the critical period time (T_{kr}) is 50 ms.

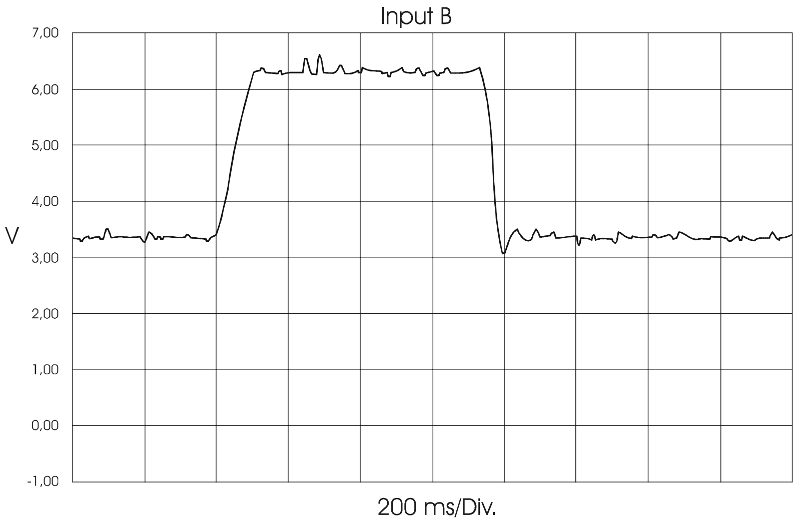
The PID parameters of the 1. approximation result from the following formulas (according to Ziegler and Nichols):

$K_p = 0{,}6\ K_{pkr}$	= 0,6 • 55000 = 33000
$T_n = 0{,}5\ T_{kr}$	= 0.5 • 50 ms = 25 ms
$T_v = 0{,}125\ T_{kr}$	= 0.125 • 50 ms = 6.25 ms

In order to test these approximation values the third part of the example program is used. For this purpose, the following values are loaded into the corresponding registers:

Register 1x500 = 8	Settling time
Register 1x501 = 670	Lower setpoint value (3.3 V)
Register 1x502 = 1300	Upper setpoint value (6.4 V)
Register 1x503 = 33000	P gain
Register 1x504 = 25	Integral action time
Register 1x505 = 6	Derivative action time

This partial program is started by setting flag 2. The CPU specifies to the PID module a setpoint value alternating between 333 and 666 with a time interval of 800 ms until flag 3 will be set. The result is shown on the following plot:



Y = 1 V/cm (DC), TB = 200 ms/cm

Fig. 11: Alternating setpoint value acc. to Ziegler and Nichols

This method results in a slightly overshooting response.

b) Adjustment criteria according to Chien, Hrones and Reswick

For this approximation method the response of the controlled system has to be known. The response is determined in the second part of the sample program. This subprogram starts when flag 1 is set. It gives an step input signal with a value specified in register 510 to the controlled system. After a period of time specified in register 511 it sends an input signal of 0 V. During this procedure, the controller is switched off. Each time flag 1 is set, this procedure is repeated. As soon as flag 3 is set this subprogram will be exited.

From the values

Register 1x510 = 1023	5 V at the output of the PID module
Register 1x511 = 20	2 s settling time

results the following step-response of the controlled system:

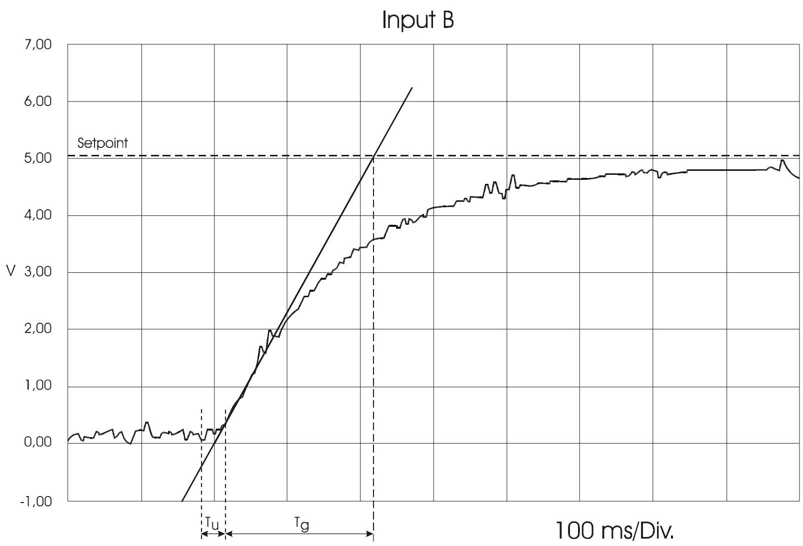


Fig. 12: Step response of the controlled system

For this controll method the delay time T_u and the compensation time T_g have to be determined on the basis of the step response.

The results are:

T_u = 17,24 ms, T_g = 220 ms.

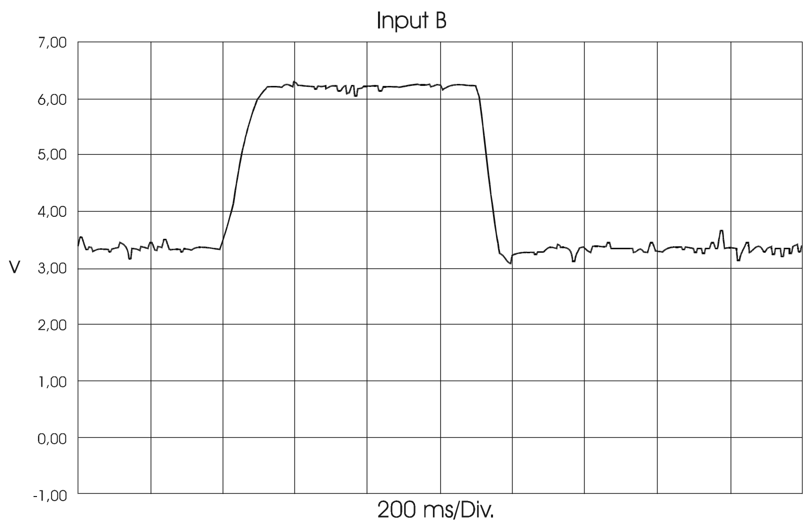
The controller parameters of the first approximation are calculated on the basis of the following equation with K_s = 1:

Kp = 0,6 Tg /(Tu * Ks)	= 0,6 * 220 ms/ 17,24 ms = 7,657
Tn = Tg	= 220 ms
Tv = 0,5 Tu	= 0,5 * 17,24 ms = 8,62 ms

These values are entered in the 3rd subprogram into the registers 1x503 to 1x505 as follows:

Register 1x503 = 7657	P gain
Register 1x504 = 220	Integral-action time
Register 1x505 = 9	Derivative-action time

The result is the control response shown in Abb. 13 :



Y = 1 V/cm (DC), TB = 200 ms/cm

Fig. 13: Alternating setpoint value acc. to Chien, Hrones and Reswick

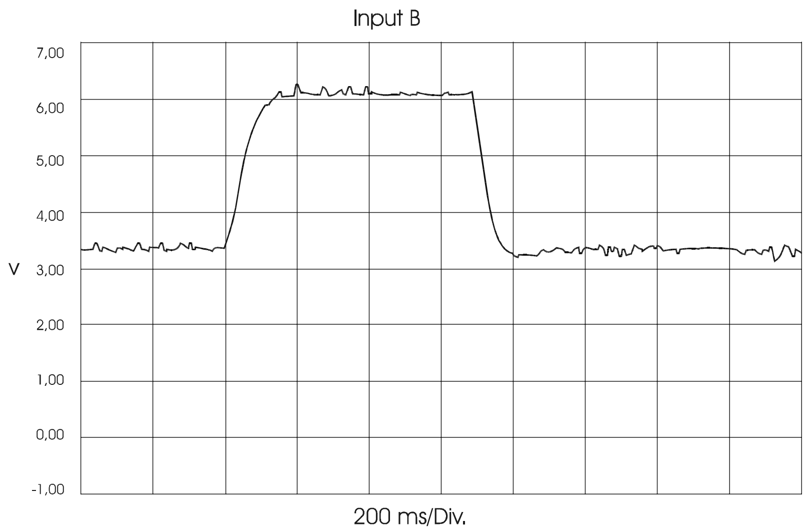
Overshooting is slightly lesser than it was with the previous method.

Proceeding from one of the both methods a manual optimisation can be carried out with the third subprogram. For this purpose, the values in the registers 1x503 to 1x505 are modified in the set-up mode. The corresponding results can directly be seen at the output of the controlled system.

A proper control response of the given system can be achieved with the following values:

Register 1x503 = 4000	P gain
Register 1x504 = 250	Integral action time
Register 1x505 = 6	Derivative action time

The resulting control response is shown in the following figure:



Y = 1 V/cm (DC), TB = 200 ms/cm

Fig. 14: Alternating setpoint value optimised according to Chien, Hrones and Reswick

3.6 JX2-PID1 Structogram

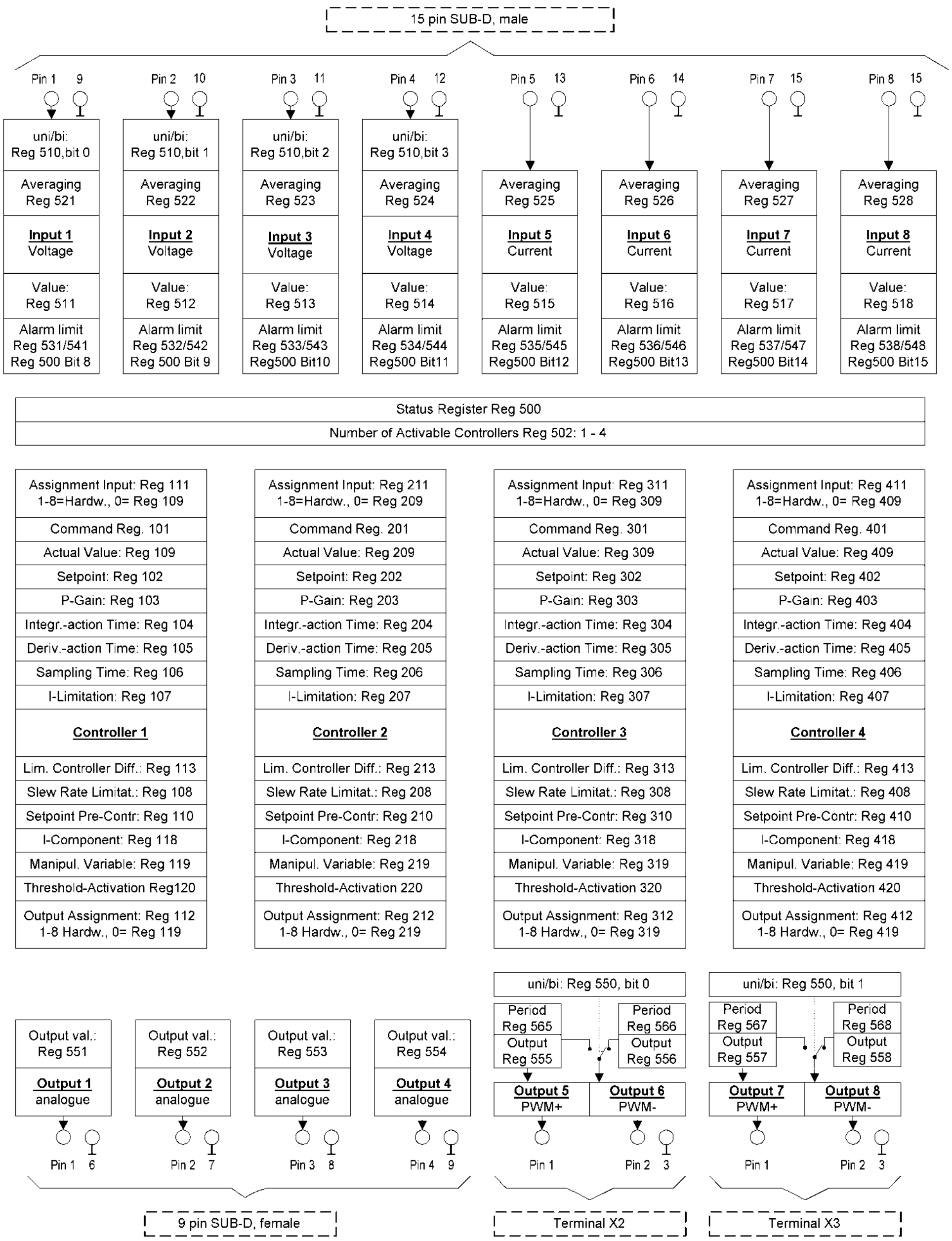


Fig. 15: Schematic register layout 1xyzz

Appendices

Appendix A: Glossary

Analogue	A parameter, e.g. voltage, which is steplessly adjustable. Contrasted with digital.
Digital	Presentation of a parameter, e.g. time, in the form of characters or figures. This parameter in digital representation can be changed in given steps only. Contrasted with analogue.
Electro-Magnetic Compatibility	Definition according to the EMC regulations: "EMC is the ability of a device to function in a satisfactory way in electro-magnetic surroundings without causing electromagnetic disturbances itself, which would be unbearable for other devices in these surroundings."
Integer	Also called "integral number". A positive or negative whole number, e.g. 37, -50 or 764. In programming "Integer" stands for a type of data representing whole numbers. Calculations with integers are considerably faster than calculations with floating point numbers. Therefore, integers are commonly used for counting and numbering procedures. Integers can have a leading sign (positive or negative) or be unsigned (positive). In addition to this, distinction is made between long and short integers depending on the number of bytes they occupy in the memory. Short integers comprise a smaller range of numbers (e.g. - 32,768 to +32,767) than long integers do (e.g. - 2,147,483,648 to +2,147,483,647). On Jetter controllers 24 bit = -8,388,608 to + 8,388,607.
Process	A program or a part of it. A related sequence of steps carried out by program.
Process level	Level of a system overriding the field level.
Pull-Up resistors	A functional resistor generating defined states for measurements and evaluations. Such a resistor pulls up the potential to a high level in contrast to a pull down transistor pulling down the potential to the ground.
Register	A high-speed memory for a group of bits placed in a microprocessor or in another electronic device where data can be buffered for a specific purpose. On JETTER controllers, usually, these are 24 bit wide storage positions in a remanent RAM.
Sensor	Electronic detector, pick-up.
Slave	A device, e.g. a JetControl 241 controller, which is controlled or influenced by another device called "Master", e.g. a JetControl 243 controller.
TASK	An individual application or sub-program which can be executed as an independent unit.

Timeout	The amount of time the system will wait for a peripheral device to respond before it detects and reports this as an error.

Appendix B: List of abbreviations

A/D	**A**nalog/**D**igital
AC	**A**lternating **C**urrent
ADC	**A**nalog-to-**D**igital **C**onverter
CPU	**C**entral **P**rocessing **U**nit
D/A	**D**igital/**A**nalog
DAC	**D**igital-to-**A**nalog **C**onverter
EMC	**E**lectro **M**agnetic **C**ompatibility
ESD	**E**lectro **S**tatical **D**ischarge
Gnd	**G**rou**nd**
I/O	**I**nput/**O**utput
IEC	**I**nternational **E**lectrotechnical **C**ommission
LC	**L**iquid **C**rystal
LCD	**L**iquid **C**rystal **D**isplay
LED	**L**ight - **E**mitting **D**iode
ms	**M**illi**s**econd
NUM 25	Keyboard module for LCD 16 user interface
PID	**P**roportional-**I**ntegral-**D**ifferential (controller)
PWM	**P**ulse **w**idth **M**odulation
SELV	**S**afe **E**xtremly **L**ow **V**oltage: Voltage up to 60 V, galvanically separated from the network.
PLC	**P**rogrammable **L**ogic **C**ontroller
SUB-D	Type name of a plug-in connector

Appendix C: Index of Illustrations

Appendix D: Index