



## IP 244 Temperature Controller with Function Block FB 162

### Manual

Order No. 6ES5998-2AB21  
Release 03

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Fabrik-Nr./Serial Number/N° d'usine

### Software-Produkt/Software Product/Logiciel

Produktname/Name/Nom du logiciel

Version/Ausgabestand, Version/Release,  
Version/édition

Serien-Nr./Serial number/ N° de série

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## SIMATIC S5

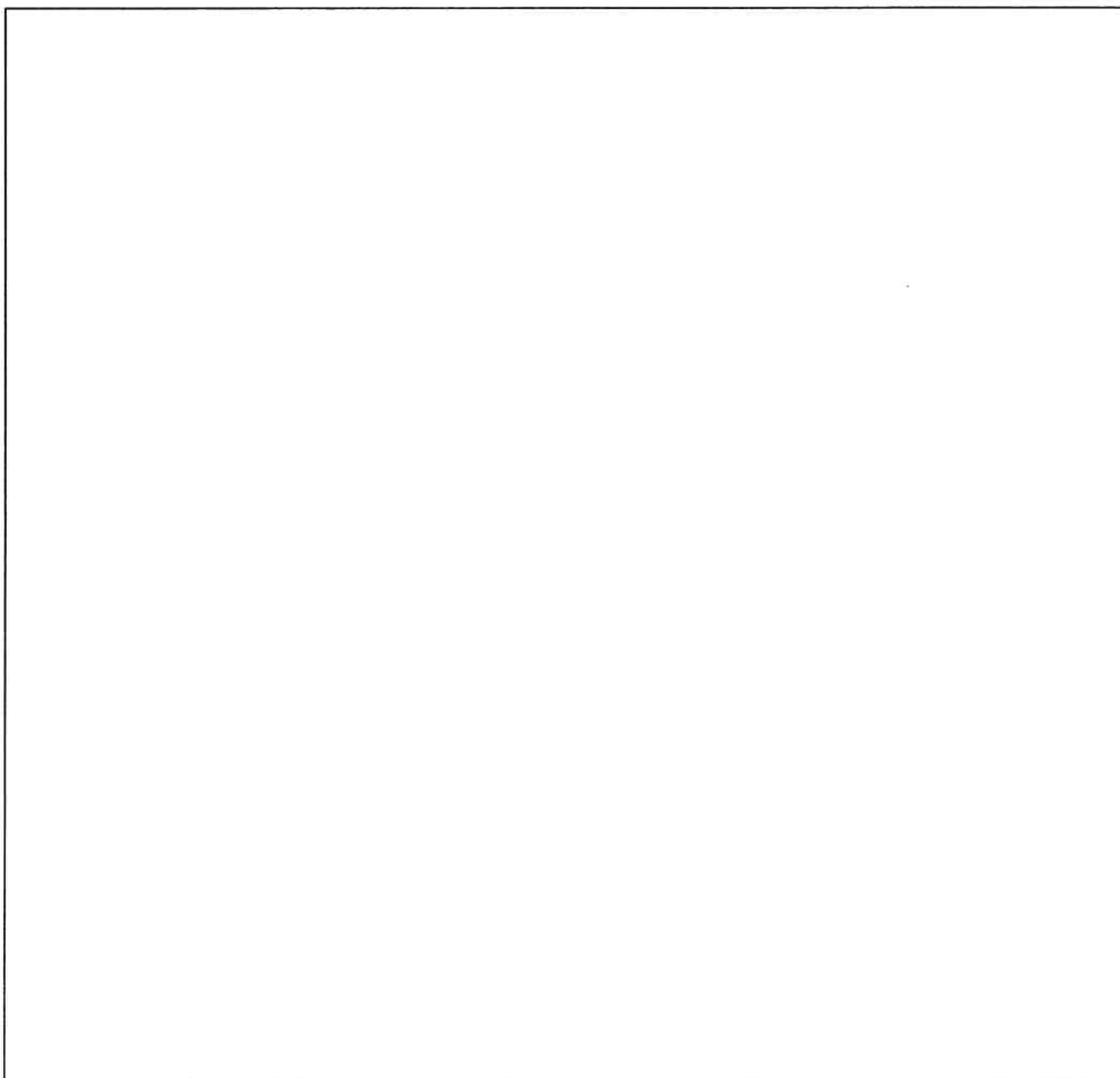
### IP 244 Temperature Controller

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Notes

Order No. C79000-B8576-C477-02

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**Notes on the use of the manual**

Closed-loop control with the IP 244 module does not only mean the use of an 'intelligent I/O module' from the SIMATIC S5 product family. It also means the FB 162 software package for commissioning and operation of the controller module from a programmer via the interface of the central controller to the programmable controller. IP 244 thus means a well-tuned system which, due to its complexity, requires careful preparation and training.

In order to make the manual as easy as possible to use, it has been subdivided into different functional sections. The most important tool during the commissioning phase, the FB 162 program package, has been designed such that wrong operations are blocked and explained.

- 1) The '**IP 244 Instructions**' explain the hardware requirements including the specification of the environmental and supply conditions.
- 2) The '**IP 244 Programming Instructions**' describe the function of the firmware on the module and its programming. These instructions are the basis for the user to determine the necessary parameters and their allocation for the data exchange between PC and module.
- 3) The '**Programming Instructions of the FB 162 function block**' discuss the program package for parameterization and test of the IP 244 temperature control module using a programmer.
- 4) With the **Test program for the IP 244 temperature control module FB 99** the user can test the complete operation of the IP 244.

The software consists of the following parts:

Organization blocks	OB 1, 20, 21, 22
Function blocks	FB 99, 162
Data blocks	DB 111, 112

After successful commissioning, the user can accept the programs from the modules OB 1, 20, 21, 22, and FB 99 into the user program. The data blocks DB 111 and DB 112 can also be modified according to the requirements of the system.

To achieve smooth commissioning, the following items should be observed:

- The program package is stored on the diskette delivered with the system and can be loaded via the programmer into the central unit of the PC. Now the user can enter a parameter set.

Using the function block, this parameter set is then transferred into the temperature control module. Individual functions can now be tested and control functions can be started by connecting analog signals.

The FB 162 is now ready for communication and data exchange with the temperature control module. Temperature control operations can obviously only be performed after the module has been fully connected.

- When working with the FB 162, you will find terms such as 'operating mode', 'control parameter' or 'limit value'. A detailed explanation of these terms and the basic operation concept of the IP 244 control module can be found under 'Terms and Definitions' on the following pages.
- During the specification of the parameters and entry in the data blocks DB-A or DB-B it is helpful to have the summary of the messages and their structures at hand. This summary can be found at the end of this manual.

**Terms and Definitions**

Automatic optimization Automatic setting	In order to achieve a good result, the controller parameters are automatically adjusted to the given task according to a mathematically described performance index.
Back-up	Battery back-up of storage supplied by the programmable controller.
Cascaded control	Series connection of loop controllers. The first controller (master controller) specifies a setpoint value for the subsequent controllers or influences their manipulated values according to the measured actual value.
Cold start	At a cold start the parameters are always transferred to the module after the system is switched on.
Comparator	In this case: comparison of the voltage at channel 13 with an internally specified voltage.
Control algorithm	Calculation program stored in the EPROM; simulates a PID controller
Control byte	8-bit information to control the module function; each bit is allocated to a different function.
Conversion time	Time between start and end of an analog-digital conversion.
Correction profile	In the case of cascaded control, a weighting factor is specified for each controller which defines the setpoint influence of the master controller on subsequent controllers. This factor is measured for the intensity of the control action. The correction profile results from this factor.
CPKL-N	Central processor ready (CPKL = 1 initiates reset).
CPU	Central processor unit.
D	Derivative-action component for the loop controller.
Data block	Data list for the function block.
Disturbance response	In order to achieve a homogeneous quality, the loop controller must be able to settle disturbances of the process quickly.

Dual-slope method	Method for analog-digital conversion. First the measured voltage is integrated for 20 ms or $16\frac{2}{3}$ ms, then a reference voltage is integrated. The measured value is proportional to the duration of the reference integration.
EPROM	Program memory; contains the loop controller program; can only be read.
Error byte	8-bit information; each bit is allocated to a specific error (1 = error).
Firmware	Program stored on the module.
Function block	Program package in the SIMATIC S5 programmable controller.
Heating/cooling ratio	Specification to take into account the different intensity of the heating/cooling interference in three-position controllers. See Programming Instructions for IP 244, 'Messages 0 to 12'.
High-byte	Higher significant part of a 16-bit word.
Hot channel control	Special control procedure for plastic extruder machines.
I	Integral-action component for the loop controller.
I/O area	Address range for I/O modules in the PC.
Integration time	Time for the measurement of the input voltage
Interpolation	Simulation, approach.
L+	24 V connection; positive pole (load voltage).
L-	24 V connection; reference point.
Low byte	Least significant part of a 16-bit word.
Lowering setpoint value	Second setpoint value, e.g. to facilitate night lowering.
Manipulated variable (S)	Percent time value of the sampling rate, results from the calculation of the control algorithm.
Manual operation	The manipulated value is not calculated by the computer (which is switched off) but specified as percent value.
Manually manipulated variable	Percent time value, which is issued as a manipulated variable when the controller is switched off (manual operation).



Master control byte	See 'control byte'
Master controller	See 'cascaded control'.
Message	In this case, a set of data with 31 bytes (for parameters, measured values etc.) (data block).
MU	Transducer; converts a physical quantity into an electric signal.
Multiplexer	Switch for the selection of the analog input channels.
Open-circuit monitoring	Break of a line to the temperature sensors (thermocouple or Pt100) or break of a sensor.
P	Proportional component for the loop controller.
Parallel structure	Special kind of controller structure (in this case: kind of mathematical consideration); P, I and D component act in parallel and are then added.
Parameter	Definition of characteristics and influence quantities for the variable adaptation of the controller response to the process.
Percent output	Output of the computed manipulated variable (output variable of the controller) in the form of a time value in percent of the sampling interval. (Cf. 'pulse-width modulation').
PESP	Address group signal for the addressing of I/O modules.
Process identification	Determination of system-specific characteristic values to guarantee a good controller setting.
Pt100	Platinum resistance thermometer (100 $\Omega$ at 0°C to DIN 43760).
Pulse setting	Suppression of mains interference
Pulse-width modulation	See 'percent output'.
RAM	Random access memory (user memory); reading and writing possible.
Ramp gradient	In this case: specified temperature rise per time unit.
Reference point temperature	Reference temperature for the thermocouple voltage (see 'thermocouple').

Restart	New start of the central controller after a power failure. The response of the PC is programmed through the organization blocks OB 20, 21, 22 (see manual for the programmable controller).
Rugged controller	The rugged controller is a PID controller with the following additional features: It has an oscillation detector and a so-called predictor, i.e. the expected actual value is pre-computed and the controller reacts to it. The controller parameters of the rugged controller depend on the operation point and the current system deviation.
Setpoint step-change	Input of a new setpoint with a different value to the old one.
Setpoint value rounding	In order to lessen the effect of a setpoint step-change, this change is not specified in the form of a step change but with a selectable ramp gradient.
Setpoint values	Desired temperature values which are to be kept by the loop-control.
Short-circuit group alarm	Red LED which indicates a short-circuit at one of the digital outputs.
Software version	Version of the program stored in the EPROM.
Special version	Special operating mode in connection with plastic extruder machines (additional description required). Additionally, it controls the reading of measured values in channels 13 and 14.
Status byte	8-bit information; each bit is allocated to a specific error (1 = error).
Subordinate control loop	Loop controllers which are influenced by a master controller in the case of cascaded control.
Sum setpoint value	The setpoint values which are really effective at the subordinate control loop (in the case of cascaded control).
Symmetric/asymmetric systems	When the configuration of the measuring device (thermocouple) is (spacially) symmetric to the heating or cooling, then the controlled system is symmetric, else asymmetric. (e.g. extrusion heating with split strip-type heater and a thermocouple in between.
System deviation	Difference between entered setpoint value and measured actual value.
T <sub>A</sub>	Sampling interval.

$T_D$	Derivative action time (describes D response).
Temperature compensation value	If temperatures are measured with a thermocouple, the voltage generated by the element is related to the temperature difference between measuring point and reference point. The temperature compensation value specifies the correction of the measured value by the reference point temperature (see 'thermocouple').
Thermocouple	Temperature sensor out of two different metals (such as iron or constantan); supplies a voltage which depends on the temperature difference between sensor head and connection point (= reference point; temperature at terminal = reference temperature).
Three-position controller	Loop controller with two switching contacts as output (heating, OFF, cooling, 3 switching states).
Three-wire circuit	Method of connecting resistance-type sensors for the compensation of the line resistance.
$T_N$	Reset time (describes integral-action response).
Tolerance values	Temperature values above and below the desired temperature (setpoint); if the actual value exceeds or falls below these values, messages are generated to start specific counter measures.
Transfer RAM	Memory on the temperature control module; the PC as well as the microprocessor on the module can read or write data from or to this memory.
Two-position controller	Controller with one switching contact as output (2 switching states).
$T_Z$	Filter time constant for the damping of the derivative action influence.
U-Batt	Backup voltage at the bus connector of the module to supply the memory in the case of a power failure.
Watchdog	The program generates a signal if it runs properly. If this signal is missing, a fault in the program execution has occurred.

Wind-up effect

If a manipulated variable of more than 100% is calculated, the integration (I component) is interrupted. Thus a faster adaptation of the controller to the desired temperature setpoint value is possible when the manipulated values return to values below 100%.

Zone control

The control action to the desired temperature value (setpoint) is only performed within the specified temperature range (defined by upper and lower zone limit).



## SIMATIC S5 IP 244 Temperature Control Module

**6ES5244-3AA13**

Instructions

Order No. C79000-B8576-C351-03

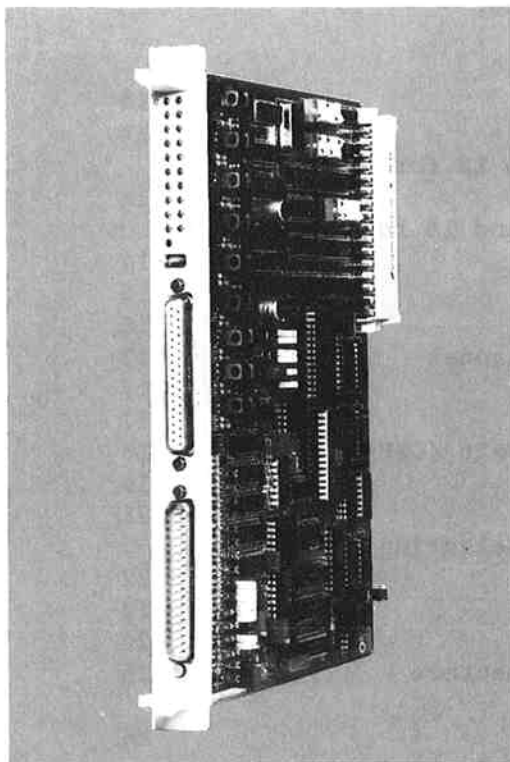


Fig. 1 Temperature control module IP 244

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## 1 Technical Description

### 1.1 Range of Application

The temperature control module 244 can be used in programmable controllers and expansion units SIMATIC S5-115 U, S5-135 U, S5-150 U, and S5-210 A as an intelligent I/O module to perform control tasks for machine control systems. With the PC 115 U, an additional adapter casing is required (order no. 6ES5 491-0LA11). The IP 244 module is used in S5 systems for temperature control or for acquisition and limit value monitoring of analog signals from field devices. The manipulated variables are output as binary signals. A special application of the module is as a temperature controller of plastic extruder machines, under consideration of the ambient temperature, together with monitoring the pressure and the closing force.

Voltage sensors may be connected to 16 analog input channels (Channels 0 to 15).

Upon delivery, the channels 0 to 12 are parameterized for thermocouples (0 to 51.2 mV), the channels 13 and 14 are set up for the acquisition of transducer signals of 0 to 20.48 V.

Channel 15 (compensation channel) is initiated for the connection of a Pt 100 resistance thermometer; it is required for the compensation of the reference point temperature.

The signals sensed at the channels 13 and 14 are not controlled but monitored for their tolerance. In addition, a comparator compares the signal of channel 13 with a limit value. The factory setting of the comparator is  $10.24 \text{ V} \cong 1024 \text{ units}$ .

The manipulated value is output in binary mode (pulse-width modulation).

The 18 output driver stages can directly operate actuators or relays (rated output current 120 mA).

The module can be used as a stand-alone controller if the PC fails.

### 1.2 Design

The temperature control module 244 is a compact module in the double-height Euroformat of the ES 902 rack system with a 48-way base connector. The base connector forms the interface to the bus of the SIMATIC S5 or MC 210 systems.

A 37-pin connector type "D" for the analog inputs (X3) and a 37-way socket connector for the digital outputs and the digital input (X4) are located on the the front panel. Two cables (with a connector at the module side and open wires for the field devices) are available for connection (see spare parts list, Chapter 3.6).

L+ (24 V load voltage) is supplied via a tab connector on the front panel. L- is connected to the reference potential of the controller (central neutral point in the cabinet). L- is fed to the module via the M<sub>ext</sub> pin (external earth).

20 green LEDs on the front panel signal the status of the temperature control module, of the input and the outputs. A red LED indicates a short-circuit of one or several digital outputs.

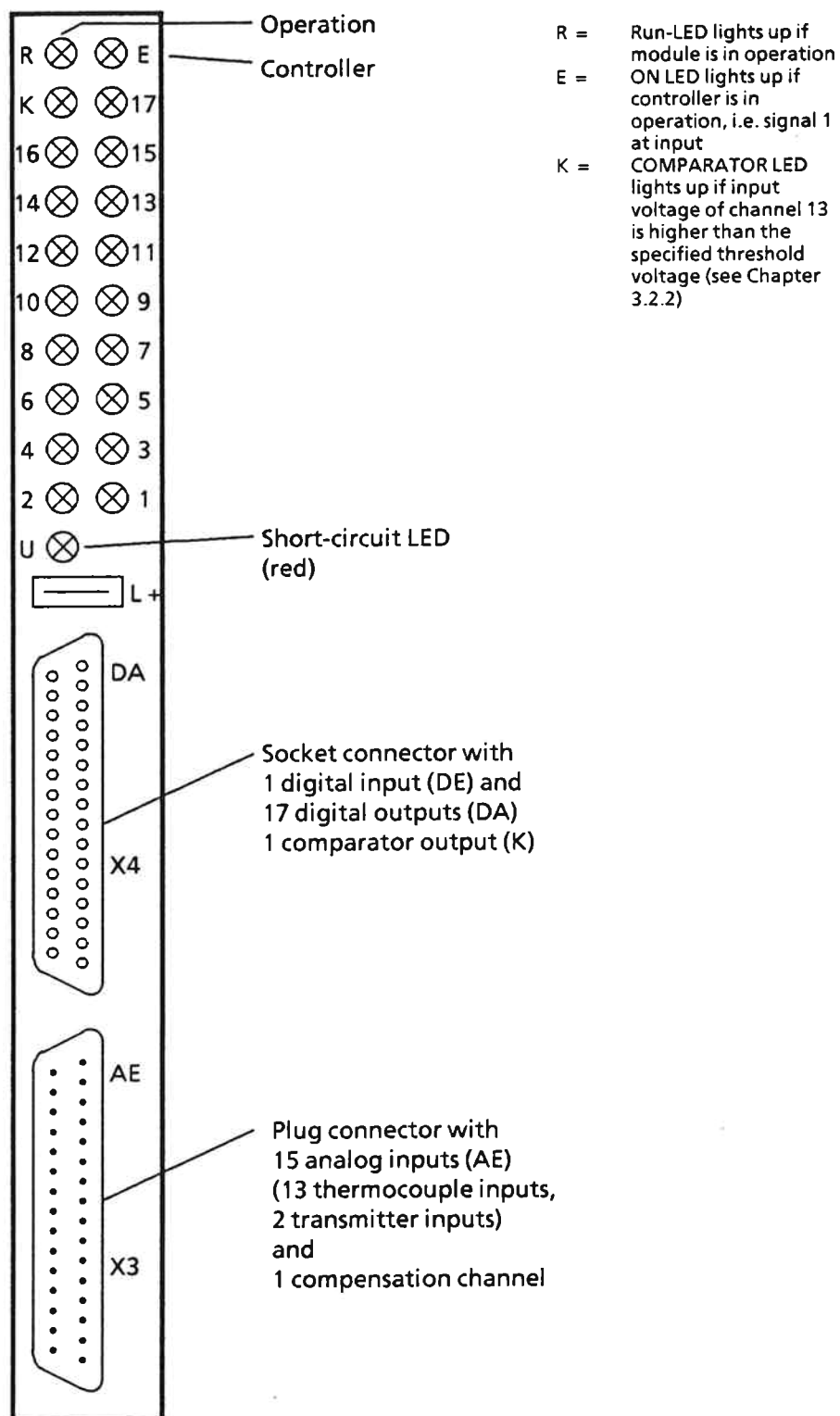


Fig. 2 Front panel

### 1.3 Mode of Operation

A multiplexer connects the analog input signals to an analog-digital converter (see block diagram, Fig. 3). According to the dual-slope method the ADC digitizes the input voltage at a conversion rate of max. 60 ms. The 13 control circuits are processed cyclically. Before each digitization the signal lines are checked for open-circuit conditions; detected faults are signalled.

An open-circuit condition is detected if the entire line resistance is  $>1$  kohm and if the thermocouple has a contact resistance of  $>1$  kohm against reference potential. An open-circuit indication is not possible if voltage dividers or shunt resistors for measuring range conditioning have been used (upon delivery, no open-circuit indication is possible for channels 13 and 14).

The parameters and control commands which are transferred from the CPU via the data bus are stored in a 1024 byte RAM area. This area is subdivided into 32 messages of 32 bytes each. The module occupies 32 bytes; 32 addresses are thus occupied in the address area of the PC.

A microprocessor controls the functional sequence of the controller module according to the operating program (firmware). This program is stored in a 64 kbyte EPROM.

The calculated manipulated variables are issued to output driver stages via an output register in a binary (pulse-width modulated) manner. The module is reset if the 5 V power supply fails or in the case of the signal  $CPKL = 1$ .

If the 24 V load voltage fails, the module continues its operation. However, the digital outputs cannot be switched any more. The signal  $NAU$  is not interpreted by the module.

Using the  $BASP$  signal, the digital outputs can be switched off; the register contents are maintained.

#### RAM backup by $U_{BATT}$

The values of the controller integrator are backed up if the controller module has been inserted in a slot with battery backup ( $U_{BATT}$ ). The module itself detects whether this is the case or not. If this backup facility is to be used for the temperature control with the controller module 244, the following points should be observed when the controller module 244 is parameterized by the PC:

- a) Bit <sup>2'</sup>21 of the master control byte 4 must be set 'on' by the PC if the PC is switched on for the first time or if the PC has detected a failure of the battery backup during mains failure. The bit is reset by the IP 244.
- b) The IP 244 places a request for parameters (bit 6 of <sup>status</sup>control byte 1 set 'on') upon power return after a power failure. This bit is reset after the parameters have been transferred.

The microprocessor ( $\mu P$ ) executes the individual functions of the controller module:

- Measurement via multiplexer and ADC.
- Processing of measured values according to the control algorithm (generation of system deviation, calculation of manipulated variable, automatic optimization).
- Monitoring the measured values for limit values and generation of alarms.
- Output of manipulated variable via registers and output driver stages.
- Calculation of the temperature compensation value according to the reference point temperature (Pt 100).
- Comparing an analog input value with a digital value (shut-down for limit value monitoring).
- Processing of the interface to S5 or MC210 system bus.

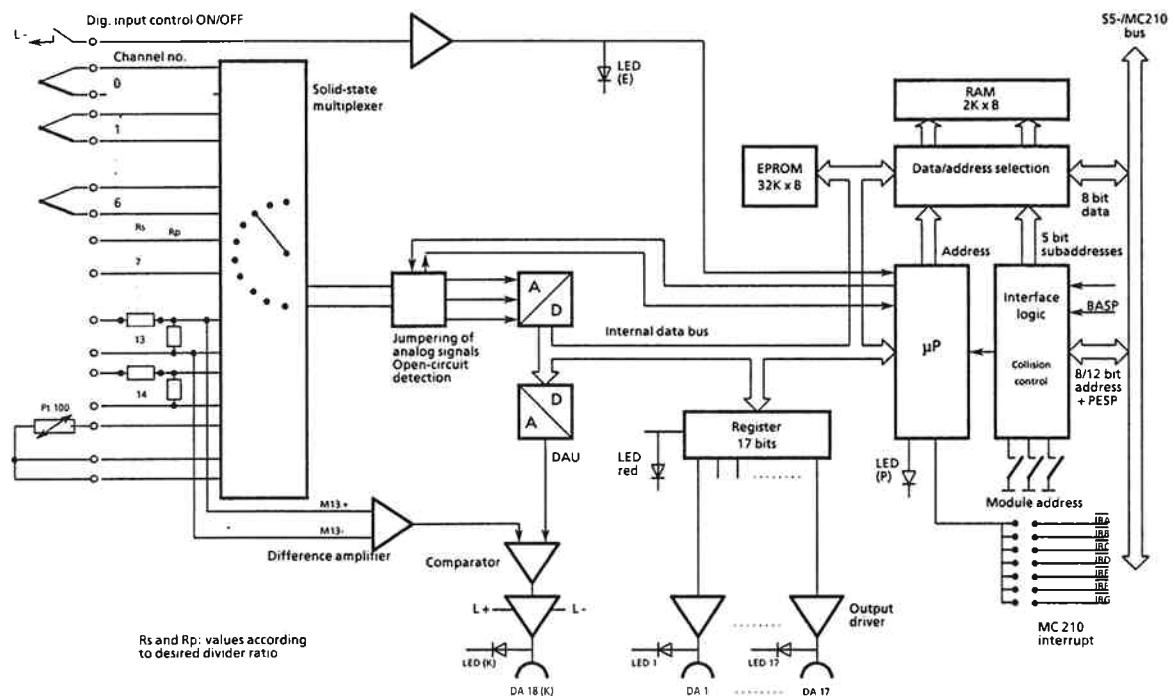


Fig. 3 Block diagram temperature controller -244-3AA13

The module can be used as a switching two- or three-position controller with percent output according to the control algorithm stored in the EPROM.

The control response (P, PI, PD, PID) is defined by the entry of the appropriate parameters. The data (setpoint values and parameters) exchange between the central controller and the temperature control module is achieved via 32 messages with a length of 32 bytes each.

## 1.4 Specifications

Power supply	+5 V $\pm 5\%$
Consumption from +5 V	approx. 650 mA (550 to 700 mA)
$U_{BATT}$	necessary for automatic setting
MC-210 address bus	PESP + 12 bits
S5 address bus	PESP' + 8 bits
<b>Analog inputs</b>	
Number of input channels and input voltages upon delivery	
- 0 to 51.2 mV = 2048 units for thermocouples	13 (channels 0 to 12)
Fe-constantan (type L), NiCr-Ni (type K) and Pt10%Rh-Pt (type S) according to DIN 43710)	
- 0 to 20.48 V $\Delta$ 2048 units	2 (channels 13 and 14)
- For Pt 100 resistance thermometer in 3-wire circuit for the compensation of the reference point temperature (-10 to +80°C)	1 (channel 15)
Galvanic isolation	No
Permissible potential difference between field devices and reference potential of the controller ( $U_{CM}$ )	$<1 V_{PP}$
Max. permissible input voltage without destruction	$\pm 18$ V for channels 0 to 12 $\pm 60$ V for channels 13 and 14 0 V for channel 15 (passive devices only)
Current rating for Pt 100	$<1.5$ mA
Input resistance	
at 0 to 50 mV	$>10$ Mohm
at 0 to 20 V	$>50$ kohm
Error, related to the rated value (internal)	
Linearity	$\pm 1$ unit
Digitization error	$\pm 1$ unit
Inversion error	$\pm 1$ unit

Noise suppression for 50/60 Hz mains frequency; common-mode noise	-86 dB, max. 1 V <sub>PP</sub>
normal-mode interference	-40 dB, max. 100 % of measuring range; related to peak value
Additional error by voltage divider for channels 13 and 14	±0.25 %
Temperature influence (range 0 - 50 mV)	1°/°C / 10 K (2 units / 10 K)
Additional error by temperature influence for channels 13 and 14 (temperature coefficient of the voltage dividers)	0.5°/°C / 10 K (1 unit / 10 K)
Error messages for exceeding tolerances, overflow or open-circuit	Yes
Recognition of open-circuits	Yes, for field devices with R <sub>i</sub> < 1 kohm
Measuring principle	Integrating (dual slope with multiplexer in incoming circuit)
Resolution (internal)	11 bits + sign (value and sign) 2048 units
Conversion time	Typ. 50 ms 40 ms for 0 60 ms for 2048 units
Integration time at 50 Hz mains frequency at 60 Hz mains frequency	20 ms 16 2/3 ms
Max. permitted line length	50 m, screened (recommended maximum length, which may be exceeded if appropriate measures to avoid voltage interferences have been taken).
Comparator channel	(Permanent connection to channel 13)
Rated input voltage	10.24 V
Resolution	1024 units (1 unit = 10 mV)
Perm. potential difference	< 1 V <sub>PP</sub>
Time constant	Typ. 0.2 ms
Error	< 0.5 %

Comparator output (K)

Digital output 18,  
specifications as digital  
outputs 1 to 17**Digital input (heating switch)**

Input voltage

at signal 0 (control off)

-2 to +4.5 V

at signal 1 (control on)

+13 to +35 V

Input current

5 mA

(rated value at 24 V)

Delay

Max. 5 ms

**Digital outputs**switching to P  
potential

Number of outputs

18

Galvanic isolation

No

Supply voltage (rated value)

DC 24 V

Max. permissible range of the  
supply voltage

DC 20 to 30 V

Ripples  $U_{pp}$ 

Max. 3.6 V

Breaking voltage (inductive)

Limited to -1 V

Breaking current

120 mA; (0.2 to 120 mA)  
short-circuit proof, current  
limiting at approx. 500 mA)

Switching capacity for lamps

Max. 2.4 W

Leakage current at signal 0

Max. 20  $\mu$ AMax. perm. line length <sup>1)</sup>400 m without screen  
1000 m screened**Mechanical features**

Dimensions

Double Euroformat

Width

1 1/3 SPS (20 mm)

Weight

Approx. 0.3 kg

1) recommended maximum length, which may be exceeded if appropriate measures to avoid voltage interferences have been taken.

**Environmental conditions**

Operating temperature	0 to 55°C
Storage and transport temperature	-40 to +70°C
Relative humidity	Max. 95 % at 25°C no condensation
Altitude	Max. 3500 m above sea level



## 2 Installation

### 2.1 Inserting and Removing the Module

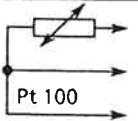
The central controller, the expansion units, and the field devices must be switched off when the module is inserted or removed.

### 2.2 Connection of Signal Lines and Power Supply

The signal lines are connected to the connectors on the front panel. The braiding of screened cables is connected to the metallic part of the connector hood. The screen must be connected to the screen rail in the cabinet.

Chapter 3.6 Spare Parts contains ordering information regarding cables for analog inputs and digital outputs. The 24 V connection is provided by a receptable B2.8-1 DIN 46247.

#### 2.2.1 Analog Inputs (plug connector X3)

Input voltage	Channel no. (AE)	Conn. M+	Pin No.	Conn. M-	Pin No.	Example parameterization
0-50 mV	0	M0+	1	M0-	20	Two-position controller
0-50 mV	1	M1+	2	M1-	21	
0-50 mV	2	M2+	3	M2-	22	
0-50 mV	3	M3+	4	M3-	23	
0-50 mV	4	M4+	5	M4-	24	
0-50 mV	5	M5+	6	M5-	25	
0-50 mV	6	M6+	7	M6-	26	
0-50 mV	7	M7+	8	M7-	27	
0-50 mV	8	M8+	9	M8-	28	
0-50 mV	9	M9+	10	M9-	29	Three-position controller
0-50 mV	10	M10+	11	M10-	30	
0-50 mV	11	M11+	12	M11-	31	
0-50 mV	12	M12+	13	M12-	32	
0-20 V/mA	13	M13+	14	M13-	33	Not used
0-20 V/mA	14	M14+	15	M14-	34	
	15	0 V M- M0+	16 17 35			Pt 100 compensation

### 2.2.2 Digital outputs and 1 digital input (socket connector X4)

Function	Pin no.	Example param.	Function	Pin no.	Example parameterization
DE controller off	1	L+ = High at input L- = Low at input	L+	20	Do not connect load here; pin 20 is linked to pin 1 via a switch
DA 1	2	R12 cool. heat.	L-	21	Three-position controller
DA 2	3		L-	22	
DA 3	4	R11 cool. heat.	L-	23	
DA 4	5		L-	24	
DA 5	6	R10 cool. heat.	L-	25	
DA 6	7		L-	26	
DA 7	8	R 9 cool. heat.	L-	27	
DA 8	9		L-	28	
DA 9	10	R 8 heat.	L-	29	Two-position controller
DA 10	11	R 7 heat.	L-	30	
DA 11	12	R 6 heat.	L-	31	
DA 12	13	R 5 heat.	L-	32	
DA 13	14	R 4 heat.	L-	33	
DA 14	15	R 3 heat.	L-	34	
DA 15	16	R 2 heat.	L-	35	
DA 16	17	R 1 heat.	L-	36	
DA 17	18	R 0 heat.	L-	37	
DA 18 (K)	18				

R = Loop controller  
K = Comparator output

The example shown in the tables contains 9 two-position controllers and 4 three-position controllers.

With the S5 115, the lines of connector pins 21 to 37 are to be connected to 0V (M rail), i.e. reference potential, using the adequate adapter casing.

Depending on the parameterization of the controllers, the 17 digital outputs are assigned subsequently as two-position or three-position controllers without leaving any gaps.

The table above shows an example.

In the case of cascaded control, DA 17 is reserved for the master controller (two-position controller).

### 3 Operation

#### 3.1 Wiring of the Analog Inputs

The analog signals are connected via the front panel connector X3. 16 differential inputs with overvoltage protection are available.

Note: Analog inputs not used must be short-circuited and connected to M (reference potential) to avoid undesired interferences.

##### 3.1.1 Input Wiring of the Channels 0 to 12 for Thermocouples (0 to 51.2 mV = 2048 units resolution)

If the thermocouple is non-floating (not insulated), the potential difference  $U_{CM}$  must not exceed 1 V  $V_{SS}$ .

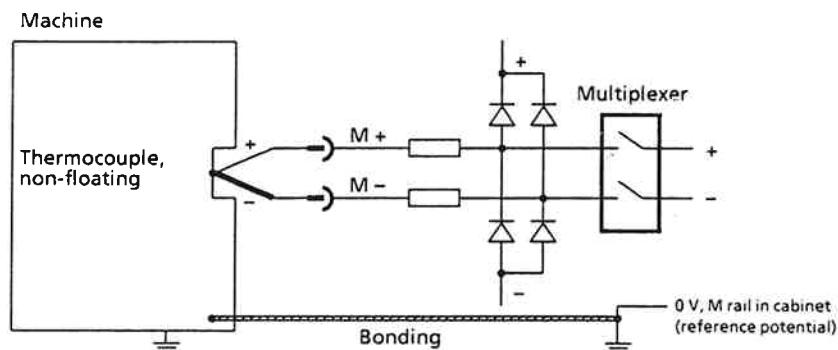


Fig. 4 Input wiring for non-floating thermocouple

The connection between the negative pole of the module and the M rail in the cabinet (reference potential) must be as short as possible if the thermocouple is floating.

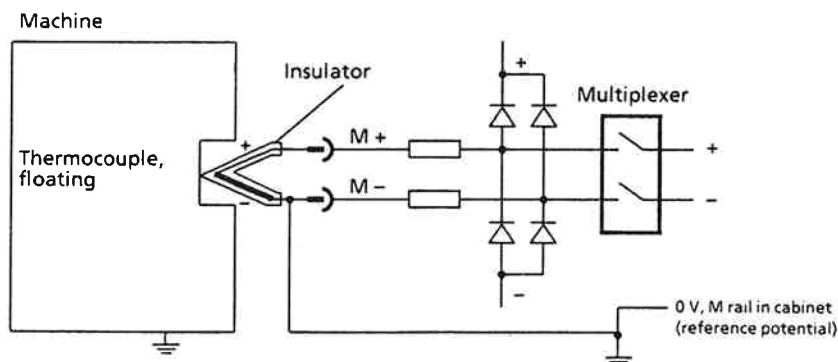


Fig. 5 Input wiring for floating thermocouple

##### 3.1.2 Input Wiring of the Channels 13 and 14 for Transmitters (0 to 20.48 V $\approx$ 2048 units resolution)

The resistors  $R_V$  and  $R_S$  form a voltage divider (400:1) which is connected in series to the inputs. This defines a signal range from 0 to 20.48 V. Different voltage ranges require different voltage dividers.

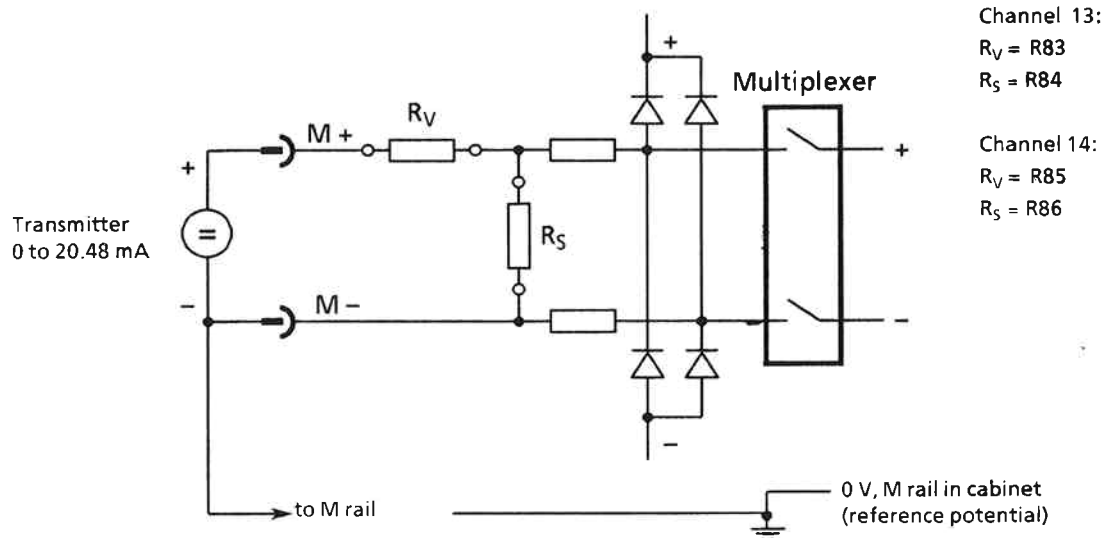


Fig. 6 Connection of floating field devices for 0 to 20.48 V

### 3.1.3 Input Wiring for Channel 15 (compensation channel)

Channel 15 provides a connection for a Pt 100 resistance thermometer in a three-wire circuit. The Pt 100 measures the reference point temperature. For this purpose, the Pt 100 resistance thermometer must have thermal contact with the terminals where the thermal wires and the copper wires are connected. The temperature values determined by the thermocouples of the channels 0 to 12 are corrected by the microprocessor using the value of the reference point temperature. These corrected values are then the actual values for the closed-loop control.

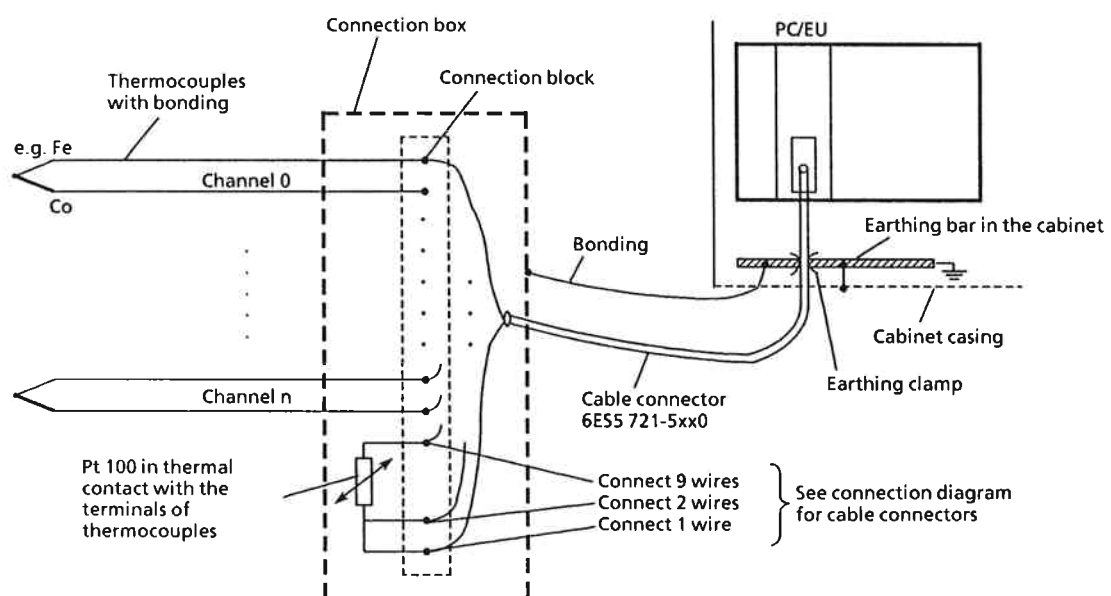


Fig. 7 Arrangement of thermocouple and Pt 100 for compensation

In the factory, the bridge circuit has been balanced to  $0^{\circ}\text{C} = 0 \text{ mV}$ . If a three-wire connection cable with a cross-section of  $3 \times 1.5 \text{ mm}^2$  is used, a cable length of 50 m results in an alignment error of  $<1.5^{\circ}\text{C}$ .

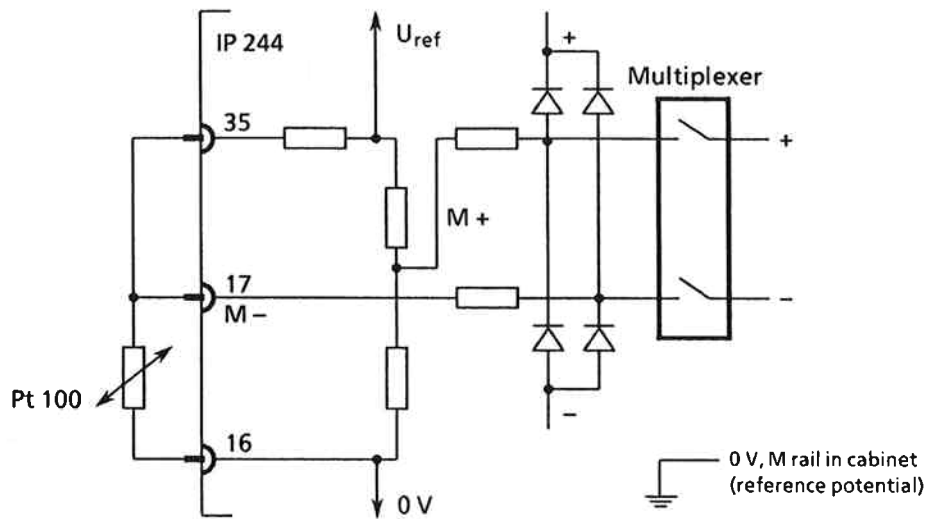


Fig. 8 Connection of a resistance thermometer for reference point temperature compensation

#### 3.1.4 Open-circuit Monitoring

Open-circuit monitoring is performed for the analog inputs 0 to 12 and 15.

For this purpose, a short-time test current is fed through the measuring loop and checked.

The source resistances of the field devices must be less than 1 kohm to ensure proper results. One side of the field devices must be connected to earth (see Chapter 3.1).

Depending on the parameterization, an emergency program can be started which switches over to replacement thermocouples.

## 3.2 Digital Outputs and Comparator Channel

### 3.2.1 Digital Outputs

18 short-circuit-proof outputs which are protected against interference voltages are available for the output of the manipulated variables. LEDs on the front panel indicate the status of the output stages. (See Section 2.2.2 for pin assignment of the socket connector X4).

If the 5-V supply is connected, the controller outputs react once and for a short time. The blinking of the LEDs can be tolerated since the reaction of heating circuits or contactors is slow.

If a short-circuit occurs at one or several outputs, a red group short-circuit indicator (LED) lights up on the front panel (see Fig. 2).

### 3.2.2 Comparator Channel

A comparator channel with the digital output DA 18 (K) is connected in parallel to the analog input channel 13 to perform a limit value monitoring.

The signal applied to analog input 13 is amplified by a differential amplifier. A comparator compares this signal with the signal which is defined as limit value by the microprocessor via a digital-analog converter.

If the input voltage of channel 13 exceeds the limit value (with 10 bits resolution) defined by the microprocessor, the digital output DA 18 (K) is switched on.

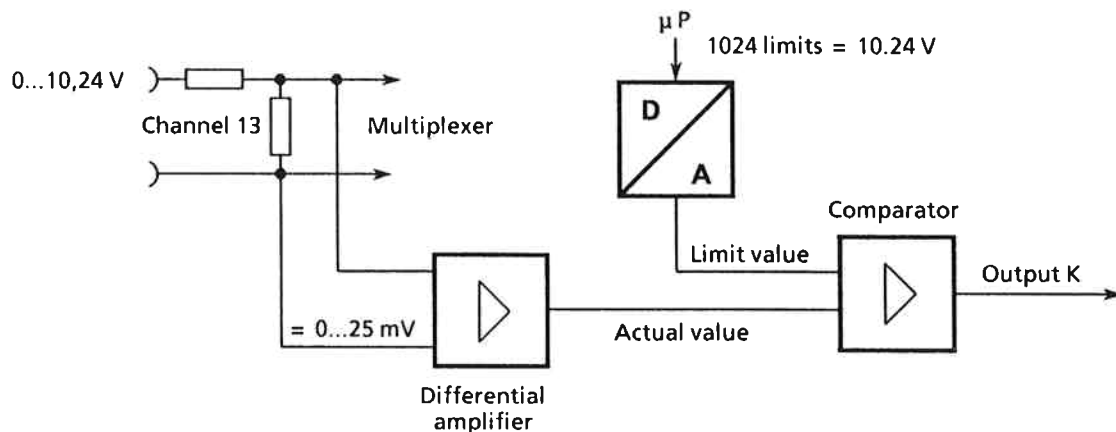


Fig. 9 Operation of the comparator channel

### 3.3 Interface to Central Processing Unit (CPU)

The data transfer to the central processing unit is performed according to the bus specifications for SIMATIC S5 or MC-210 systems. The temperature control module occupies 32 bytes of the address area in the CPU. Up to 32 different data block messages of 31 bytes each can be transferred from or to the CPU (see message structure) by writing a message number (0 to 31) into byte 32 (address 31) of the RAM on the module. Thus 1024 bytes are available in the transfer RAM on the module for the transfer of parameters or measured values.

In order to operate and assign parameters to the module, function block FB 162 can be supplied.

The address code can be switched over (addressing socket J77) from the S5 bus (PESP' + 8 address lines) to the MC-210 bus (PESP + 12 address lines). Both S5 and MC-210 allow a data transfer using byte or word instructions. A sequence of high and low byte need not be observed.

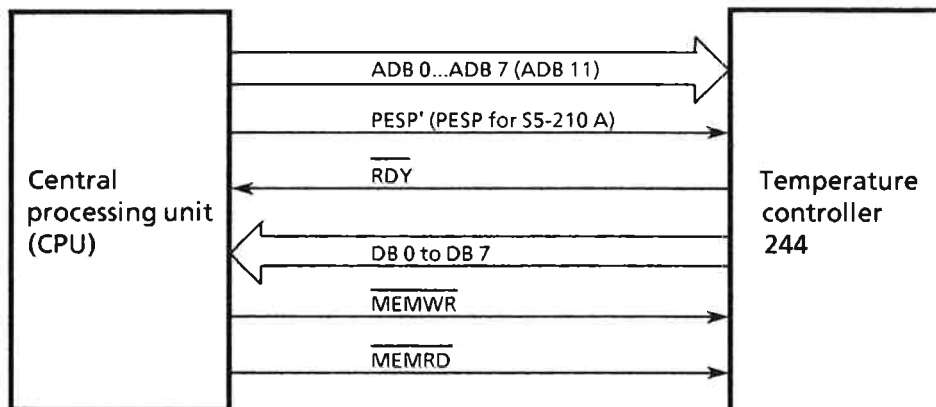
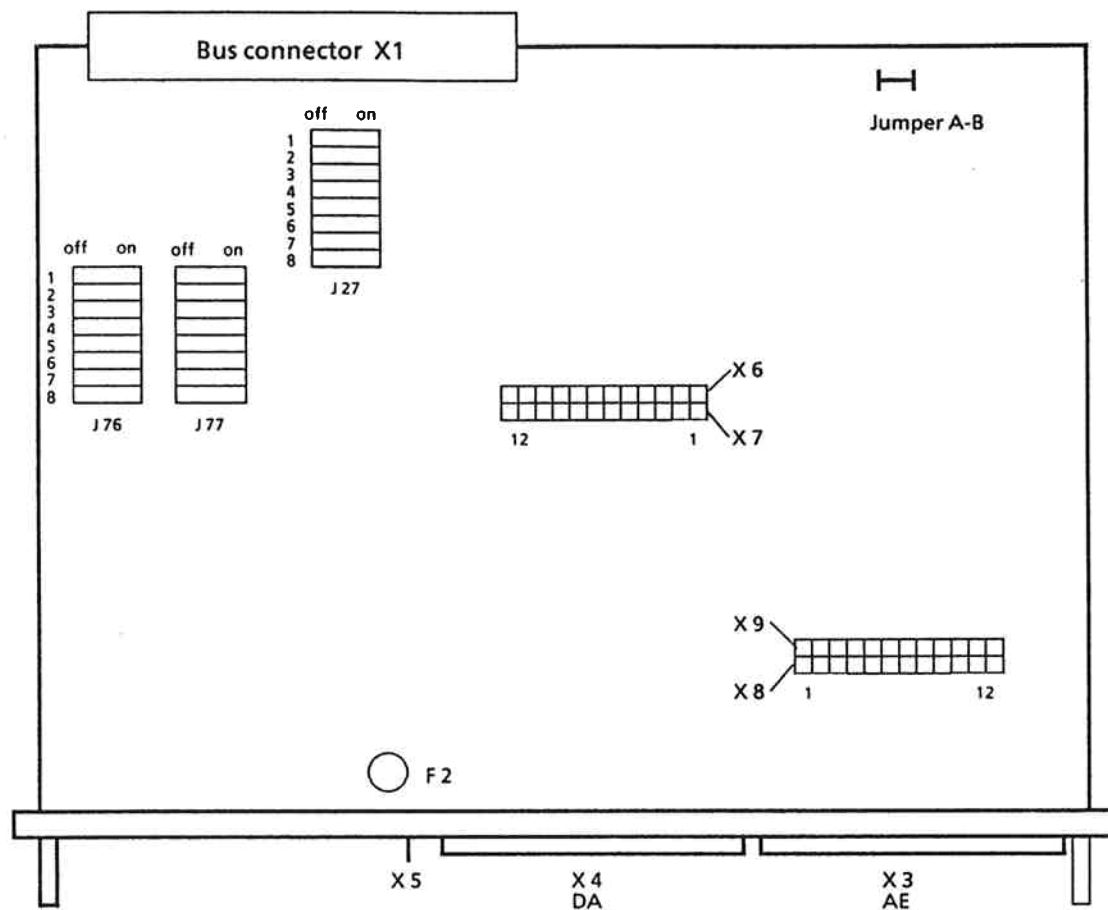


Fig. 10 Signal transmission

### 3.4 Jumpers and Switches



- L+      Connections for load voltage
- X1      Base connector
- X3      Front connector for analog inputs
- X4      Front connector for digital outputs
- F2      Fuse
- J76      Module address ADB 8-11 (DIP switch)  
          see Chapter 3.4.1
- J77      Module address ADB 5- 7 (DIP switch)  
          see Chapter 3.4.1
- J27      Interrupt jumpering      (DIP switch), not mounted
- X6/7    Jumpers, see page 14 (top)
- X8/9    Jumpers, see page 19 (bottom)

Fig. 11 Location of jumpers and switches



X 6 / X 7				Open	Closed	
1	<input type="radio"/>	<input type="radio"/>	1		Ju. C	Not used
2	<input type="radio"/>	<input type="radio"/>	2		Ju. D	See Chapter 3.4.2
3	<input type="radio"/>	<input type="radio"/>	3			<input type="checkbox"/> <input type="checkbox"/> 50 Hz <input type="radio"/> <input type="radio"/> or <input type="radio"/> <input type="radio"/> 60 Hz <input type="checkbox"/> <input type="checkbox"/>
4	<input type="radio"/>	<input type="radio"/>	4			
5	<input type="checkbox"/>	<input type="checkbox"/>	5		(*)	Test points (must be closed)
6	<input type="checkbox"/>	<input type="checkbox"/>	6		(*)	Test points (must be closed)
7	<input type="checkbox"/>	<input type="checkbox"/>	7		(*)	Test points (must be closed)
8	<input type="checkbox"/>	<input type="checkbox"/>	8		(*)	Test points (must be closed)
9	<input type="radio"/>	<input type="radio"/>	9	(*)		Standard setting 244-3AA13
10	<input type="checkbox"/>	<input type="checkbox"/>	10		(*)	Standard setting 244-3AA13
11	<input type="checkbox"/>	<input type="checkbox"/>	11		(*)	Standard setting 244-3AA13
12	<input type="radio"/>	<input type="radio"/>	12	(*)		Not used

X 8 / X 9				Open	Closed	
1	<input type="checkbox"/>	<input type="checkbox"/>	1	not permitted	(*)	51.2 mV input sensitivity
2	<input type="checkbox"/>	<input type="checkbox"/>	2	not permitted	(*)	51.2 mV input sensitivity
3	<input type="checkbox"/>	<input type="checkbox"/>	3	not permitted	(*)	51.2 mV input sensitivity
4	<input type="checkbox"/>	<input type="checkbox"/>	4		(*)	No BASP evaluation
5	<input type="checkbox"/>	<input type="checkbox"/>	5		(*)	Must be closed
6	<input type="checkbox"/>	<input type="checkbox"/>	6		(*)	Must be closed
7	<input type="radio"/>	<input type="radio"/>	7	(*)		Must be open
8	<input type="radio"/>	<input type="radio"/>	8	(*)		Must be open
9	<input type="checkbox"/>	<input type="checkbox"/>	9		(*)	Pt-100 at channel 15
10	<input type="checkbox"/>	<input type="checkbox"/>	10		(*)	Pt-100 at channel 15
11	<input type="radio"/>	<input type="radio"/>	11	(*)		Not used
12	<input type="radio"/>	<input type="radio"/>	12	(*)		Not used

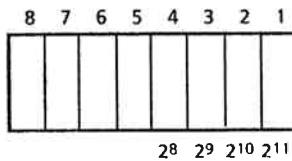
## (\*) Factory setting

This setting is required for proper functioning of the module. It must not be changed (measuring points necessary for testing the module).

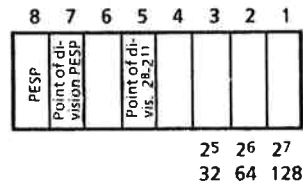
Jumper A-B (for test purposes) must be inserted (Fig. 11).

### 3.4.1 Setting the Module Address

Each temperature control module 244 requires 32 addresses for the transfer of the necessary parameters. Only the start address of each module need be set. The following 31 addresses are then occupied by the internal decoder and are thus no longer available for other modules. The addresses can be set in steps of 32.



DIP switch J76  
for ADB 8 to 11



DIP switch J77  
for ADB 5 to 7

#### S5 bus

Process area	Switch J77			Switch J76		Module address		Address parameter for FB 162
	No.	EU	CC	EU	CC	Setting	Range	
'Q' area S5 135 U S5 150 U	5	OFF	ON	$2^8-2^{11}$	$2^8 = \text{ON}$	via J77	0-244	0
	7	ON	ON	= OFF	$2^9-2^{11}$			
	8	ON	ON		= OFF			
'P' area all PCs	5	OFF	ON	$2^8-2^{11}$	$2^8-2^{11}$	via J77	128-224	1
	7	ON	ON	= OFF	= OFF			
	8	ON	ON					
'ABS' area S5 115 U	5	ON			$2^8-2^{11}$	via J76 and J77	0-00FFH	2
	7	ON			= OFF			
	8	OFF						

#### 210 bus

	J77 switch no.	Module address	
		Setting	Range
210	5 = ON 7 = ON 8 = ON	via J76 and J77	0-4064

#### Example:

If the start address  $n = 64$  has been set for a temperature control module (J77, switch 2 = ON), the addresses up to  $n + 32 - 1$  are occupied by the internal decoding. This means that the last address occupied by the module is  $64 + 32 - 1 = 95$ . The start address for the next module can then be defined at 96.

### 3.4.2 Setting the Conversion Time and Selecting the Thermocouples

Floating or non-floating Fe-Constantan, NiCr-Ni or Pt10%Rh-Pt thermocouples can be connected to the 13 analog inputs of the temperature control module 244. One side of insulated thermocouples must be connected to M on the module.

The resolution of the analog input signals in coding units is determined by the conversion time set at the analog-digital converter.

The conversion time can be set using the plug-in jumper D on the pin connectors X6/X7.

Jumper D (X6/X7, 2-2)		Conversion time and resolution	
<div style="display: flex; align-items: center;"> <div style="margin-right: 10px;">           D            1   12            X6 oooooooooo              Jumper D            X7 oooooooooo            1   12         </div> <div>           Plugged in         </div> </div>	60 ms	= 0 - 51.2 mV (channels 0-12)	
		= 0 - 20.48 V (channels 13-15)	
		= 0 - 2048 units	
<div style="display: flex; align-items: center;"> <div style="margin-right: 10px;">           D            1   12            X6 oooooooooo              Jumper D            X7 oooooooooo            1   12         </div> <div>           Open         </div> </div>	50 ms	= 0 - 25.6 mV (channels 0-12)	
		= 0 - 10.24 V (channels 13-15)	
		= 0 - 1024 units	

Using the three possible thermocouples, the following maximum temperatures result from the supplied thermoelectric voltages at the selectable conversion times:

Thermocouple	Conversion time 50 ms at	Conversion time 60 ms at
Fe-Constantan (type L)	450°C/ 842°F	700°C/1292°F
NiCr-Ni (type K)	600°C/1112°F	1200°C/2192°F
PtRh-Pt (type S)	1600°C/2912°F	1600°C/2912°F

For the characteristic curves of the thermocouples and their output voltages please refer to DIN 43710. The Fe-Constantan and the NiCr-Ni characteristics are interpolated linearly using a line; the Pt10%Rh-Pt characteristics uses four line segments. The largest deviations which occur by the interpolation for the PtRh-Pt element are at temperatures below 300°C.(or 572°F).

See Chapter 3.1.3 in Part 5 of the manual.

### 3.4.3 Setting the Clock Frequency

To achieve maximum interference suppression at the mains frequencies of 50 or 60 Hz, the integration time can be selected.

		X6/X7		Integration time
		3 - 3	4 - 4	
1	12	x		50 Hz mains interference suppression (20 ms)
			x	60 Hz mains interference suppression (16 2/3 ms)

X6 oooooooooooooo  
     |  $\triangleq$  50 Hz  
 X7 oooooooooooooo  
     1               12

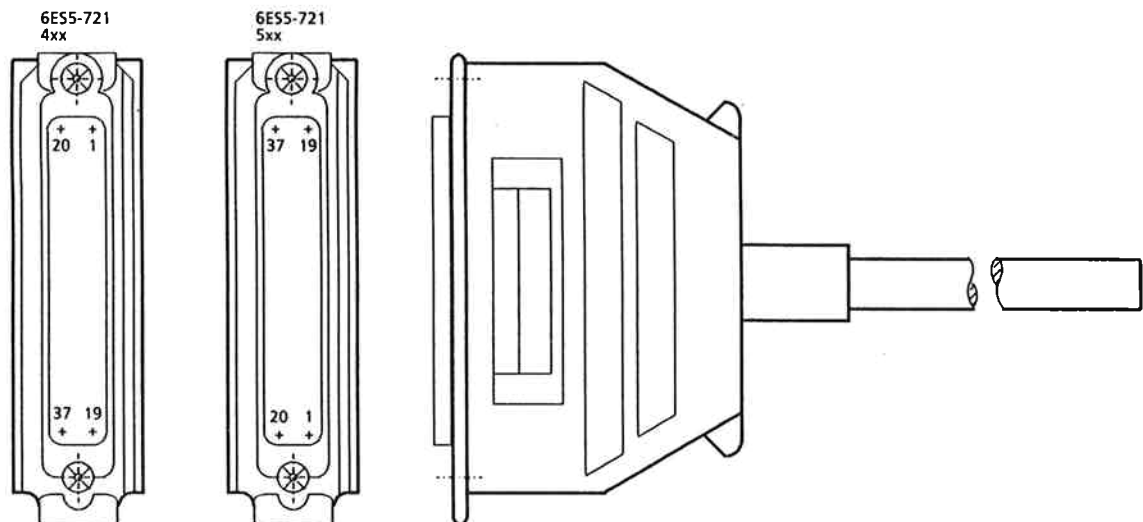
Switch J27 is reserved (all switches OFF) or not mounted.

### 3.5 Connector Pin Assignment

Base connector 1:

	d	b	z
2	UBAT	0 V	+ 5 V
4		PESP	
6		ADB 0	CPKL
8		ADB 1	MR
10		ADB 2	MW
12	IR A IR B IR C IR D IR E IR F IR G	ADB 3	RDY
14		ADB 4	DB 0
16		ADB 5	DB 1
18		ADB 6	DB 2
20		ADB 7	DB 3
22		ADB 8	DB 4
24		ADB 9	DB 5
26		ADB 10	DB 6
28		ADB 11	DB 7
30		BASP	
32		0 V	

### 3.6 Connection Diagram for Cable Connectors



Cable connector  
for temperature  
controllers  
ES5721-4...

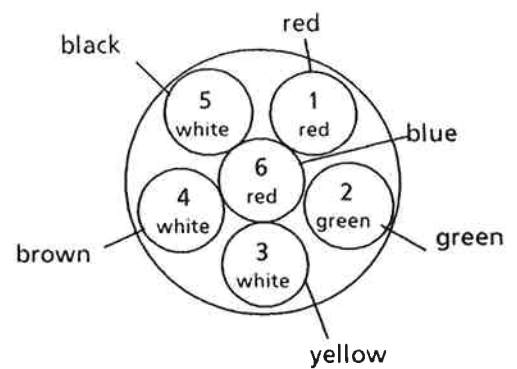
Cable connection table (x4)		
Color of bundle/ sleeves	Color of wires	37-way con- nector pin
1 red	white	1
	brown	20
	green	2
	yellow	21
	grey	3
	pink	22
	blue	4
	red	23
2 green	white	5
	brown	24
	green	6
	yellow	25
	grey	7
	pink	26
	blue	8
	red	27
3 yellow	white	9
	brown	28
	green	10
	yellow	29
	grey	11
	pink	30
	blue	12
	red	31
4 brown	white	13
	brown	32
	green	14
	yellow	33
	grey	15
	pink	34
	blue	16
	red	35
5 black	white	17
	brown	36
	green	37
	yellow	18
	grey	19
	pink	
	blue	
	red	
6 blue	white	
	brown	
	green	
	yellow	
	grey	
	pink	
Screen		Casing

for digital signals  
(pin connector)

## ES5721-5...

Cable connection table (x3)		
Color of bundle/ sleeves	Color of wires	37-way con- nector socket
1 red	white	1
	brown	20
	green	2
	yellow	21
	grey	3
	pink	22
	blue	4
	red	23
2 green	white	5
	brown	24
	green	6
	yellow	25
	grey	7
	pink	26
	blue	8
	red	27
3 yellow	white	9
	brown	28
	green	10
	yellow	29
	grey	11
	pink	30
	blue	12
	red	31
4 brown	white	13
	brown	32
	green	14
	yellow	33
	grey	15
	red	34
	blue	16 <sup>2)</sup>
	red	35
5 black	white	17 <sup>1)</sup>
	brown	36
	green	37
	yellow	18
	grey	19
	pink	16 <sup>2)</sup>
	blue	16 <sup>2)</sup>
	red	16 <sup>2)</sup>
6 blue	white	17 <sup>1)</sup>
	brown	16 <sup>2)</sup>
	green	16 <sup>2)</sup>
	yellow	16 <sup>2)</sup>
	grey	16 <sup>2)</sup>
	pink	16 <sup>2)</sup>
Screen		Casing

for analog signals  
(socket connector)



Cable layout with specification  
of the colors of identification  
foil strips and sleeves

Length code and order  
number:

MLFB No corresponds to indi- cation on the rating plate	Rated Length
6ES5721-5 ... 0	m
6ES5721-4 ... 0	
AG0	0.6
AJ0	0.8
BB0	1.0
BB2	1.2
BB5	1.5
BC0	2.0
BC5	2.5
BD2	3.2
BE0	4.0
BF0	5.0
BG3	6.3
BJ0	8.0
CB0	10
CB2	12
CB5	15
CC0	20
CC5	25
CD2	32
CE0	40
CF0	50
CG3	63
CJ0	80
DB0	100
DB2	120
DB5	150
DC0	200
DC5	250
DD2	320
DE0	400
DF0	500
DG3	630
DJ0	800
EB0	1000

- 1) Pt 100 connection / connect 2 wires 17 } see Fig. 7  
2) Frame connection / connect 9 wires 16 }

#### 4 Spare Parts

Jumper plug (mini jump)	W79070-G2601-N2
Connecting cable for digital outputs	6ES5-721-4xxx0
Connecting cable for analog inputs	6ES5-721-5xxx0

See catalogue for length code \_\_\_\_\_

## SIMATIC S5

### IP 244 Temperature Control Module

6ES5244-3AA13

Programming Instructions

Order No. C79000-B8576-C478-02

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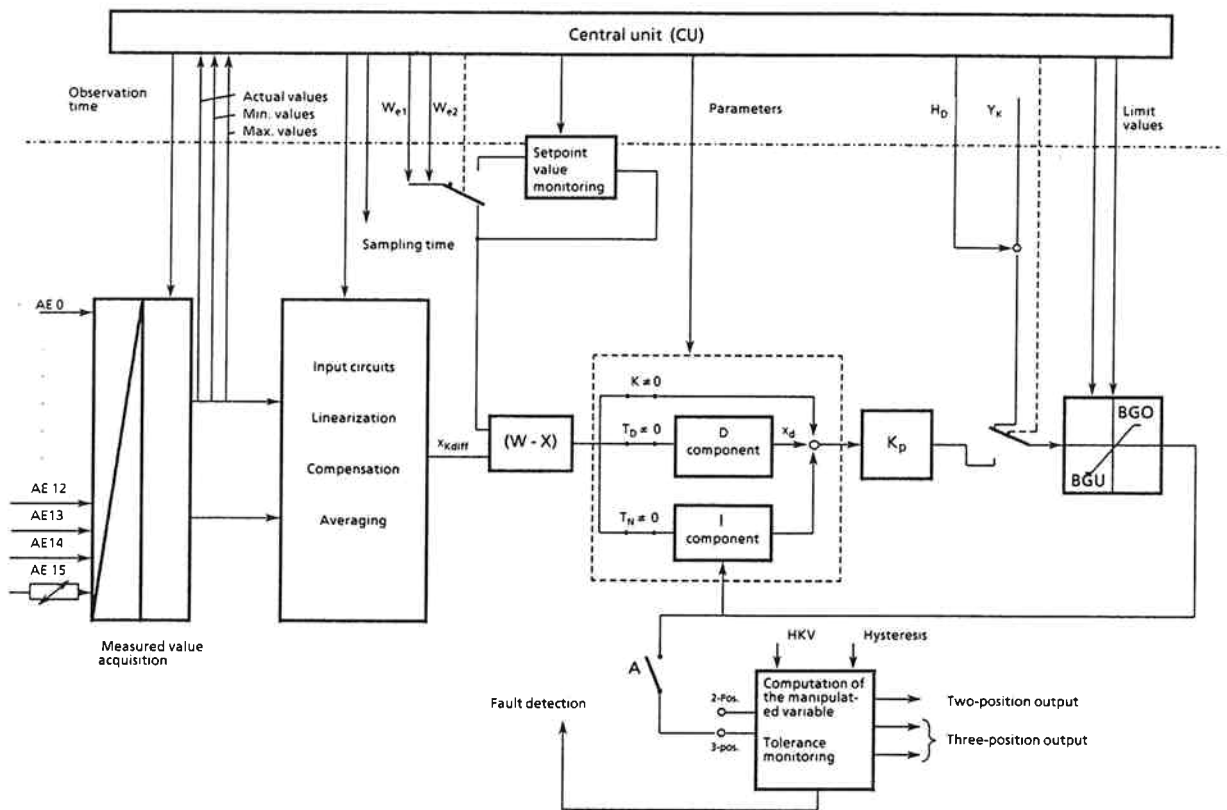


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## 1 Firmware Description

### 1.1 Description of Temperature Control Functions



A	One-way switch for controller (heating system switch)
AE 0...14	Analog inputs (channels 0 to 14)
AE 15	Compensation input (channel 15)
BGO	Upper limit
BGU	Lower limit
HKV	Heating/cooling ratio
W	Smoothed setpoint value
H <sub>D</sub>	Manually manipulated variable
K <sub>p</sub>	Controller gain
W <sub>e</sub>	Setpoint value
X <sub>d</sub>	Offset
X <sub>korrr</sub>	Compensated analog value
Y <sub>K</sub>	Compensation value (internal)

Fig. 1 Block diagram of the controller functions

The controller functions are stored in an EPROM in the form of algorithms. They are switching-type two-position or three-position controllers with percent output. The 13 controller circuits are cyclically processed in the processor part of the module.

The module can be configured within certain limits. The required functions can be selected out of a set of functions which is contained in the firmware. This selection is performed by setting the appropriate bits in the control bytes.

For each individual controller, the controller parameters are transferred within a message.

Temperature setpoint values and temperature actual values can optionally be input/output in Celsius or Fahrenheit. To convert Celsius into Fahrenheit use the following formula:

$$1^{\circ}\text{F} = 1.8^{\circ}\text{C} + 32$$

The parameters are entered into the module's transfer RAM at restart or when putting into operation. Use therefore function block FB 162.

The controller is set up in a parallel structure.

#### **1.1.1 Monitoring of Actual Values, Upper and Lower Zone Limits**

Two setpoint values, two positive and two negative tolerances can be specified for each controller. An error bit is set 'on' if these values are violated.

If no actual value is specified (open circuit), tolerances will not be evaluated.

Individual upper and lower zone limits can be specified for the controllers. A closed-loop control should occur within these zones.

It is also possible to specify a response threshold for the output manipulated variable. For example, if a response threshold of 10 % has been specified, the computed values are output in the range from 10 to 90 % only; the output is switched off below 10 % and always switched on above 90 %.

#### **1.1.2 Processing of Actual Values**

The thermocouple inputs are checked for open-circuit conditions. If an open-circuit is detected, three different reactions can be specified by software configuration:

- a) Closed-loop control and output of the manipulated variable (averaged for an adjustable period of time) are switched off as long as the open-circuit condition has not been repaired (emergency program, see Chapter 2.3).
- b) The manipulated variable is switched off until a percent value for this variable is entered manually (manually manipulated variable).
- c) Automatic switch-over to a spare thermocouple connected to a different input (if spare inputs are available). The bit for spare thermocouples is set.

In addition, an open-circuit bit is set 'on' which can be interrogated by the PC. The actual maximum value (450 to 1600°C) is output instead of the actual value.

Temperature compensation is normally performed by a Pt 100 resistance thermometer which is used to acquire the ambient temperature at the beginning of each cycle.

Pt 100 is also checked for open circuit. If there is an open circuit or a temperature  $> 60^{\circ}\text{C}$  an error bit is set (message 16, byte 2). In this case, calculation is continued using the value of the ambient temperature which was read before the error occurred. If the error occurs immediately after the parameters have been assigned, control is carried out on the basis of  $0^{\circ}\text{C}$  ambient temperature ( $= 32^{\circ}\text{F}$ ).

**Caution!** If an open circuit occurs on pin 17 or on this line of the Pt 100 - three-position circuit, the actual value of controller 0 is not valid!

For the display of the actual value a filter can be inserted into the signal path. This can be achieved by resetting a bit. The actual value display becomes slow by the averaging of 8 values.

If more than 1024 (2048) coding units are entered, the system sets a limit at the maximum value (1024 or 2048). Depending on the configuration, the actual values can be represented either in binary or in BCD code. The actual values are stored in message 17.

If BCD coding is required, the data is stored in the following formats, depending on the type of PC.

210-format:

address n:	Tens	Units
address n+1:	Thousands	Hundreds

S5-format:

address n:	Thousands	Hundreds
address n+1:	Tens	Units

### 1.1.3 Processing of Setpoint Values

A setpoint value must be specified for each temperature controller. This setpoint value must not exceed the respective maximum value. If a greater setpoint value is entered, an error bit is set. Closed-loop control is not performed if the setpoint value is 0; only the actual value is displayed in this case (controller OFF).

A lowering setpoint value (e.g. for lowering the temperature during the night) can be specified for each controller.

If the lowering setpoint value is greater than the temperature setpoint value, the control range is limited to the temperature setpoint value and an error bit is set 'on'.

A ramp function with a gradient in  $^{\circ}\text{C}/\text{h}$  can be configured to reduce the effect of a sudden change of the setpoint value. The characteristic of the setpoint value in Fig. 2 is shown as an example (setpoint value rounding).

The ramp begins with the current actual value and continues to the specified setpoint value. If the setpoint value is changed before it has been reached, such as  $t_4$  in Fig. 2, the ramp function is restarted with a negative gradient.

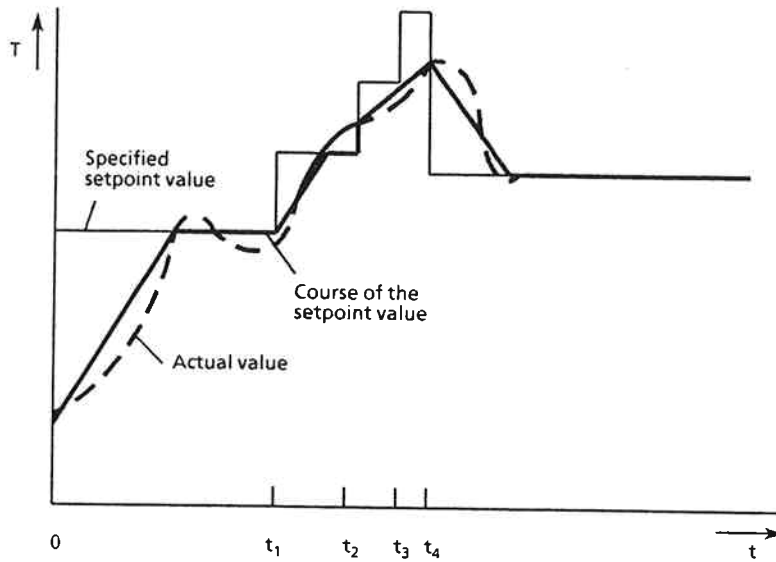


Fig. 2 Characteristic of the setpoint value

#### 1.1.4 Closed-loop Control

The manipulated variable  $y(t)$  follows the well-known equation for PID controllers as a function of the deviation  $x(t)$ .

$$y_{PID}(t) = K_P \left( x(t) + \frac{1}{T_N} \int x(t) dt + T_D \frac{dx(t)}{dt} \right)$$

The implementation in the form of a sampling controller allows the representation in a parallel arrangement, as shown in the figure:

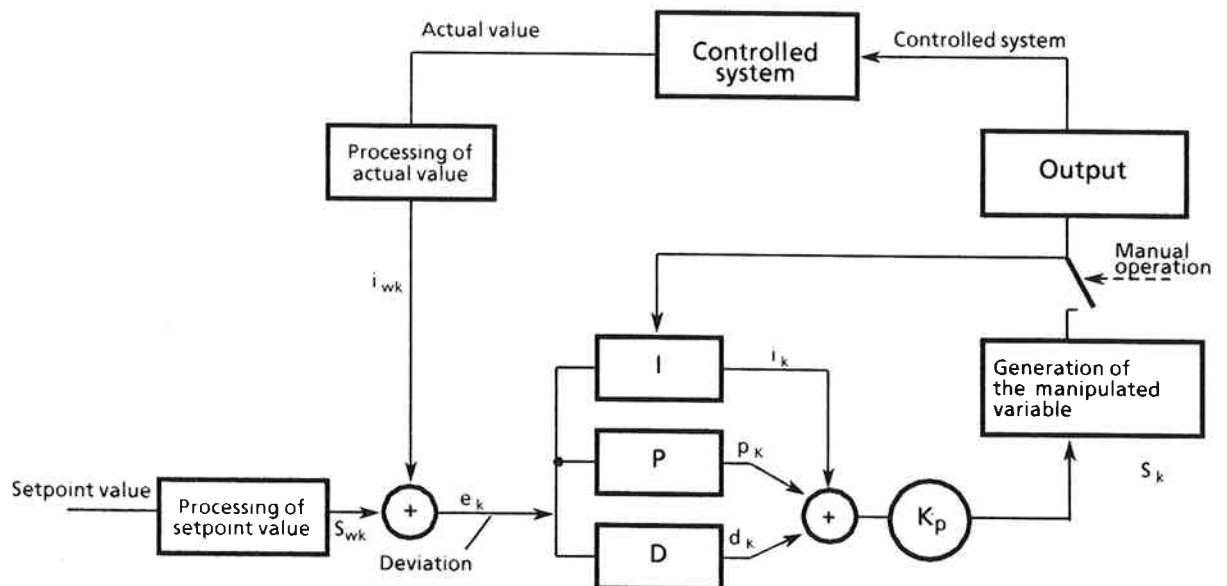


Fig. 3 Basic structure of the controller

At the instant  $k \cdot T_A$ , the system deviation is processed in the three parallel branches:

P-branch:  $P_k = e_k$

I-branch:  $i_k = i_{k-1} + \frac{T_A}{2T_N} (e_k + e_{k-1})$

D-branch:  $d_k = \frac{2T_D}{T_A + 2T_Z} (e_k - e_{k-1}) - \frac{T_A - 2T_Z}{T_A + 2T_Z} d_{k-1}$

With

$$\begin{aligned} T_A &= \text{Sampling interval} \\ T_N &= \text{Reset time} \\ T_D &= \text{Derivative action time} \\ T_Z &= \text{Filter time constant for the damping of the} \\ &\quad \text{derivative influence; selected: } T_Z = 2T_A \end{aligned}$$

The manipulated variable ( $S_k$ ) results from

$$s_k = K_P (P_k + i_k + d_k),$$

converted into a percent value of the sampling interval.

The individual branches can be switched off by setting the appertaining parameters  $T_N$ ,  $T_D$  to zero. To switch off the P-branch, gain  $K_R = 0$  must be entered;  $K_P$  is internally set to 1.

To avoid a wind-up effect, the integration is interrupted when the manipulated variable has reached  $\pm 100\%$  or, in the case of a two-position controller, the manipulated variable is less than  $-12\%$ . The derivative branch contains a first order filter for the damping of the control action.

The calculated manipulated variable is converted into a heating or cooling time value, which is a multiple of 50 or 60 ms and differentiated by the heating/cooling ratio.

### 1.1.5 Processing of Manipulated Variables, Outputs - Heating Switch

The module provides 17 digital control outputs for the 13 controllers. Thus 9 two-position and 4 three-position controllers or up to 8 three-position controllers and 1 two-position controller can be configured (control byte 1).

The outputs are allocated to the inputs according to the configuration of the two-position and three-position controllers. This is carried out internally by the firmware.

If, for instance, the three controllers with the input channels 0, 1, and 2 are configured as two-position controllers, the manipulated values are output at the outputs 17, 16 and 15 in the corresponding sequence. If a three-position controller has been configured for a fourth controller with the input channel 3, the manipulated variable (e.g. heating, cooling) is issued at the outputs 14 and 13.

The value of the manipulated variable computed by the control algorithm is converted into a two-level or three-level signal, according to the configuration. Due to the pulse-pause behaviour (percent output), the manipulated variable is only switched on for the part of the sampling interval ( $T_A$ ) which corresponds to the calculated value of the manipulated variable. The shortest ON period is 50 or 60 ms, depending on the jumper D (see Instructions in Part 4 of the manual, Chapter 3.4.2). For example, a resolution of up to 0.5 % can be achieved at a sampling interval of 10 s. A response value can be entered to suppress short ON or OFF intervals. The computed controlled variables in % of the channels 0 to 12 are output in message 18.

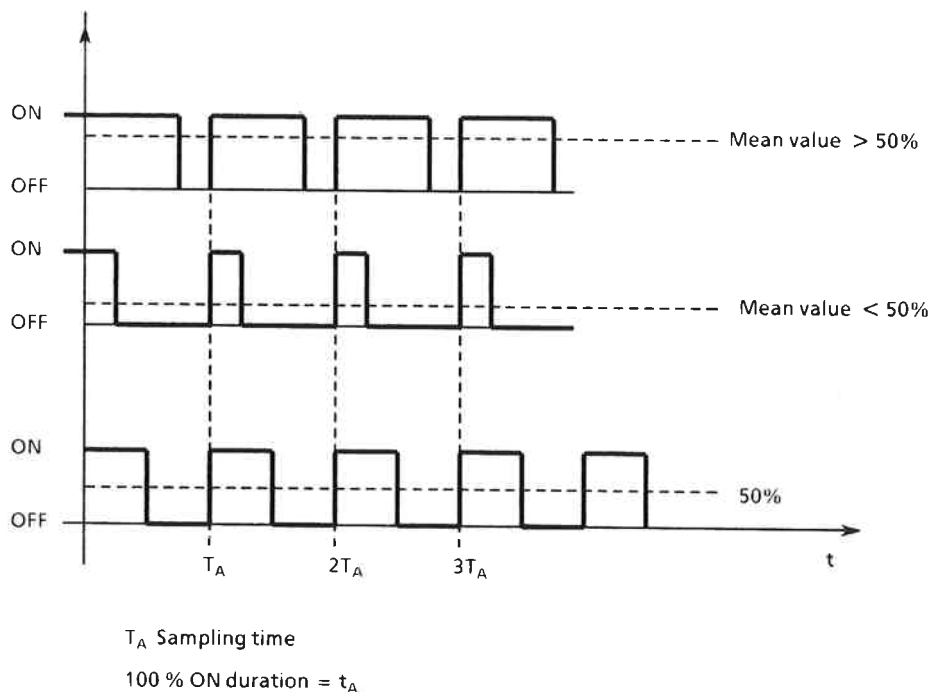


Fig. 4 Percent output

With percent output, the mean value of the manipulated variable is controlled by the pulse-pause ratio with the frequency ( $= 1/TA$ ) constant.

Three-position controllers can take into consideration the stronger or weaker control action of the cooling compared with the heating (e.g. water cooling) by a heating/cooling ratio (in %). If manual operation has been configured, the manually manipulated variable is converted into the appropriate part of the sampling interval, according to the specified pulse-pause behaviour.

### **Heating switch (digital input)**

The controller outputs can be switched off by the heating switch (socket connector X4, Pin 1).

Pin 1, X4 connected with L+  $\Rightarrow$  DA are enabled

Pin 1 not connected  $\Rightarrow$  DA are switched off

For each individual controller, the switch-off effect of the heating switch can be inhibited by setting bit 2 in the control byte 2 of the controller message to 'on'.

The controllers are stopped at the same time as DA is switched off. System restart is thus bumpless.

### **1.1.6 Sequence Control System**

In turn, the inputs are read in cyclically.

A switchover setpoint value can be parameterized for channel 13. If the input voltage exceeds the specified setpoint value, the digital output 18 is switched on.

### **1.1.7 Fault Detection**

#### **• Reset circuit**

A monitoring circuit is provided to monitor the module for failures and dips of the 5 V power supply. Upon power return, it generates a defined reset pulse ( $< 10$  ms) for the microprocessor and the output registers of the digital outputs.



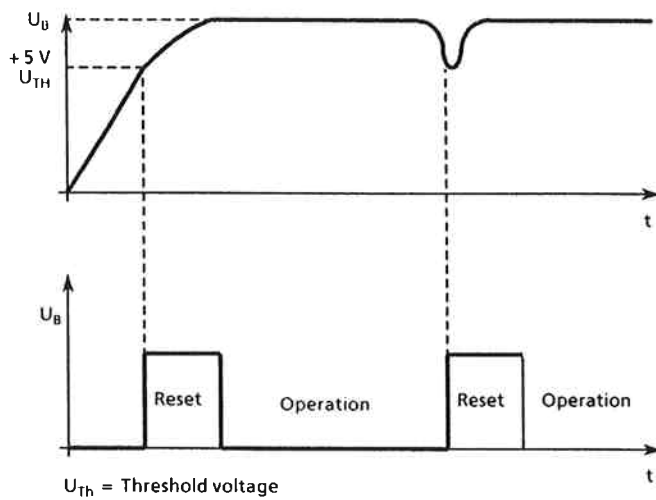


Fig. 5 Reset pulse diagram

### ● BASP interpretation

It is possible to interpret the BASP signal or to inhibit interpretation by a jumper.

All digital outputs are switched off if  $BASP = 1$ .

A selective BASP signal can be issued via bit  $2^6$  of the message number (byte 31).

The digital outputs are inhibited if bit  $2^6 = 1$ .

The message number is insignificant if the function 'selective BASP' has been selected.

$2^7$	$2^6$	$2^5$	$2^4$	$2^3$	$2^2$	$2^1$	$2^0$
x		x	x	x	x	x	x

Message number (byte 31)  
Module address + 31

└─ 0 no selective BASP  
   1 selective BASP

### ● Request for restart

In the S5 systems, the microprocessor sets a fault detection signal on the module to initiate a re-parameterization of the controllers by the CPU (bit 6 of status byte 1 in message 16). This ensures that the control algorithm is performed with correct parameters - even after a module has been replaced.

### ● Watchdog function

The CPU software interrogates a check bit to monitor the program. If the program runs properly, this bit changes its status every second (firmware watchdog).

The CPU indicates failures via the function block (FB 162) or the user program.

A message is issued through the function block if the internal time sequence has been disturbed by too many accesses to the module by the CPU.

### ● Fault messages

Single fault bits are set for each individual controller (0 to 12), if:

- the 1st positive tolerance has been exceeded,
- the 1st negative tolerance has been exceeded,
- the 2nd positive tolerance has been exceeded,
- the 2nd negative tolerance has been exceeded,
- the temperature setpoint value is too high,
- the lowering setpoint value is higher than the temperature setpoint value,
- there is an open-circuit in the thermocouple,
- the system has switched over to a spare thermocouple.

The following faults are indicated for the channels 13 and 14:

- positive tolerance has been exceeded,
- negative tolerance has been negatively violated.

A controller group fault bit is generated for each individual controller, a general group fault bit for the module.

Using the function block, these error messages can easily be accessed by the user.

### 1.1.8 Monitoring

The entered setpoint values are monitored for positive violation of their maximum values. If this happens, an error bit is set 'on'.

Two upper and two lower tolerance values can be specified for each controller (Fig.6). The appertaining error bit is set to 'on' if the actual value exceeds the setpoint value plus the upper tolerance value or if it falls below the setpoint value minus the first lower tolerance value. If the actual value returns to the first tolerance band without violation of the second tolerance band, the extreme value reached is stored and can be read in by the CPU. An error bit is set 'on' if the actual value exceeds the setpoint value plus the second upper tolerance value or if it falls below the setpoint value minus the second lower tolerance value. Depending on the parameters assigned (message 15) the corresponding controller can thus be switched off.

The percent manipulated values may be read in order to monitor the outputs (message 18).

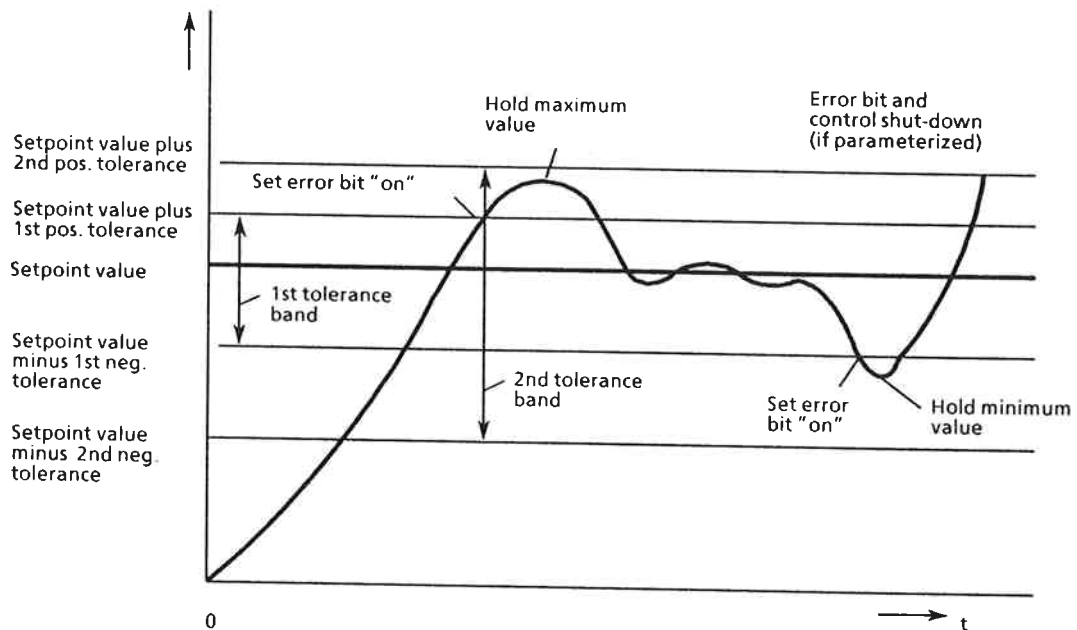


Fig. 6 Tolerances

### 1.1.9 20.48 V Channels

If the jumper D (see jumper assignments in Instructions C79000-B8576-C351, Fig. 10) has been inserted, a voltage between 0 and 20.48 V (2048 units) can be applied to the channels 13 and 14. An error bit is set 'on' if a measured value is outside the tolerance band of the setpoint value.

The actual values of the two channels are stored in message 17, together with the actual temperature values of the controllers. (The resolution is 10 mV).

The sampling interval for the transmitter inputs 13 and 14 is with

- jumper D inserted:	1920 ms	0 to 20.48 V
- jumper D not inserted:	1600 ms	0 to 10.24 V

### 1.1.10 Comparator

The comparator issues a 24 V signal at the digital output K if the voltage applied to channel 13 reaches or exceeds a value which can be specified in the range between 0 and 1024  $\hat{=}$  0 to 10.24 V. The comparator cannot be switched to channel 14.

### 1.1.11 Software Version

The software version is stored in the firmware under address 7FFFH. It can be read by the PC from byte 15 in message 16.

## 1.2 Temperature Controller with Automatic Setting function

### 1.2.1 Introduction

If they are properly adjusted, PID controllers provide a good control response for the various thermal processes. However, the definition of the control parameters takes a relatively long time.

The controller's automatic setting function, which is implemented in the temperature control module (EPROM), performs an independent process identification during the heating-up phase, from where it determines the optimum control parameters.

The automatic setting function is suitable for slowly changing processes with interlinked systems, which occur, for example, in plastic processing. The controller's automatic setting function is especially useful if the system shows different responses for different operating points, since the control parameters can be optimized for the current operating point.

### 1.2.2 Mode of Operation

Fig. 7 shows the structure of a temperature controller with automatic setting facility.

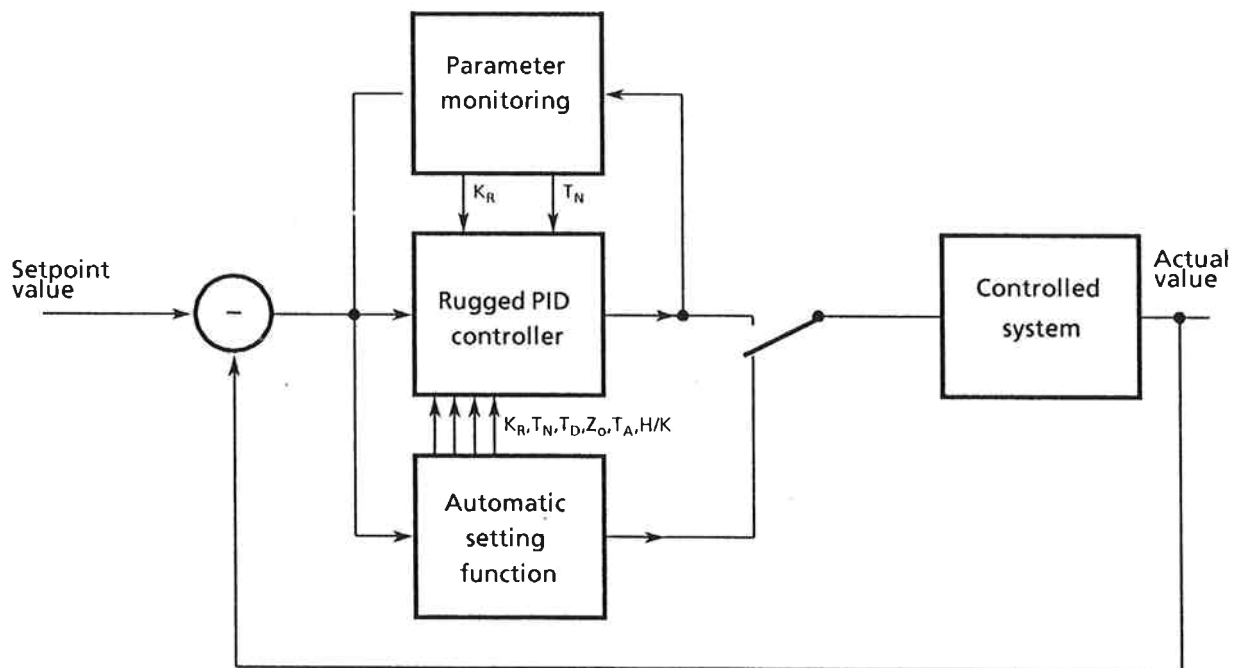


Fig. 7 Structure of the temperature controller with automatic setting function

The PID controller as described in Chapter 1 has the following additional function modules:

- Automatic setting
- Parameter monitoring
- PID controller becomes rugged
- The function module 'automatic setting' performs process identification and determines the optimum control parameters. It also controls the process during the automatic setting phase.  
After automatic setting has been terminated, the rugged PID controller takes over process control.
- The function module 'parameter monitoring' checks if the control system has changed its response greatly and reduces the controller gain if necessary.
- The conventional PID controller becomes a 'rugged PID controller' which is insensitive to smaller changes in the system, as caused, for example, by a change of the granulated plastic material.

Fig. 8 shows a typical temperature response during a heating-up process where the automatic setting function performs process identification. The automatic setting function determines the optimum control parameters from the process identification data. Overshoot values of up to 8°C can occur during this heating-up process.

Fig. 9 shows a heating-up process which has been performed at the same control system as shown in Fig. 8. The controller uses the parameters which have been determined for this system by the automatic setting function.

Fig. 10 shows the temperature response during a heating-up process with a three-position controller where the automatic setting function performs process identification. During the heating-up process, the automatic setting switches the cooling system on together with the heating in order to determine the ratio of heating and cooling interference.

### 1.2.3 Parameters Determined

After process identification, the automatic setting function determines the control parameters sampling interval ( $T_A$ ), controller gain ( $K_P$ ), reset time ( $T_N$ ), derivative action time ( $T_D$ ), upper and lower control zone (ZONOB, ZONUN) and, in the case of three-position controllers, the heating/cooling ratio (HKV).

Criteria for the parameter determination:

- $T_A$ : Longest sampling interval possible to achieve a control accuracy of less than  $\pm 1^\circ\text{C}$ .
- $K_P$ ,  $T_N$ ,  $T_D$ : For a good interference suppression at the operating point.
- ZONOB, ZONUN: For a good response to large setpoint changes.
- HKV: For the operating point in the range of  $\pm 100^\circ\text{C}$  (3-position controllers only)

It is advantageous to continue the heating-up process near to the operating point, since some of the parameters are optimized for the operating point.

### 1.2.4 In which Control Systems Can the Automatic Setting Function be Used?

The automatic setting function can be used in systems which meet the following requirements:

- The system must show a low-pass response.  
This requirement is normally met by temperature control systems.
- The system must allow the following temperature change:  
50°C for two-position controllers,  
110°C for three-position controllers.
- The gradient of the actual value must not exceed 60°C per minute (at full heating).
- The duration of the heating-up process must not exceed 12 hours.

To convert the values specified in Celsius to Fahrenheit use the formula  $1^\circ\text{F} = 1.8^\circ\text{C} + 32$ .

### 1.2.5 Operation and Parametrization of the Automatic Setting Function

Each of the 13 temperature controllers can be parameterized as a standard or as an automatic setting temperature controller. It is thus possible to use one temperature control module for mixed control systems which meet the requirements and for control systems which do not meet the required conditions.

The automatic setting function is specified in the byte 'automatic setting' (byte 22).

In message 16 (bytes 4 and 5) it is indicated if the automatic setting function is running or terminated.

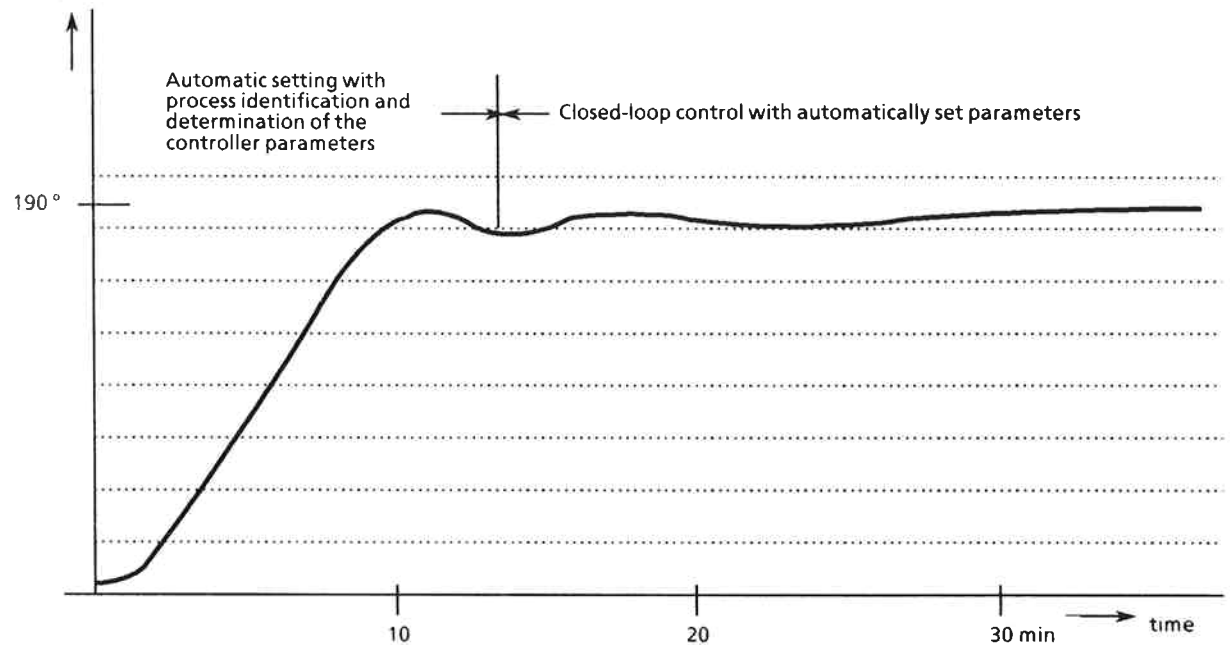


Fig. 8 Heating-up process with automatic setting function (two-position controller) while the parameters are determined

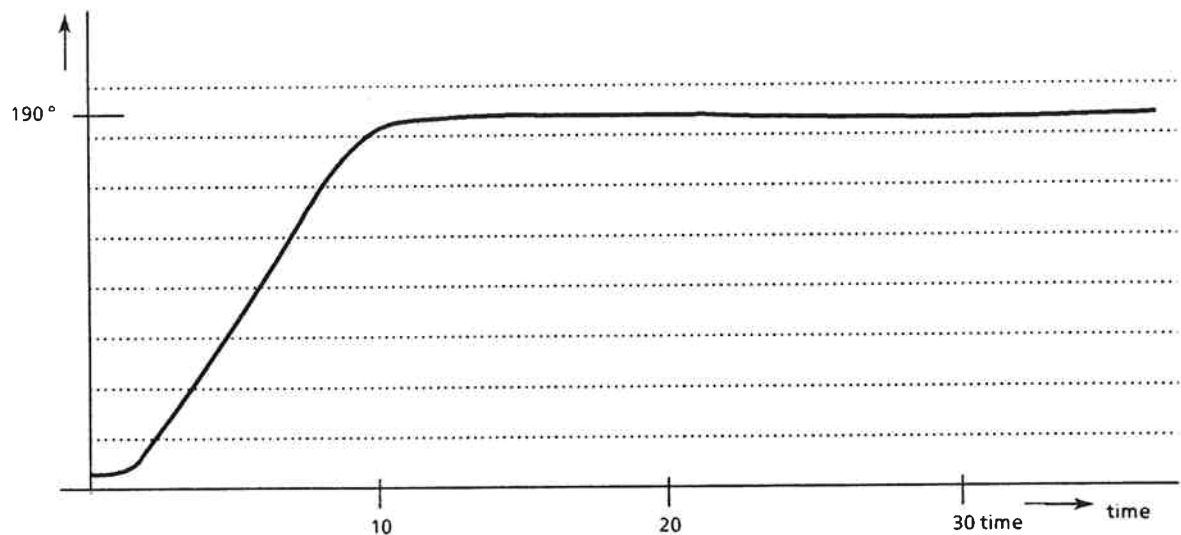


Fig. 9 Heating-up process with automatically set controller after the parameters have been determined



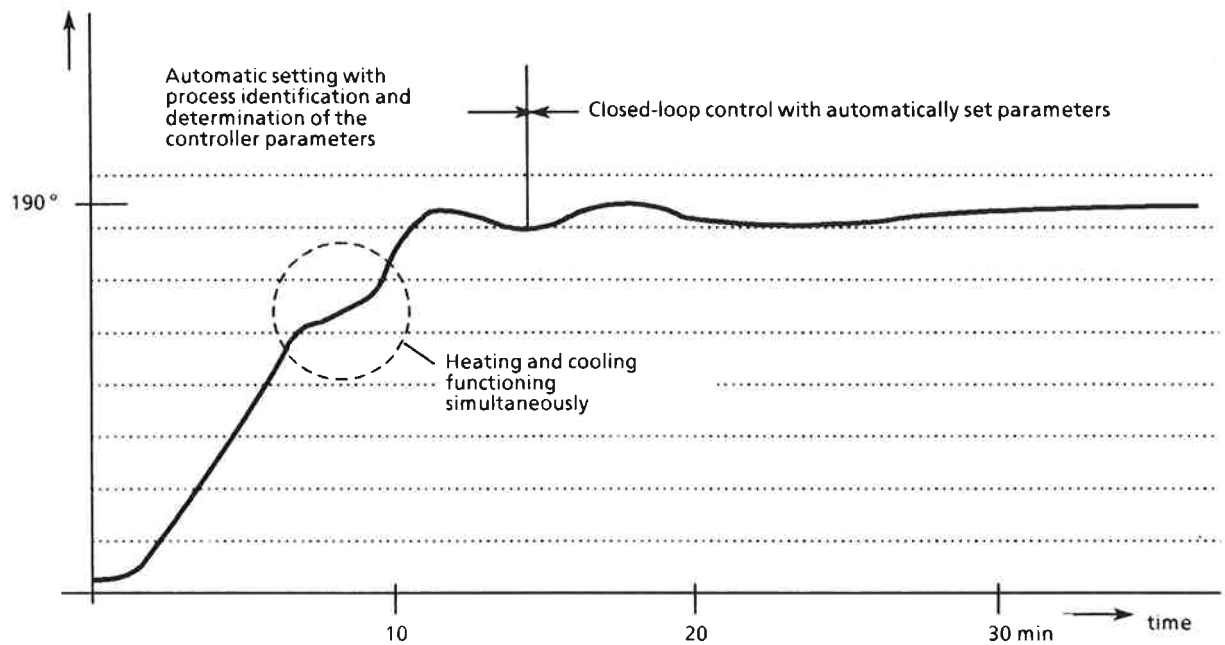


Fig. 10 Heating-up process with automatic setting function (three-position controller) while the parameters are determined

## 2 Data Communication (Message Interchange) with Central Unit

A RAM area of 1024 bytes on the module can be addressed by the central unit. This area is subdivided into 32 x 32 bytes. The message length and thus the address range required by the module is 32 bytes.

The module is addressed by writing the message number into the highest address. If, for instance, the module address is defined as F080H, the controller number must be written into the address F09FH. Up to 31 bytes can then be written or read from address F080H.

The address of the message number cannot be read back. With 16-bit parameters a distinction is made between the S5 and MC 210 data formats (sequence of high and low bytes of a parameter).

**Caution!** The controllers must be allocated/parameterized without leaving any gaps.

#### List of messages:

Message no.	0	Controller parameter	0
Message no.	1	Controller no.	1
Message no.	2	Controller no.	2
Message no.	3	Controller no.	3
Message no.	4	Controller no.	4
Message no.	5	Controller no.	5
Message no.	6	Controller no.	6
Message no.	7	Controller no.	7
Message no.	8	Controller no.	8
Message no.	9	Controller no.	9
Message no.	10	Controller no.	10
Message no.	11	Controller no.	11
Message no.	12	Controller no.	12
Message no.	13	Parameter channel	13
Message no.	14	Parameter channel	14
Message no.	15	General parameter and master control bytes	
Message no.	16	Status and error bytes	
Message no.	17	Actual values	0 to 14
Message no.	18	Manipulated variables	0 to 12
Message no.	19	Minimum values	0 to 12
Message no.	20	Maximum values	0 to 12
Message no.	21	Group setpoint values with cascades	
Message no.	22	Internal use	
Message no.	23	Internal use	
Message no.	24	Internal use	
Message no.	25	Internal use	
Message no.	26	Not used	
Message no.	27	Not used	
Message no.	28	Not used	
Message no.	29	Not used	
Message no.	30	Not used	
Message no.	31	Not used	

### 2.1 Messages 0 ... 12 (Controller Parameters)

Each message contains the setpoint values and the parameters for the appertaining controller. The structure is shown in Fig. 11.

0	Temperature setpoint value	0 ... 1600 °C in steps of 1°C
1		
2	1st positive tolerance	0 ... 255 °C in steps of 1°C
3	1st negative tolerance	0 ... 255 °C in steps of 1°C
4	Lowering setpoint value	0 ... 1599 °C in steps of 1°C
5		
6	2nd positive tolerance	0 ... 255 °C in steps of 1°C
7	2nd negative tolerance	0 ... 255 °C in steps of 1°C
8	Control byte 1	
9	Control byte 2	
10	Manually manipulated variable	0 ... 228 %, 1 E = 1 %
11	Limiting value (K)	0 ... 255 %, } with cascaded control only
12	Weighting factor (K)	
13	Not used	
14	Sampling time (SE)	800 ... 65535 ms, 1 E = 1 ms
15		
16	Gain $K_R$ (SE)	1 ... 25599, 1 E = $K_R = 0.01$
17		
18	Reset time $T_N$ (SE)	0 or $(T_A \leq T_N \leq 512 T_A)$ , 1 E = 4 s
19		
20	Derivative action time $T_D$ (SE)	0 or $(\frac{T_A}{2} \leq T_D \leq 512 T_A)$ , 1 E = 1 s
21		
22	Automatic setting -parameters	
23	Internal use	
24	Upper limit of control zone or setpoint value rounding (SE)	0 ... 1600 °C/0 ... 3000 °C/h or 0 ... 2047 °F/h (= 1119 °C/h) (ramp gradient)
25		
26	Lower limit of the control zone (SE)	0 ... 1600 °C
27		
28	Heating/cooling ratio (SE)	0 ... 255 %, 1 E = 1 %
29	Response value	0 ... 50 %, 1 E = 1 %
30	Not used	
31	Message number	1 ... 12

(Parameters with (K) are only valid for cascaded control  
(Parameters with (SE) are only valid for controllers without  
automatic setting function)

For temperature values specified in °F:  
°F = 1.8 °C + 32;

**Fig. 11 Structure of messages 0 to 12**

Byte 0/1

**Temperature setpoint value**

If the value 0°C or 32°F (if Fahrenheit is selected for input) is entered, no control is carried out; only the actual value is displayed. The entered setpoint is checked if its value is between 0 and a maximum value which depends on the connected thermocouple.

Maximum value for	without jumper D	with jumper D
Fe-Constantan	450°C (842°F)	700°C (1292°F)
NiCr-Ni	600°C (1112°F)	1200°C (2192°F)
Pt10%Rh-Pt	1600°C (2912°F)	1600°C (2912°F)

An error bit is set 'on' (bit 4 of the appertaining error byte) and the controller is switched off if the maximum value is exceeded.

Byte 2

**1st positive tolerance**

If the actual temperature value is higher than the setpoint value plus the first positive tolerance, an error bit is set 'on' (bit 0 of the appertaining error byte). If value 0 is entered, the tolerance processing is switched off.

Byte 3

**1st negative tolerance**

If the actual temperature value is lower than the setpoint value minus the first negative tolerance, an error bit is set 'on' (bit 1 of the appertaining error byte). If value 0 is entered, the tolerance processing is switched off.

Byte 4/5

**Lowering setpoint value**

If bit 5 of the master control byte has been set 'on', the lowering setpoint value is used as temperature setpoint value if it is lower than the temperature setpoint value. The plausibility check is the same as for the temperature setpoint value.

Byte 6

**2nd positive tolerance**

If the actual temperature value is higher than the setpoint value plus the second positive tolerance, an error bit is set 'on' (bit 2 of the appertaining error byte) and the controller is switched off. If value 0 is entered, the tolerance processing is switched off.

Byte 7

**2nd negative tolerance**



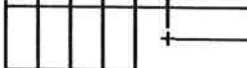
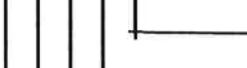
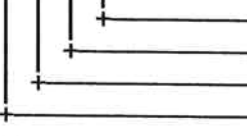
If the actual temperature value is lower than the setpoint value minus the second negative tolerance, an error bit is set 'on' (bit 3 of the appertaining error byte) and the controller is switched off. If value 0 is entered, the tolerance processing is switched off.

**Byte 8/9 Control bytes 1 and 2**




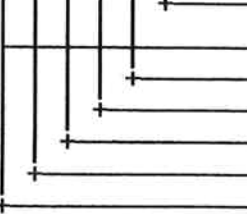
The functions to be performed are specified in the control bytes 1 and 2 (bytes 8 and 9) of the message for the controller channel whose number is defined in byte 31.

The four tolerance values must be in the range between 0 and 255°C (1 byte).

**Byte 8: Control byte 1**

Significance of bit $2^n$ ; n = 7 6 5 4 3 2 1 0	Logic state	Desired function
	1 0	Three-position controller Two-position controller
	1 0	Switches S0-S12 (cascade) ON OFF
	0/1	Not used
	1 0	With spare thermocouple Without spare thermocouple
	$0/1 \hat{=} 2^0$ $0/1 \hat{=} 2^1$ $0/1 \hat{=} 2^2$ $0/1 \hat{=} 2^3$	Number of the input channel for the thermocouple (binary-coded)

**Byte 9: Control byte 2**

Significance of bit $2^n$ ; n = 7 6 5 4 3 2 1 0	Logic state	Desired function
	1 0	Yes      Manual operation No
	1 0	Setpoint value rounding (not valid for automatic setting) Zone control
	1 0	Heating switch influences controller Heating switch without influence
	1/0 1/0 1/0 1/0 1/0	\   >      Not used   /

**Example 1:**

Desired function	Control byte 1		
Three-position controller with spare thermocouple channel 12	1 1 0 0 1 0 0 1	binary	
	C	9	hexadecimal
Desired function	Control byte 2		
Manual operation and zone control, heating switch without influence	0 0 0 0 0 0 0 1	binary	
	0	1	hexadecimal

As in example 1, the binary or hexadecimal representation of the control bytes 1 and 2 are compiled for the examples 2 and 3 according to the structure table.

**Example 2**

Two-position controller in manual operation with zone control; no spare thermocouple, heating switch without influence.  
Control byte 1 = 00H; control byte 2 = 01H

**Example 3**

Three-position controller with setpoint value rounding; spare thermocouple connected to channel 12; no manual operation; heating switch without influence.  
Control byte 1 = C9H; control byte 2 = 02H

**Byte 10      Manually manipulated value**

If a manual operation of the controller is required, bit 0 of the control byte 2 must be set to '1'. The manually manipulated variable which the operator must enter in percent values is then used for the pulse-pause output instead of the manipulated value computed by the controller. With a three-position controller, 128 must be added to the desired percent value if the output for cooling is to be addressed.

Example: Control byte 1      =    1 (3-position contr.)  
Control byte 2                =    1 (manual operation)  
Manually manipulated variable    = 60 (heating with 60 %)  
Manually manipulated variable    = 168 (cooling with 40 %)

If a thermocouple fails, manual operation can prevent the system from switching off. Switching over into a controlled operation, after the defective thermocouple has been replaced, is bumpless, since the integrator contents of the controller have been processed continuously. Bit 0 of control byte 2 must be reset.

Byte 11/12 For explanations see "Cascaded Control" (Chap. 3.2.5).

Byte 13 Not used

Byte 14/15 **Sampling interval**

For the control sampling interval, a time base results from the A/D conversion time and the number of AEs to be converted.

The following features apply to the time base:

a) in normal operation incl. cascaded control

Set conversion time	50 ms	60 ms
Time base	800 ms	960 ms

b) in hot channel control

Number	Conversion time	50 ms (fixed in hot channel control)	
	Controller	1 to 6	7 to 13
	Time base	350 ms	700 ms

Note thus the following:

a) The minimum sampling interval is  $1 * \text{time base}$ !

b) The sampling intervals which are beyond the limits of the time base are rounded off by the module to the next lower time base, however, limited to at least  $1 * \text{time base}$ .

The sampling intervals can be determined according to the 'Notes on the Setting', Chapter 4. The calculated value, however, should be rounded off according to the time base.

Bytes 16  
to 21

### Controller parameters

Various controller types can be generated by setting one or several parameters to zero:

Controller type	$K_R$ Byte 16/17	$T_N$ Byte 18/19	$T_D$ Byte 20/21
P	W	0	0
PI	W	W	0
PD	W	0	W
PID	W	W	W

0 = set parameter in message 0 to 12 to '0'

W = enter desired value in message 0 to 12

The following ranges are valid for the selection and input of the controller parameters (all values binary coded):

$$1 \leq K_R \leq 25\,599 \text{ (input in steps of } 0.01\text{)}$$

$$T_A \leq T_N \leq 512 T_A \text{ (input in multiples of } 4 \text{ s)}$$

$$1/2 T_A \leq T_D \leq T_A \text{ (in s)}$$

The sampling interval  $T_A$  is in ms as in the bytes 14 and 15 of the messages 0 to 12.

Byte 22



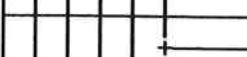
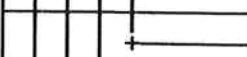
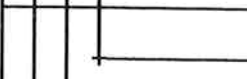
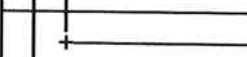



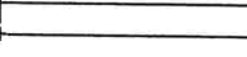
### Automatic setting parameters

If you do not wish an individual controller to work with the automatic setting function, set every bit of the automatic setting byte to '0'; else set bit 1 to '1'.

If "repeated automatic setting" is required (bit 4 = 0) automatic setting is carried out again during the next heating-up process, provided that the setpoint value 0 has been entered prior to the first heating-up process.

If "single automatic setting" (bit 4 = 1) is required, following the first heating-up process the controller will only work with the parameters once determined.



Significance of bit $2^n$ n = 7 6 5 4 3 2 1 0	Logic state	Desired function
	0	Must be set to '0'
	1 0	Controller with aut. setting funct. Standard PID controller
	0	Must be set to '0'
	1	Must be set to '0'
	1 0	Single automatic setting Repeated automatic setting
		Must be set to '0'
	0 1	Must be set to '0' for 3-position controllers
	0	Asymmetric controlled system for 2-position controllers
	0	Symmetric controlled system for 2-position controllers
	0	Must be set to '0'

If the automatic setting is to be repeated once, the following procedure must be observed:

- "Automatic setting" byte, bit 4 = 0: repeated automatic setting.
- "Master control byte 4" byte, bit 2 = 1: valid parameters.
- Wait at least 60 ms.
- "Automatic setting" byte, bit 4 = 1: single automatic setting.
- "Master control byte 4", bit 2 = 1: valid parameters.

If, prior to the heating-up process, setpoint value 0 has been entered, automatic setting is carried out again during the next heating-up process.

Byte 23      Internal use

Bytes            **Upper control zone (ZONOB)/ramp gradient**

24/25

If a zone control is required:

Bit 1 of control byte 2 = 0.

Upper control zone ZONOB: see Fig. 12

If setpoint value rounding is required:

Bit 1 of control byte 2 = 1.

Ramp gradient in °C/h or °F/h.

**Caution:** Setpoint value rounding is not possible  
with automatic setting controllers.

Bytes            **Lower control zone ZONUN (see Fig. 12)**

26/27

If the entered value exceeds the control range, the  
upper and lower control zones are limited to the  
maximum possible temperature value by software.

**Control zones (upper control zone, lower control zone)**

Temperature controllers are generally expected to meet (amongst  
others) two requirements:

- a) Heating-up time as short as possible while overshooting is  
reduced to a minimum.
- b) Correction of temperature interferences as fast as possible.

As a result from b), a relatively short reset time of the PID  
controller is required. In the case of large setpoint step-  
changes (e.g. heating-up), however, this leads to a quick  
"inflation" of the I element and results in the preset set-  
point being considerably overshoot.

Remedy:

The PID controller is active only within a determined temperature  
area. If this "temperature band" (here referred to as control  
zone) is violated, the PID algorithm is stopped. Heating/cooling  
is then carried out on a 100 % basis (depending on the system  
deviation).

Calculating the control zone:

The control zone is determined by the special features of the  
controlled system. The most important features are the two  
parameters 'dead time' and 'max. temperature gradient' of the  
controlled system (see Notes on the Setting, Chapter 4).  
Generally, you only need to enter the control zone symmetrically,  
i.e. upper control limit = lower control limit.

Guide values (very generalized):

Upper control limit = lower control limit

Minimum	Normal	Extreme
5°C	10 to 30°C	40 to 60°C

Note that if the control zone is too small (0 to 4°C) the control response is similar to that of a pure switching controller (bimetal controller).

Notes: The control zone has nothing to do with the tolerances described above! These are used for monitoring purposes only, whereas upper control limit and lower control limit are controller parameters!

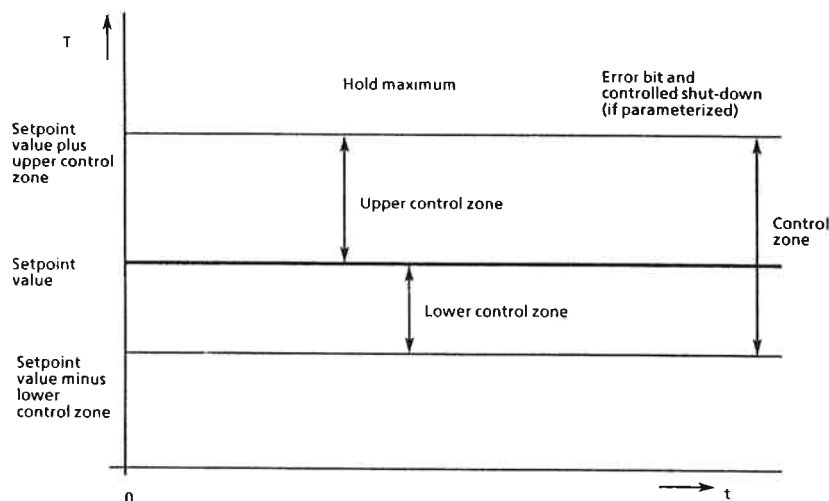


Fig. 12 Upper and lower control zone

**Examples:**

- a) Zone control, bit 1 of control byte 2 = 0
  - ZONOB = 20°C
  - ZONUN = 30°C
  - Setpoint value = 200°C
  - Control zone = 170°C to 220°C
- b) No zone control, bit 1 of control byte 2 = 0
  - ZONOB = 1600°C
  - ZONUN = 1600°C
  - Setpoint value = 220°C
  - Control zone = 0°C to maximum value (in °C)
- c) Setpoint ramp, bit 1 of control byte 2 = 1
  - ZONOB = 200°C
  - ZONUN = 20°C
  - Setpoint value = 300°C
  - Control zone = 0°C to maximum value (in °C)

Following the ramp function, the setpoint value is reached within 1.5 hours.

**Byte 28 Heating/cooling ratio in % (0 to 255 %)**

In the case of three-position controllers, the different effect of the cooling and heating control action may lead to oscillations with normal controller response. These oscillations can be compensated by the heating/cooling ratio which is specified in %.

**Example 1: Water cooling**

10 s heating increases the temperature by 2°C. 10 s cooling decreases the temperature by 4°C. Thus cooling is approximately twice as effective as heating. If a value of 50 % is specified for the heating/cooling ratio, the operating time of the cooling is only half of the heating time, i.e. only 5 s instead of 10 s.

**Example 2: Air cooling**

10 s heating increases the temperature by 2°C. 10 s cooling decreases the temperature by 1°C. The cooling is approximately half as effective as the heating. Thus the heating/cooling ratio is 200 %.

**Byte 29 Response value in % (0 to 50 %)**

If the calculated manipulated value (in percent) is less than the response value, 0 is output. If it is greater than 100 % minus response value, 100 % (= sampling interval) is output (see Fig. 13).

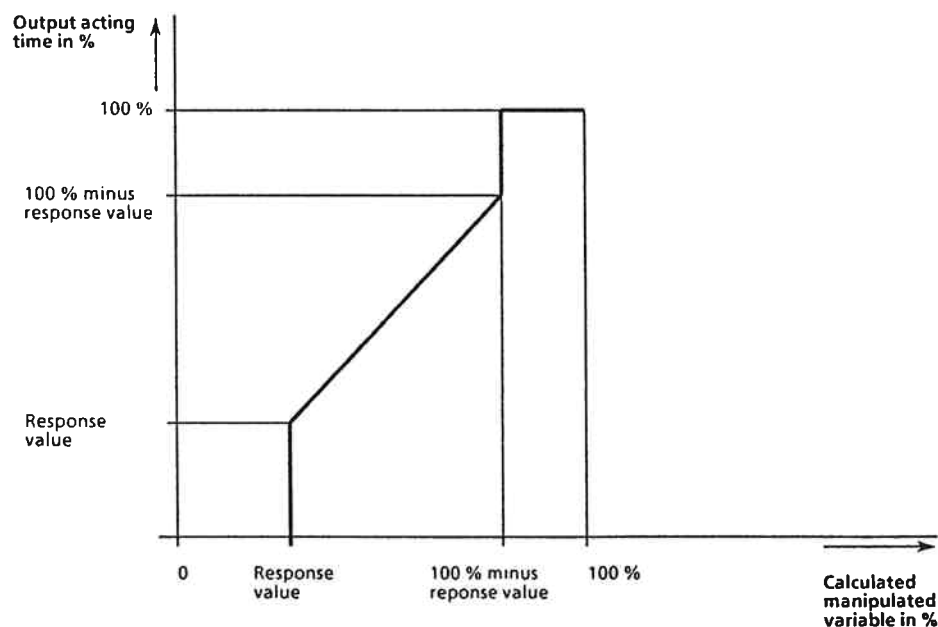


Fig. 13 Response value

Contact elements (contactor, Triac, etc) can be used to output the manipulated variable by means of an adequate pulse-pause ratio.

Very short ON intervals, however, occur in the case of manipulated variables near 0 %, having a negative effect on the endurance of mechanical contact elements.

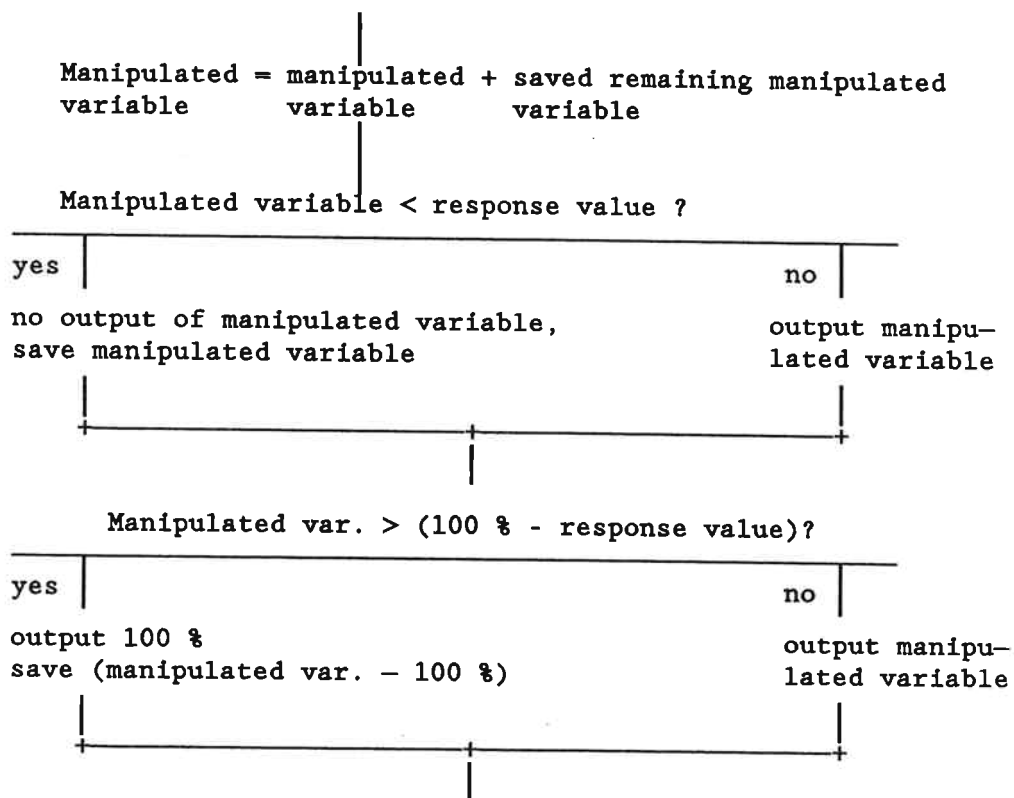
The same applies to manipulated variables near 100 %. Here, OFF intervals are short.

Example: Sampling interval      16 s  
           Manipulated variable    3 %

$$\text{ON interval} = \frac{3}{100} * 16 \text{ s} = 0.48 \text{ s}$$

These undesired switching cycles can be suppressed by means of the response value.

The module reacts then as follows:



Despite the suppression of short switching cycles, the "processing of the remainder" as described above leads thus to a good controller response.

Computing the response value:

$$\text{Response value} = \frac{\text{min. switching time}}{\text{sampling interval}} * 100 \%$$

Example: Sampling interval = 16 s  
 Min. switching time = 1 s (required)

$$\text{Response value} = \frac{1 \text{ s}}{16 \text{ s}} * 100 \% = 6.25 \% \sim 6 \%$$

Note: The response value should not exceed 10 %, even if a "processing of the remainder" is carried out. If the value is greater than 10 %, depending on the controlled system, undesired temperature oscillations may occur.

Guide values for the response value:

- when using electronical contact elements (Triac, etc):  
   response value = 0 %
- when using mechanical contact elements:  
   response value = 3 to 6 %
- for three-position controllers with air cooling  
   (including the use of electronical contact elements):  
   response value = 3 to 10 % (for a better preservation of the fans)

Byte 30      Not used

Byte 31      Message no.

## 2.2 Messages 13 and 14

The messages 13 and 14 contain the setpoint values and the monitoring tolerances for the two voltage channels 13 and 14.

0	Setpoint value	0 ... 2048, 1 E = 10 mV
1		
2	Positive tolerance	0 ... 255, 1 E = 10 mV
3	Negative tolerance	0 ... 255, 1 E = 10 mV
4	Not used	
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		
31	Message number (13) or (14)	

Fig. 14 Structure of messages 13 and 14

Byte  
0/1

### Setpoint value channels 13 and 14

The actual values read in via channel 13 are compared with the setpoint value and checked for positive or negative violation of the tolerance values. Input: 0 to 1024 units  $\hat{=}$  10.24 V or 0 to 2048 units  $\hat{=}$  20.48 V.

Byte 2

### Positive tolerance channels 13 and 14

If the actual value is higher than the setpoint value plus the positive tolerance, an error flag is set 'on' (bit 0 of the appertaining error byte). The processing of tolerances is switched off by entering the value 0.

Byte 3

**Negative tolerance channels 13 and 14**

If the actual value is lower than the setpoint value minus the negative tolerance, an error flag is set 'on' (bit 1 of the appertaining error byte). Positive and negative tolerance values are specified in the range between 0 and 255 units. The processing of tolerances is switched off by entering the value 0.

**2.3 Message 15**

Message 15 contains general parameters as well as the master control bytes.

0	Switching value for comparator	0 ... 1024, 1E = 10 mV (jumper D open) 1E = 20 mV (jumper D inserted)
1		
2	Monitoring time (emergency program)	0 ... 3600 s, 1E = 1 s
3		
4	Internal use	
5		
6	Internal use	
7		
7	Start-up time (hot channel)	0 ... 60 min, 1E = 1 min
8	Start-up manipulated value (hot channel)	0 ... 100 %
9	Start-up zone (hot channel)	0 ... 255°C
10	Start-up setpoint value (hot channel)	0 ... 1600°C
11		
12	Max temperature difference	°C/min (1 ... 255)
13	Not used	
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27	Master control byte 1	
28	Master control byte 2	
29	Master control byte 3	
30	Master control byte 4	
31	Message number (15)	

Fig. 15 Structure of message 15



**Bytes 0/1     Switching setpoint value for the comparator**

The value entered via channel 13 is fed to a comparator together with a switching setpoint value which has been D/A-converted and specified in units. A maximum of 1024 units can be specified. If the switching setpoint value is reached, the comparator output is switched to 1.

If the jumper D has been inserted, the specified value (up to 1024 units) corresponds to an input value of up to 20.48 V (corresponding to 2048 units).

If the jumper D is open, the specified value (up to 1024 units) corresponds directly to the value of up to 10.24 V (max. 1024 units) specified by the analog-digital converter.

**Bytes 2/3     Monitoring time**

Bit 4 of the master control byte 4 must be set 'on' and the monitoring time entered in seconds (max. 3,600 s) if the manipulated variable averaged during a certain period of time is to be output if a thermocouple fails.

Bytes     For internal use  
4 to 6

Byte 7     Start-up time; see "hot channel"

Byte 8     Manipulated start-up value; see "hot channel"

Byte 9     Start-up zone; see "hot channel"

Bytes     Start-up setpoint value; see "hot channel"  
10/11

**Byte 12     Maximum temperature difference**

A maximum rate of the actual temperature per minute is specified to enable detection of faulty actual temperature values. If the maximum temperature rise is 5°C at a sampling interval of 10 s and a given heating input, all actual values which are higher than 5°C compared with the previous sampling are to be regarded as faults. Such a fault is suppressed and is replaced by an actual value which results from the last actual value plus the maximum gradient.

Byte     Not used  
13 to 26

Byte 27      **Master control byte 1**

Significance of bit $2^n$ ; n = 7 6 5 4 3 2 1 0	Logic state	Desired function
	1 0	Filter for actual value display OFF Filter for actual value display ON.
	1 0	Not used
	1 0	Not used
	1 0	Internal use, must be set to 0
	1 0	Yes                  Hot channel control No
	1 0	Yes                  Cascaded control No
	1 0	Actual values          in BCD binary
	1 0	S5 format 210 format

- Bit 0      If the actual value display becomes irregular a filter can be inserted into the display processing sequence.  
Bit 0 = 0 —> Filter ON (slow display)
- Bit 1/2    Not used
- Bit 3      For internal use
- Bit 4      If this bit is set 'on', the hot channel control (see Chapter 3.1) is activated.
- Bit 5      Cascaded control is switched on by this bit (see Chapter 3.2)
- Bit 6      Numeric representation in BCD (1) or binary code (0).  
Only for the 16-bit values which can be read from the IP (messages 17 to 25).
- Bit 7      Numeric representation of setpoint values and actual values (16 bits) in S5 format (1) or 210 format (0).



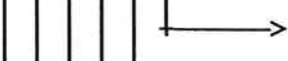
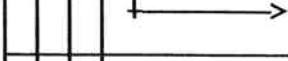


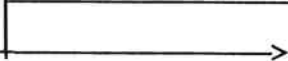

	Format	Numeric representation		
		binary	BCD code	
Byte n	S5	High byte	Thousands	Hundreds
Byte n + 1		Low byte	Tens	Units
Byte n	210	Low byte	Tens	Units
Byte n + 1		High byte	Thousands	Hundreds

## Byte 28      Master control byte 2

Significance of bit $2^n$ ; n = 7 6 5 4 3 2 1 0	Logic state	Desired function
	1 0	Type of thermocouple (see below)
	1 0	
	1 0	
	1 0	
	1 0	Yes      Monitoring of channel 13 No      + error processing
	1 0	Yes      Monitoring of channel 14 No      + error processing
	1 0	Temperature    in°F value            in°C
	1 0	Not used

Bit 3 2 1 0	Type of thermocouple
0 0 0 0	Not used
0 0 0 1	Thermocouples Fe-Constantan type L acc. to DIN 43710
0 0 1 0	Thermocouples NiCr-Ni type K acc. to IEC 584
0 0 1 1	Thermocouples PtRh-Pt type S (Pt10%Rh-Pt) acc. to IEC 584
0 1 0 0	<del>Not used</del> Typ 3 Fe-Constantan
0 1 0 1	Not used
0 1 1 0	Not used
0 1 1 1	Not used
1 0 0 0	Not used
1 0 0 1	Not used
1 0 1 0	Not used
1 0 1 1	Not used
1 1 0 0	Not used
1 1 0 1	Not used
1 1 1 0	Not used
1 1 1 1	Not used

Byte 29      **Master control byte 3**

Significance of bit $2^n$ ; n = 7 6 5 4 3 2 1 0	Logic state	Desired function
	1 0	Must be set by the PC at the end of a cycle (e.g. a complete injection) as a trigger bit; the IP resets it (for cascaded control only).
	1 0	Not used
	1 0	Not used
	1 0	Not used
	1 0	Not used
	1 0	Not used
	1 0	Not used
	1 0	Not used

Byte 30      **Master control byte 4**

Significance of bit $2^n$ ; n = 7 6 5 4 3 2 1 0	Logic state	Desired function
	1 0	Internal use
	1 0	Yes    { Cold start (set by the PC; No        reset by the IP)
	1 0	Yes    { Parameter transfer No        terminated (set by PC; reset by the IP)
	1 0	Internal use
	1 0	Yes    { Output of averaged manipu- No        lated variable (open circ.)
	1 0	Yes    { Switchover to lowering No        setpoint value
	1 0	Internal use
	1 0	Yes    Use of 2nd tolerance values No

**Master control byte 4**

Bit 0      Internal use.

Bit 1      Initiates cold start which clears specific memory areas of the IP (e.g. 'integrator history values'). This bit must be set 'on' if

- a) the PC is switched on for the first time;
- b) the PC detected a failure of the back-up battery during power-off (with PC 115U/135U).

This bit is reset by the IP.

Bit 2      After either the controller parameters or the monitoring time have been altered, or after the cascade has been switched ON or OFF, the bit 'parameter transfer terminated' must be set 'on' by the PC. This bit is reset by the IP.

Bit 3      Internal use

- Bit 4      Must be set 'on' if the manipulated variable which has been averaged during the monitoring time (byte 2/3 of message 15) is to be output in the case of a thermocouple failure. This applies for all controllers.
  
- Bit 5      If this bit is set 'on', the lowering setpoint values are used instead of the temperature setpoint values (night lowering).
  
- Bit 6      Internal use.
  
- Bit 7      A controller is switched off if its actual value is outside the 2nd tolerance value and if bit 7 is set 'on'.  
When returning to the 2nd positive tolerance band the controller continues the processing automatically; when returning to the 2nd negative tolerance band, however, it does **not**: the controller can only be put into operation again using the KS instruction (see "function block FB 162")!

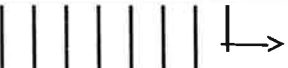


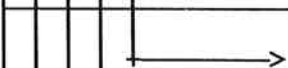




## 2.4 Message 16

Message 16 is used for status messages. It contains general status information as well as the error bytes of the controllers and voltage channels.

0	Status byte 1	
1	Internal use	
2	Controller group fault/Channel group fault	8 ... 12/13 and 14
3	Controller group fault	0 ... 7
4	Automatic setting status	8 ... 12
5	Automatic setting status	0 ... 7
6	Internal use	
7		
8		
9		
10		
11		
12		
13		
14		
15	Software version	
16	Error byte 0	
17	Error byte 1	
18	Error byte 2	
19	Error byte 3	
20	Error byte 4	
21	Error byte 5	
22	Error byte 6	
23	Error byte 7	
24	Error byte 8	
25	Error byte 9	
26	Error byte 10	
27	Error byte 11	
28	Error byte 12	
29	Error byte 13	
30	Error byte 14	
31	Message number (16)	

Fig. 16 Structure of message 16

Byte 0 = Status byte 1

Significance of bit $2^n$ ; n = 7 6 5 4 3 2 1 0	Logic state	Desired function
	1 0	Yes No      Group fault
	1 0	Internal use
	1 0	Internal use
	0	Internal use
	0	Not used
	1 0	Yes No      Overflow sampling interval
	1 0	Yes {      Parameter request No      (set by the IP)
	1 0	Yes No      Watchdog function

Byte 0 = Status byte 1

Bit 0      The bit for group faults is set 'on' if a bit is set 'on' in one of the error bytes 0-14 or if an error has occurred in the Pt 100.

Bits      Internal use  
1 to 3

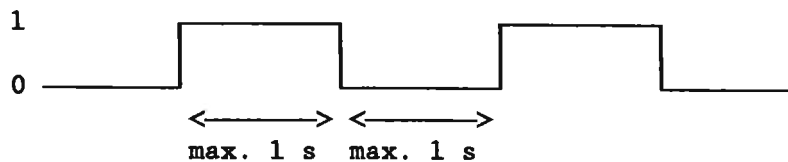
Bit 4      Not used (always 0)

Bit 5      The IP processor is inhibited as long as the PC accesses the message RAM. If the access lasts too long a time, a sampling time overflow can occur. An access rate of one message every 100 ms is permitted.

Bit 6      Upon power return after a power failure the IP sets a 'parameter request'. Thereupon the PC has to transmit the messages 0 - 15 and eventually set the bit 'parameter transfer terminated'. The request by the IP 244 is thus also reset.



Bit 7 This bit changes its state at least once per second.



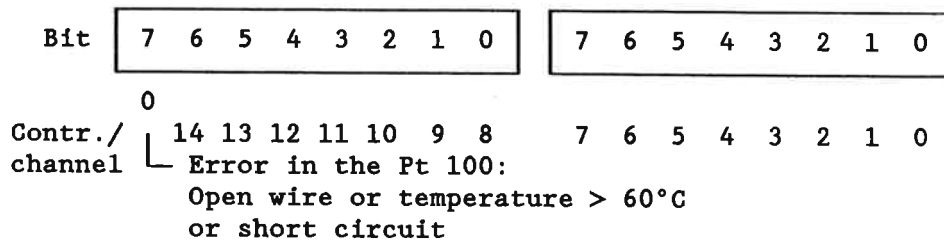
Using this bit, the PC can detect a program failure of the IP.

Byte 1 Internal use.

Bytes 2/3 **Controller group fault/Channel group fault**

The bit assigned to the controller/channel is set 'on' if an error bit has been set 'on' in the appertaining error byte.

Assignment of bits and controllers:



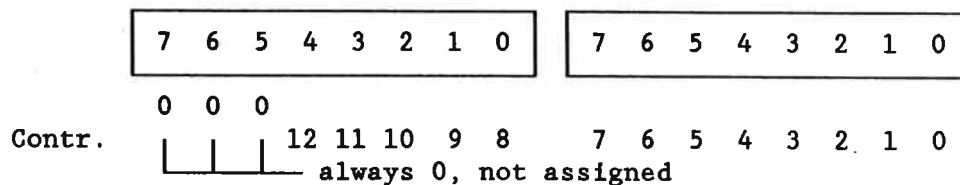
Byte 2

Byte 3

Bytes 4/5 **Automatic setting status**

If the module performs an automatic setting run for one or more controllers, the bit assigned to this controller is set 'on'. This bit is reset after the parameters have been determined, i.e. after the automatic setting function has been terminated (see Chapter 1.2, automatic setting function).

Assignment of bits and controllers:



Byte 4

Byte 5

For automatic setting see Chapter 1.2.5.

Bytes 6      Not used  
to 14

Byte 15      This byte contains the version number of the software  
as entered in the EPROM.

Bytes 16      Error byte 0-12  
to 28

Significance of bit $2^n$ ; n = 7 6 5 4 3 2 1 0	Logic state	Desired function
	1 0	Yes { 1st positive tolerance No { exceeded
	1 0	Yes { 1st negative tolerance No { undershot
	1 0	Yes { 2nd positive tolerance No { exceeded
	1 0	Yes { 2nd negative tolerance No { undershot
	1 0	Yes { Temperature setpoint value No { too high
	1 0	Yes { Lowering setpoint value No { too high
	1 0	Open wire identification A
	1 0	Open wire identification B

Explanations to 'open wire identifications' A and B

Bit 7 (B)	6 (A)	Significance
0	0	No open circuit
0	1	Orig. thermocouple defective, no replacement specified
1	0	Orig. thermocouple def., replacement active
1	1	Orig. thermocouple and replacement defective

Bytes  
29/30

Error bytes 13, 14

Significance of bit $2^n$ ; n = 7 6 5 4 3 2 1 0								Logic state	Desired function
								1 0	Yes { 1st positive tolerance No exceeded
								1 0	Yes { 1st negative tolerance No undershot
								0	Not used
								0	Not used
								0	Not used
								0	Not used
								0	Not used
								0	Not used

## 2.5 Messages 17 to 20

The numeric representation of messages 17 to 20 is determined by bit 6 (BCD/binary) and bit 7 (S5/210) of the control byte 1.

### Message 17

This message contains the actual temperature values in °C/°F of the sensors 0-12 (bytes 0 to 25) and the actual values of the voltage channels 13 and 14 (2048 units  $\triangleq$  20.48 V) (bytes 26 to 29).

0 1	Actual value temperature controller 0
2 3	Actual value temperature controller 1
4 5	Actual value temperature controller 2
6 7	Actual value temperature controller 3
8 9	Actual value temperature controller 4
10 11	Actual value temperature controller 5
12 13	Actual value temperature controller 6
14 15	Actual value temperature controller 7
16 17	Actual value temperature controller 8
18 19	Actual value temperature controller 9
20 21	Actual value temperature controller 10
22 23	Actual value temperature controller 11
24 25	Actual value temperature controller 12
26 27	Actual value temperature controller 13
28 29	Actual value temperature controller 14
30	Not used
31	Message number (17)

Fig. 17 Structure of message 17  
(actual values)

**Message 18**

This message contains the manipulated variables of the controllers 0-12. These values are issued in %. The following assignments apply:

Range  $0 \leq x \leq 100$   $\Rightarrow$  Heating with  $x$  %  
 Range  $101 \leq x \leq 128$   $\Rightarrow$  Prohibited area (does not occur)  
 Range  $128 \leq x \leq 228$   $\Rightarrow$  Cooling with  $x-128$  %  
 Range  $228 \leq 65535$   $\Rightarrow$  Prohibited area

0	Manipulated value controller 0
1	
2	Manipulated value controller 1
3	
4	Manipulated value controller 2
5	
6	Manipulated value controller 3
7	
8	Manipulated value controller 4
9	
10	Manipulated value controller 5
11	
12	Manipulated value controller 6
13	
14	Manipulated value controller 7
15	
16	Manipulated value controller 8
17	
18	Manipulated value controller 9
19	
20	Manipulated value controller 10
21	
22	Manipulated value controller 11
23	
24	Manipulated value controller 12
25	
26	Not used (00H)
27	
28	Not used (00H)
29	
30	Not used (00H)
31	Message number (18)

**Fig. 18 Structure of message 18  
(manipulated values)**

**Message 19**

Message 19 contains the minimum values which are determined when the 1st negative tolerance is negatively violated (see Chapter 1.1.1). The values are given in °C/°F.

0	Minimum value controller 0
1	
2	Minimum value controller 1
3	
4	Minimum value controller 2
5	
6	Minimum value controller 3
7	
8	Minimum value controller 4
9	
10	Minimum value controller 5
11	
12	Minimum value controller 6
13	
14	Minimum value controller 7
15	
16	Minimum value controller 8
17	
18	Minimum value controller 9
19	
20	Minimum value controller 10
21	
22	Minimum value controller 11
23	
24	Minimum value controller 12
25	
26	Not used      (00H)
27	
28	Not used      (00H)
29	
30	Not used      (00H)
31	Message number (19)

**Fig. 19 Message 19 (minimum values)**  
(see Chapter 1.1.8)

**Message 20**

According to message 19, message 20 contains the maximum values.

0 1	Maximum value controller 0
2 3	Maximum value controller 1
4 5	Maximum value controller 2
6 7	Maximum value controller 3
8 9	Maximum value controller 4
10 11	Maximum value controller 5
12 13	Maximum value controller 6
14 15	Maximum value controller 7
16 17	Maximum value controller 8
18 19	Maximum value controller 9
20 21	Maximum value controller 10
22 23	Maximum value controller 11
24 25	Maximum value controller 12
26 27	Not used (00H) (00H)
28 29	Not used (00H) (00H)
30	Not used (00H)
31	Message number (20)

**Fig. 20 Message 20 (maximum values)**  
(see Chapter 1.1.8)

## **2.6 Messages 21 to 31**

### **Message 21**

This message contains the 'cumulative setpoint values' which are generated with a cascaded control by the influence of the master controller (see Chapter 3.2).

### **Message 22 to 25**

For internal use only.

### **Messages 26 to 31**

Not used.



### 3 Special Functions for Plastic Processing Machines

#### 3.1 Hot Channel Control

##### 3.1.1 Introduction

The heating cartridges used for the hot channel control are extremely sensitive to quick temperature changes. A 'start-up phase' has been developed to fulfil this condition.

If these heating cartridges are used, the system time constants are small compared with those using heating jackets. Therefore very short controller sampling intervals must be selected.

##### 3.1.2 Start-up Phase

The same manipulated value  $S$  (e.g. 25 %) is specified for all controllers until the actual value = start-up setpoint value ( $SW_A$ ) - start-up zone ( $Z_A$ ) has been reached (no closed-loop control).

The start-up time  $t_{AZ}$  is started when the system enters the start-up zone. During this time the system is controlled towards the start-up setpoint value. After the time  $t_{AZ}$  has expired, the system is controlled towards the respective temperature setpoint value. If the actual value falls under the value = start-up setpoint value ( $SW_A$ ) minus zone ( $Z_A$ ) during operation, then the start-up process starts again for this zone.

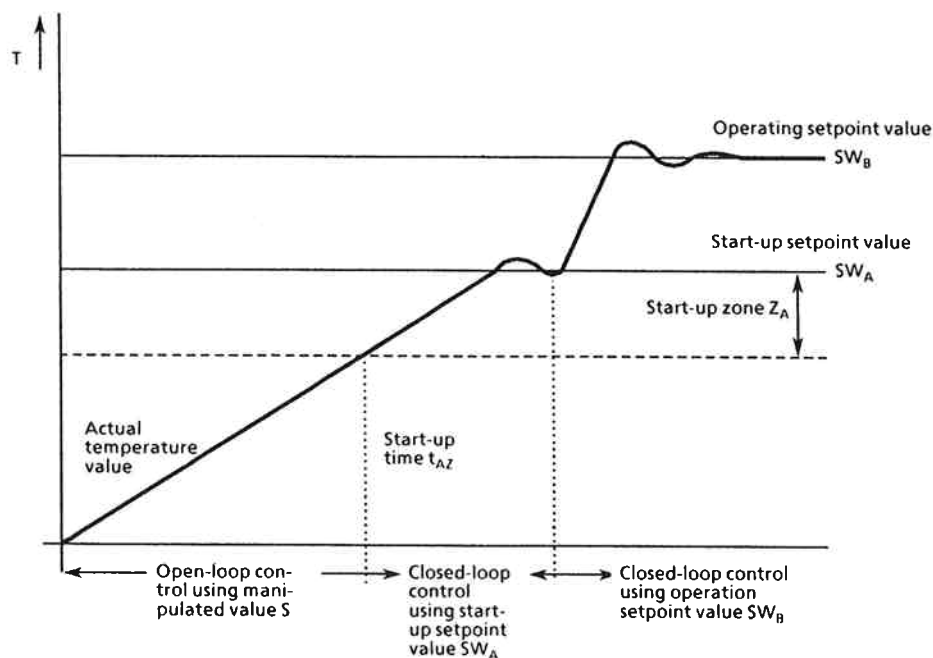


Fig. 21 Start-up phase of hot channel control

Note: Hot channel controllers can only be configured as two-position controllers.

The parameters which are required for the start-up must be entered in message 15.

Start-up time $t_{AZ}$	in byte 7	(0 to 60 min)
Start-up manipulated value S	in byte 8	(0 to 100 %)
Start-up zone $Z_A$	in byte 9	(0 to 255°C)
Start-up setpoint value $SW_A$	in byte 10/11	(0 to 1600°C)

### 3.1.3 Control Sampling Interval for Hot Channel Control

The sampling interval can be decreased by switching off individual controllers (setpoint value = 0). In addition, the processing of the two voltage channels and of the comparator are omitted.

With a hot channel control the conversion time is 50 ms (regardless of the position of jumper D).

This results in the following minimum sampling intervals:

1 to 6 controllers:  $T_{A \min} = (6+1) * t_c = 350 \text{ ms}$

7 to 13 controllers:  $T_{A \min} = (13+1) * t_c = 700 \text{ ms}$

$t_c$  = conversion time

### 3.2 Cascaded Control

#### 3.2.1 Introduction: Plastic Processing Machines (Example)

Up to now, a zone side control has been used for the extruder equipment of plastic processing machines. The disadvantage of this method is that the temperature of the extruded plastic material is only constant in one operating state. Changes of the worm speed for example always result in changes of the material temperature. This can be compensated by an adjustment of the setpoint values of the control zones at the extruder.

The cascaded control performs this adjustment by measuring the material temperature at the exit of the extruder and by readjusting the setpoint values of the individual zones in the case of a temperature change.

#### 3.2.2 Description of the Control Structure

Fig. 22 shows the control structure of the cascaded control system. The extruder is subdivided into individual heating zones. The temperature of these zones can be controlled by up to 12 zone controllers which are subordinate to the master controller. The control structure of the zone controllers is identical to the one of the temperature controllers previously discussed.

The material temperature is averaged over the time of a machine cycle. This averaging procedure is necessary since temperature variations occur during the discharge of the reservoir-head (see Fig. 23). The difference between actual value and setpoint value is fed to a PI controller (master controller). The manipulated variable for this master controller is computed every time a machine cycle is finished. The master controller's manipulated variable is output in °C or °F. The influence of the master controller can be totally switched off by the switch S0; the switches S1 to S12 switch off this influence on the individual zone controllers.

When the cascaded control is switched on the digital output DA17 is assigned to the master controller (controller 0).

A controller can be used as independent temperature controller if the appertaining switch is in 'OFF' position.

The setpoint correction can be influenced by the weighting factors F1 to F12. Thus a correction profile can be established. The delimiters B1 to B12 prevent the zone setpoint values from being too de-adjusted.

A temperature profile can be set using the individual zone setpoint values.

#### 3.2.3 Selection of the Cascaded Control

The cascaded control is switched on by setting bit 5 of the master control byte 1 'on'. A start-up procedure must always be performed when this function has been selected (set bit 2 of the master control byte 4 'on').

### 3.2.4 Parameterization of the Cascaded Control

The definitions of the messages 0 to 12 change after the cascaded control has been selected. Message 0 and thus controller 0 are permanently assigned to the master controller. The twelve subordinate zone controllers are also permanently assigned to the messages 1 to 12 respectively. Figs. 24 and 25 show the structures of these modified messages.

### 3.2.5 Changes/Amendments to the Messages

#### Explanations regarding message 0 of the master controller

The same rules as for conventional controllers apply for the bytes 0/1 (material temperature setpoint value) and the bytes 2 and 3 (positive and negative tolerance). A second setpoint value and the appertaining tolerance values (bytes 4 to 7) are omitted.

Control byte 1 has the following assignments:

Bit 0	Always 0 (two-position controller)
Bit 1	Switch S0 'OFF' (0) or 'ON' (1)
Bits 2 to 7	Always 0

Control byte 2 has the following assignments:

Bit 0	Always 0 (no manual operation)
Bit 1	Always 0 (no setpoint value rounding possible)
Bits 2 to 7	Always 0

Controller gain (bytes 16/17), reset time (bytes 18/19) and control zones (bytes 24 to 27) are as described in the Operating Instructions.

The values for derivative action time (bytes 20/21), heating/cooling ratio (byte 28) and response value (byte 29) are omitted. Automatic setting is not possible for the master controller.

#### Explanations regarding the messages 1 to 12 of the subordinate controllers:

The messages 1 to 12 of the subordinate controllers are identical to the message structure as described in the Operating Instructions. However, they have the following additional features:

Bit 1 of control byte 1 corresponds to the switches S1 to S12 of Fig. 22. If bit 1 is set 'on', the influence of the master controller is switched on. If bit 1 = 0, the respective controller operates independently from the superimposed one and can be used for other purposes. Weighting factor and delimiter value (see below) have no influence in this case.

The delimiter value (byte 11) specifies the maximum possible value of the setpoint correction after the weighting in thousandths of the entered setpoint value (bytes 0/1). The entered value must be in the range between 0 and 255 thousandths.

The weighting factor specifies what percentage of the master controller's correction value is to be added to the setpoint value. The valid ranges are 0 to 127 for a positive weighting

factor and 128 to 255 for a negative weighting factor of 0 to -127 %. The master controller can thus be weighted by individual zones.

#### **Explanations regarding the master control bytes (message 15)**

Bit 5 of the master control byte 1 (byte 27) must be set to 1 (cascaded control 'ON').

Bit 0 of the master control byte 3 (byte 29) must be set to 1 after the end of each machine cycle (triggering). Setting this cycle bit 'on' starts the averaging of the actual value and the processing of the master controller. This bit is reset automatically by the module.

#### **Explanations regarding message 21 (group setpoint values)**

The bytes 0/1 contain the setpoint value of the master controller. The bytes 2 to 25 contain the corrected setpoint values (group setpoint values) of the subordinate zone controllers 1 to 12. With a 'non-cascaded controller' (switch S0 'OFF'), these positions contain the setpoint values (Fig. 26). SBn = setpoint values of the individual controllers.

#### **3.2.6 Comments on the Operation of the Cascaded Control**

The master controller should not be switched on (S0 'ON') until the actual values of the subordinate controllers are within the first tolerance band (interrogation of the error bytes) and the extruder has been switched on. If the master controller is switched on too early, the integral part can cause a high overshooting of the material temperature.

The gain of the master controller should not be too high since the system might start oscillating. If a delimiter (B1 to B12) is active, the integral part is slowed down. A longer period of time is then required until the material temperature has been adjusted. This should be noted when the delimiter values are selected.

Weighting factor and delimiter values set limits to the correction of the zone values, which can be calculated for each zone in the following way. The maximum correction of the setpoint value (in degrees centigrade) is the minimum of the two following values:

$$K1 = \frac{460^{\circ}\text{C} * \text{weighting factor (in \%)}}{100}$$

$$K2 = \frac{\text{zone setpoint value} * \text{delimiter value (in } ^{\circ}/_{\text{oo}})}{1000}$$

If the material temperature has not been adjusted after a longer period of time, a check should be made to see if the correction limit has been reached.

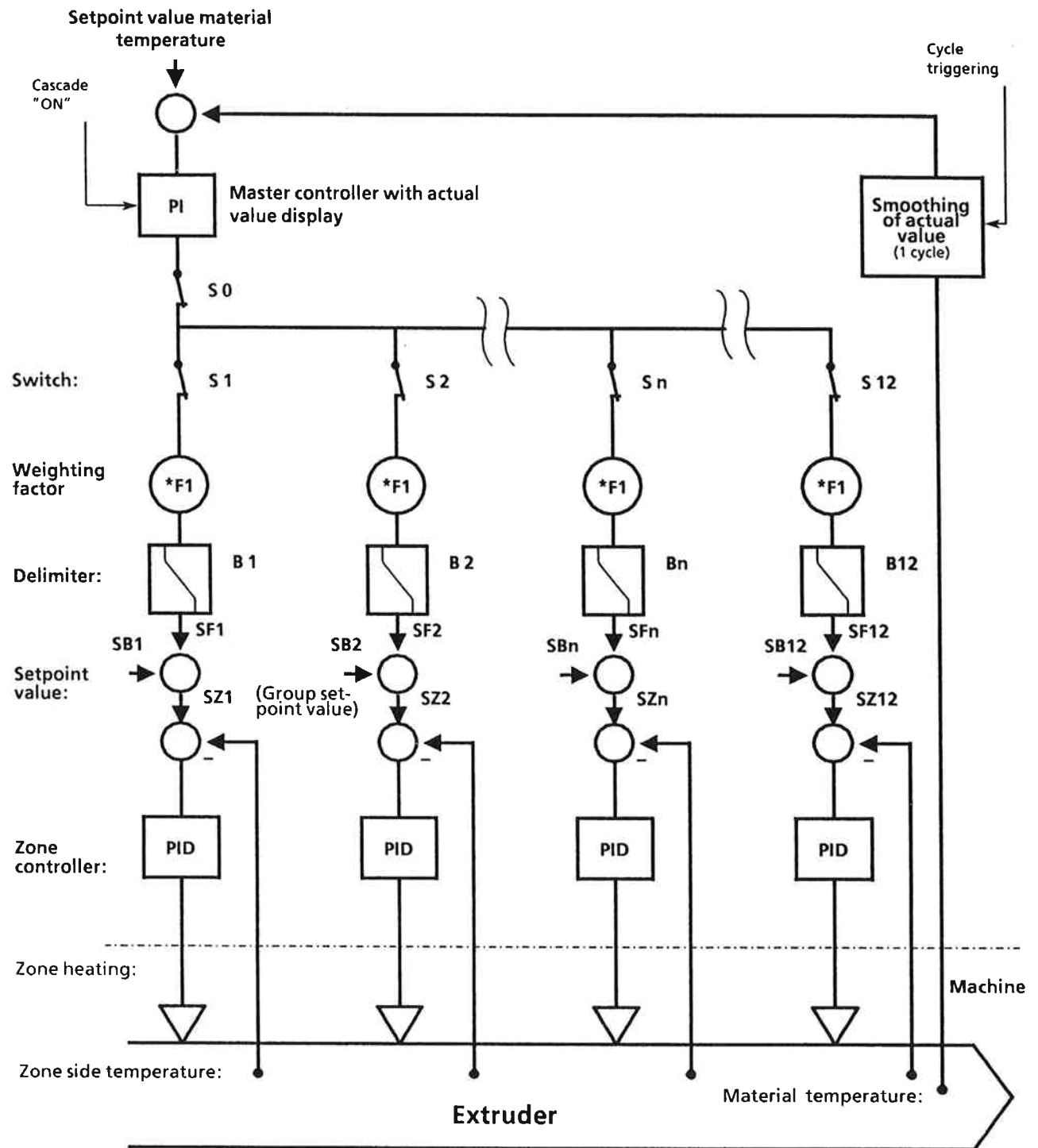
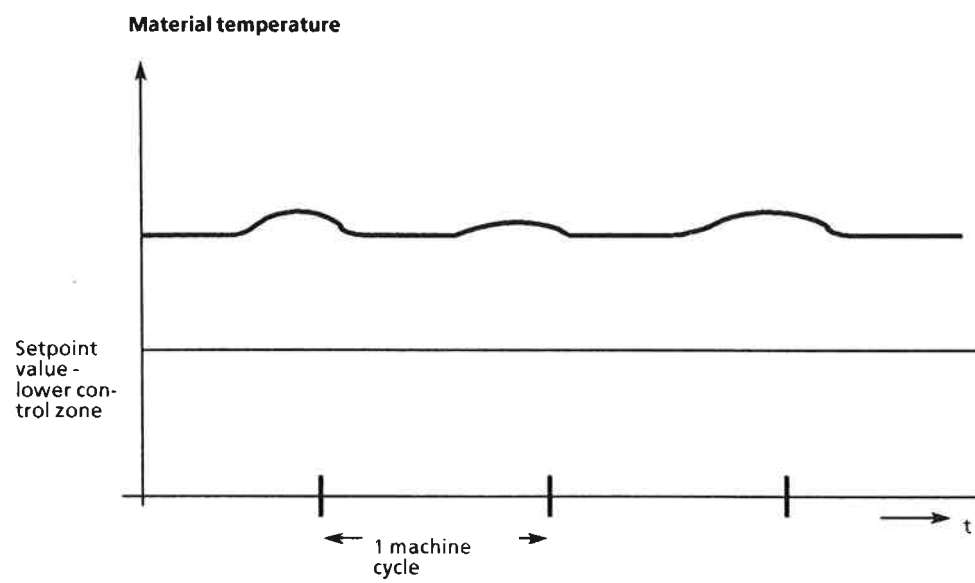


Fig. 22 Cascaded control for extrusion machines



**Fig. 23** Course of the material temperature with reservoir-head blow molding machines

Master controller		
0	1st setpoint value	0 ... 1600 °C in steps of 1 °C } or corresponding value in °F
1		
2	1st positive tolerance	
3	1st negative tolerance	0 ... 255 °C in steps of 1 °C
4	x	0 ... 255 °C in steps of 1 °C
5		
6	x	
7	x	
8	Control byte 1	Assignment with cascaded control Control byte 1: 0 0 0 0 0 0 / 1 0 Control byte 2: 0 0 H → SO ON / OFF
9	Control byte 2	
10	x	
11	x	
12	x	
13	x	
14	x	
15		
16	Gain $K_R$	Input as with standard controller 1 ... 25599      1E = 0.01
17		
18	Reset time $T_N$	0 or $(T_A \leq T_N \leq 512 T_A)$ 1E = 4s
19		
20	x	
21		
22	x	
23		
24	Upper limit of the control zone	0 ... 1600 °C } or corresponding value in °F
25		
26	Lower limit of the control zone	0 ... 1600 °C }
27		
28	x	
29	x	
30	x	
31	0	

x = irrelevant

Fig. 24 Message 0 with cascaded control



Subordinate controllers		
0	1st setpoint value (SB n)	0 ... 1600°C in steps of 1°C      n = 1 ... 12
1		
2	1st positive tolerance	0 ... 255 °C in steps of 1°C
3	1st negative tolerance	0 ... 255 °C in steps of 1°C
4	2nd setpoint value (SB n)	0 ... 1599 °C in steps of 1°C      n = 1 ... 12
5		
6	2nd positive tolerance	0 ... 255 °C in steps of 1°C
7	2nd negative tolerance	0 ... 255 °C in steps of 1°C
8	Control byte 1	} Assignment as with standard control
9	Control byte 2	
10	Manually manipulated variable	0 ... 200 %, 1 E = 1 %
11	Limiting value (K)	0 ... 255 ‰,
12	Weighting factor (K)	0 ... 127% for positive influence 128 ... 255% for negative influence
13	Not used	
14	Sampling time (SE)	1 ... 65535 ms, 1 E = 1 ms
15		
16	Gain $K_R$ (SE)	1 ... 25599, 1 E = 0.01
17		
18	Reset time $T_N$ (SE)	0 or $(T_A \leq T_N \leq 512 T_A)$ , 1 E = 4 s
19		
20	Derivative action time $T_D$ (SE)	0 or $(\frac{T_A}{2} \leq T_D \leq 512 T_A)$ , 1 E = 1 s
21		
22	Automatic setting parameters	
23	Internal use	
24	Upper limit of control zone or setpoint value rounding (SE)	0 ... 1600 °C/0 ... 65536 °C/h, 1 E = 1 °C or 0 ... 2047 °F/h (= 1119 °C/h)
25		
26	Lower limit of control zone (SE)	0 ... 1600°C
27		
28	Heating/cooling ratio (SE)	0 ... 100 %, 1 E = 1 %
29	Response value	0 ... 50 %, 1 E = 1 %
30	Not used	
31	Message number	1 ... 12

(Parameters with (K) are only valid for cascaded control)

(Parameters with (SE) are only valid for controllers without automatic setting function)

**Fig. 25 Messages 1 to 12**

0	Setpoint value controller 0	( Controller 0 is master controller)
1		
2	Group setpoint value controller 1 (SZ1)	
3		
4	Group setpoint value controller 2 (SZ2)	
5		
6	Group setpoint value controller 3 (SZ3)	
7		
8	Group setpoint value controller 4 (SZ4)	
9		
10	Group setpoint value controller 5 (SZ5)	
11		
12	Group setpoint value controller 6 (SZ6)	
13		
14	Group setpoint value controller 7 (SZ7)	
15		
16	Group setpoint value controller 8 (SZ8)	
17		
18	Group setpoint value controller 9 (SZ9)	
19		
20	Group setpoint value controller 10 (SZ10)	
21		
22	Group setpoint value controller 11 (SZ11)	
23		
24	Group setpoint value controller 12 (SZ12)	
25		
26	Not used	
27		
28		
29		
30	Not used	
31	Message number (21)	

Fig. 26 Message 21 (group setpoint values)

#### 4 Notes on the Setting of the Controllers (for non-automatic setting controllers)

The following notes for adjustment apply to the PID zone controller with pulse-pause output which is used as a standard device in the field of plastic processing.

##### 1) Determination of the system parameters

The heating up and cooling down characteristics of the system are recorded in the following way:

- Enter non-critical controller parameters

$T_A$  = 5 s (numeric value 5000)

$K_R$  = 1 (numeric value 100)

$T_N, T_D$  = 0

Upper control limit = 30°C

Lower control limit = 30°C

HKV = 100 % (for three-position controllers)

- Enter setpoint temperature (1).  
=> Module switches heating 'ON'.
- Wait until actual value is settled (2).  
Note: It is not necessary to reach the setpoint value.
- Enter setpoint temperature = 1°C (3).  
=> Module switches cooling 'ON'.

Note: (2) and (3) is only required for three-position controllers.

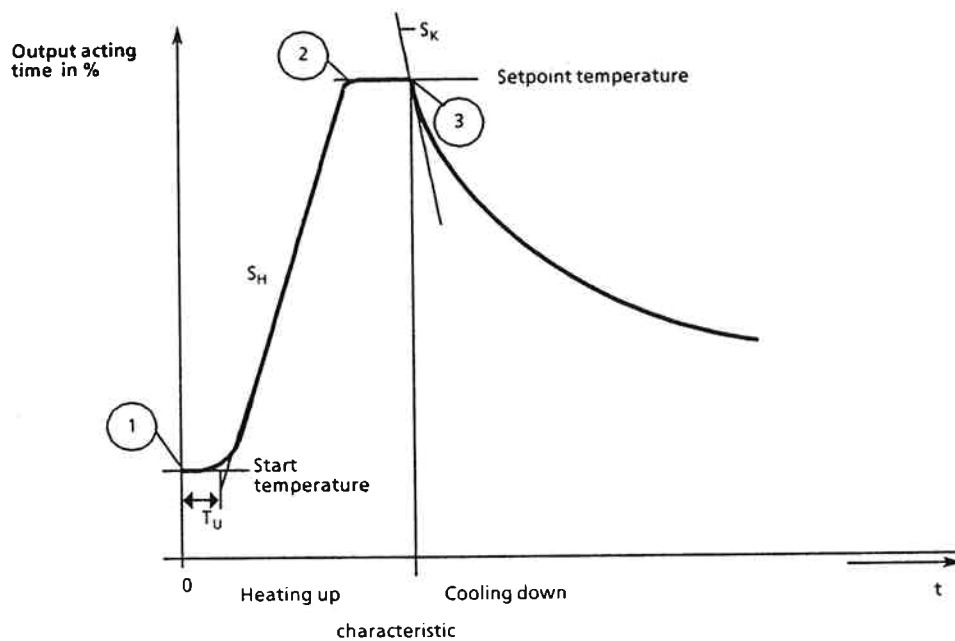


Fig. 27 Determined heating and cooling characteristic

The following parameters are determined from this curve:

- TU delay time (in s)  
 S<sub>H</sub> max. gradient of the heating characteristic (in °C/s)  
 S<sub>K</sub> max. gradient of the cooling characteristic (in °C/s)  
 (only for three-position controllers)

**2) Determination of the controller parameters (figures valid for IP 244) (see Chapter 2.1)**

- (a)  $T_A = \frac{3000}{S_H}$  Value given in ms; round off calculated value according to time base.
- (b)  $K_R = \frac{23000}{S_H * \left(T_U + \frac{T_A}{2000}\right)}$
- (c)  $T_N = \left(T_U + \frac{T_A}{1000}\right) * 1.665$
- (d)  $T_D = \left(T_U + \frac{T_A}{1000}\right) * 0.6$
- (e)  $\begin{matrix} \text{Upper limit} \\ \text{of control zone} \end{matrix} = \begin{matrix} \text{Lower limit} \\ \text{of control zone} \end{matrix} = \left(T_U + \frac{T_A}{1000}\right) * S_H$

Additionally for three-position controllers:

- (f)  $HKV = \frac{S_H}{S_K} * 100 \%$

### ● Parameters

The calculated values can be entered directly into the messages or into data block A. As an alternative to the parameter calculation, the controller parameters can be determined by selective trial-and-error. This method is illustrated in Fig. 28.

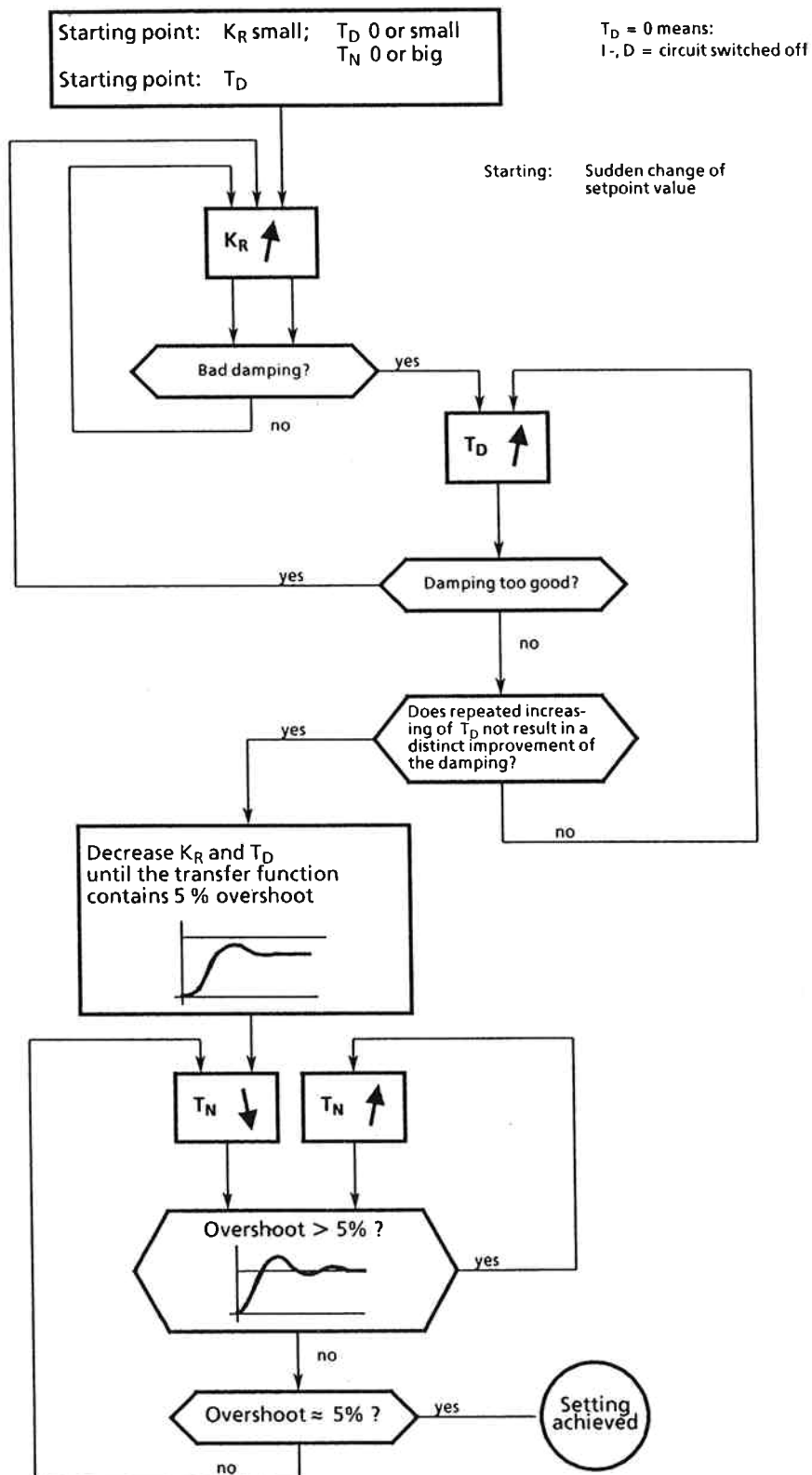


Fig. 28 Setting the controller by selective trial-and-error

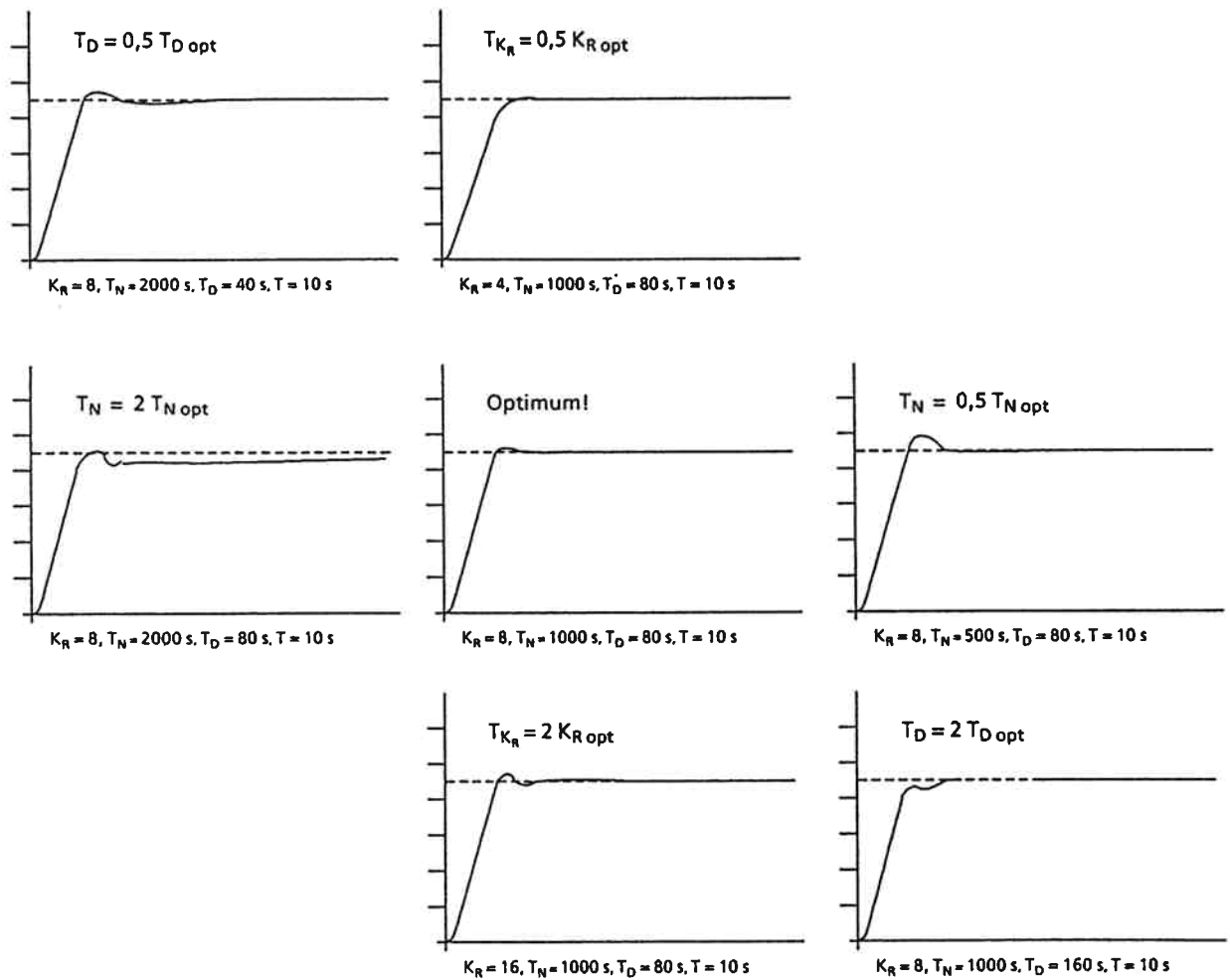


Fig. 29 Sensitivity of the optimum controller adjustment vs. changes of the controller parameters



## SIMATIC S5 FB 162 Function Block

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Programming Instructions

Order No. C79000-B8576-C480-02

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### Initialize temperature controller

for AG S5-115U  
AG S5-135U (R and S processors)  
AG S5-150U

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## **1 Summary**

These programming instructions deal with the function block

**FB 162 (PER:TREG) "Initialize Temperature Controller".**

A separate function block with the identification FB 162 PER:TREG is available for each of the following programmable controllers:

AG S5-115 U

AG S5-135 U (R and S type processors)

AG S5-150 U

The individual function modules are used together with the

**Temperature control module (6ES5 244-3AA13).**

## 2 Description of Functions

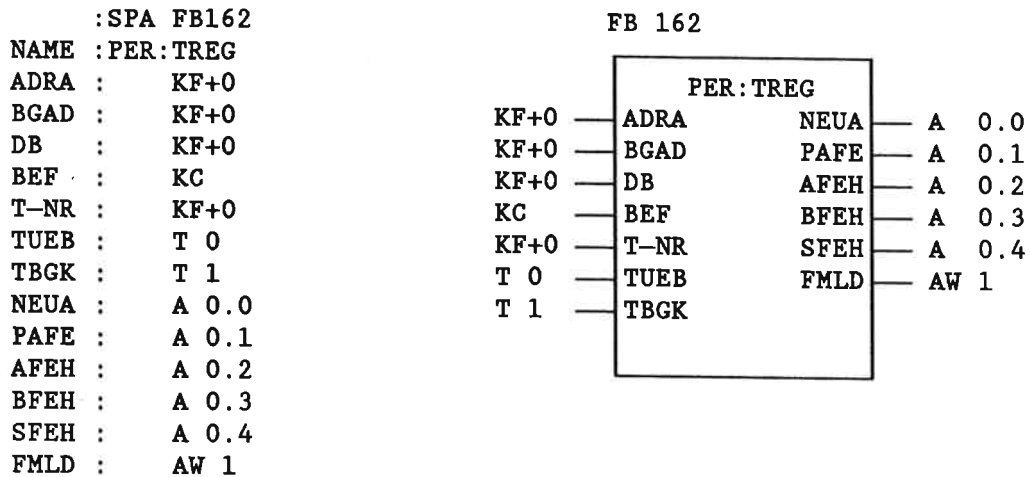
The function block "initialize temperature controller" writes the controller parameters and setpoint values into the module and reads the actual values and error messages. The data of the individual controllers is stored in two data blocks. The function block can either parameterize the entire module or transfer the data for a single loop controller.

The user program may only call the function block "initialize temperature controller" once for each temperature control module. Only one message is read or written per execution; exceptions are the functions 'cold start' or 'parameterization'. In these functions, the messages 0 to 15 are transferred during one cycle. (Permissible only in the start OBs).

### 3 Function

Open-loop control of the module 'temperature controller 244'.

#### 3.1 Calling the Function Block



#### 3.2 Parameter Definition

NAME	TYPE	FORM	DEFINITION
ADRA	D	KF	Addressing type
BGAD	D	KF	Module address
DB	D	KF	Definition of 1st data block
BEF	D	KC	Definition of instruction to be executed
T-NR	D	KF	Message number
TUEB	T	—	Time cell module monitoring
TBGK	T	—	Time cell module access control
NEUA	A	BI	Request for restart from module
PAFE	A	BI	Parameterization error
AFEH	A	BI	Scanning error (sampling time exceeded)
BFEH	A	BI	Module fault (watchdog)
SFEH	A	BI	Group error (all channels)
FMLD	A	BI	Number and error byte of faulty channel

### 3.3 Parameter Assignments

**ADRA: KF=x**       $x = 0$

The module is addressed in the extended I/O area (Q area).  
(S5-135UR, S5-135US, S5-150U).

$x = 1$

The module is addressed in the normal I/O area (P area).  
(S5-115U, S5-130WB, S5-135UR, S5-135US and S5-150U).

$x = 2$

The module has been addressed by an absolute address. (S5-115U only).

**BGAD: KF=y**       $0 \leq y \leq 224$

Extended I/O area (Q area).

$128 \leq y \leq 224$

Normal I/O area (P area)

$0 \leq y \leq 224$

Absolute addressing.

**DB: KF=z**      The function block uses two data blocks DB-A and DB-B (see 'use of the function block'). The number of the first data block is specified in parameter DB. If the number  $z = 0$ , the parameters ADRA, BGAD, DB, and BEF are indirectly parameterized.

$z = 0$

The data block DB-A must be opened before the function block is called. The current message number must be entered into the left data byte DL 2. The module address is to be entered into data word DW 3. The data block number of the first data block (DB-A) must be specified in the left data byte DL 4, the addressing mode in the right data byte DR 4.

The function block executes the instruction entered in data word DW 1. The data word is set to zero after the instruction has been executed.

**DB:**    **KF=z**         $z \geq 0$

In direct parameterization, the following ranges are valid for the individual programmable controllers:

S5-115U :  $2 \leq z \leq 254$   
 S5-135UR:  $3 \leq z \leq 254$   
 S5-135US:  $2 \leq z \leq 254$   
 S5-150U :  $2 \leq z \leq 254$

The data block defined at the parameter DB is valid. The function block uses the values specified with the assignable parameters: ADRA (addressing type), BGAD (module address), BEF (instruction), and T-NR (message number).

**BEF:**    **KC=KS**        Cold start

The messages 0 to 15 are transmitted. The module recalculates all control parameters.

This instruction must only be executed in the organization blocks OB20, OB21, and OB22.

The message number need not be specified!

This instruction must be used for parameter assignment

- with the first start-up;
- if a battery backup does not exist (e.g. expansion unit EG 183);
- whenever it is not absolutely clear, if the storage on the IP 244 has been buffered uninterruptibly.

**KC=PA**        Parameterize

The messages 0 to 15 are transferred. The module calculates the control parameters under consideration of the old values.

This instruction may only be executed in the organization blocks OB20, OB21, and OB22.

The message number need not be specified!

This instruction may only be used, if

- a first start-up has been performed and if
- the data contained in the storage on the module has **safely** been backed up during a power failure (i.e., the central controller or expansion unit must therefore be equipped with a backup battery and the IP 244 plugged in a buffered location;
- the module has not been removed from the subrack following the first start-up.

If the IP 244 is operated with the "automatic setting" function, please note the following:

- Start-up is performed by means of the KS instruction.
- When, following a power failure, a warm start is performed, the IP 244 should proceed using the data determined by the automatic setting function. The PA instruction is to be used for this purpose. Please note the corresponding conditions and requirements.

KC=S1      Setpoint switched over to temperature setpoint value

The function block resets bit 5 of the master control byte 4 and transfers the latter to the module. Once this instruction is executed, it is set to zero in the DW1 data word.

KC=S2      Setpoint switched over to lowering setpoint value

The function block sets bit 5 of the master control byte 4 and transfers the latter to the module. Once this instruction is executed, it is set to zero in the DW1 data word.

KC=T1      Tolerance switched over to tolerance values 1

If the 2nd tolerance values are violated, the controller will not be switched off.

The function block resets bit 7 of the master control byte 4 and transfers the latter to the module. Once this instruction is executed, it is set to zero in the DW1 data word.

KC=T2      Tolerance switched over to tolerance values 2

If the 2nd tolerance values are violated, the controller will be switched off.

The function block sets bit 7 of the master control byte 4 and transfers the latter to the module. Once this instruction is executed, it is set to zero in the DW1 data word.

KC=AS      Change of setpoint values  
Parameter T-NR: KF 0 to 15

If the data words n to n+6 contained in messages 0 to 15 are subject to a change, then the corresponding message (T-NR) only needs to be transferred to the module by means of the AS instruction.

**KC=AE** Change of controller parameters  
Parameter T-NR: KF 0 to 15

If the data words  $n+7$  to  $n+15$  are subject to a change then the corresponding message needs to be transferred to the module by means of the AE instruction. The parameters of the controller specified are recalculated on the module.

**KC=AB** Switchover to automatic operation  
Parameter T-NR: KF 0 to 12

With the AB instruction (automatic operation), the function block resets bit 0 of the control byte 2 in the controller message specified (T-NR parameter) and transfers this control byte to the module. In indirect parameterization, the AB instruction will then be set to zero in data word 1 of the DB-A data block.

**KC=HB** Switchover to manual operation  
Parameter T-NR: KF 0 to 12

With the HB instruction (manual operation), the function block sets bit 0 of the control byte 2 in the controller message specified (T-NR parameter) and transfers this control byte to the module. In indirect parameterization, the HB instruction will then be set to zero in data word 1 of the DB-A data block.

**KC=IW** Read actual value  
Parameter T-NR: KF 17 to 21 (e.g. actual values, manipulated variables, minimum values, etc.)

The actual values are only read on request using the IW instruction. The message number containing the desired actual values is to be specified. The contents of the actual value messages are described in the Instructions.

The actual values of channels 13 and 14 will only be updated, if bit 12 (monitoring of K13) of data word DW32 in the DB-B data block and bit 13 (monitoring of K14) are set to "1".

**TUEB:** Time cell for the monitoring of the module functions  
(see "BFEH")

**TBCK:** Time cell for the monitoring of the accesses (data transfer) to and from the module

**NEUA:** Request for restart from the module

After the power supply has been switched on, the module signals (message 16, byte 0, bit 6) that it must be parameterized. Signal state '1' is then contained in the NEUA parameter. If the module is parameterized with the KS instruction (cold start) or the PA instruction (parameterize) it resets the bit 'request for restart' as well as the NEUA parameter.

**PAFE:** The parameter PAFE is set to '1' in the case of an invalid parameterization. The detected error can be identified using the bit significance of the flag byte 255.

- M 255.0 The module address is outside the specified range or is not in a 32-pattern.
- M 255.1 Addressing type not permitted or outside of valid range.
- M 255.2 The entered data block number is outside the valid range.  
For programmable controller S5-135US also: one of the data blocks is not within the 16-bit-range.
- M 255.3 The data block specified (DB-A) does not exist or is too short.
- M 255.4 The following data block (DB-B) does not exist or is too short.
- M 255.5 Wrong instruction has been entered (parameter BEF with direct parameterization; data word DW1 in data block DB-A with indirect parameterization).
- M 255.6 The message number is outside the specified range.
- M 255.7 Permanently on signal state '0'.

**AFEH:** The AFEH parameter (scanning error, sampling time exceeded) is set if the bit 'sampling time overflow' (message 16, byte 0, bit 5) is set. Once the AFEH parameter is set, it does not influence the processing in the function block. The bit 'sampling time overflow' may be reset by switching off the voltage or by a single transfer of message number 15 using the AE instruction (change of controller parameters).



**BFEH:** The BFEH parameter (module fault) is set if the signal state of the watchdog bit is not changed within 1 sec (DB-B data block, data word 32, bit 7). The monitoring time cell is specified with the TUEB parameter.

Should the cyclic program execution in the programmable controller (incl. FB 162) exceed 1 sec, the signal edge of the watchdog bit cannot properly be evaluated anymore.

The BFEH parameter will then be set, though the module works properly. Evaluating this message is then no longer useful.

The processing of function block FB 162 is not interrupted by the BFEH message.

The BFEH parameter is reset by switching off the voltage of the programmable controller or by means of the KS instruction (cold start) or PA instruction (parameterize). The KS and PA instructions can only be used within the organization blocks OB 20, OB 21 and OB 22.

**SFEH:** If an error occurs at one of the module's controller or measurement channels, the SFEH parameter (group error) is set (for its evaluation see 'FMLD').

**FMLD:** If the parameter SFEH is on signal state '1', the number of the faulty controller is in the left-hand byte; the right-hand byte contains the error indicator byte of the controller.  
If a data word is specified to this parameter, it is stored in data block DB-B.

The error bytes with the lower numbers are evaluated first; i.e., when there are several faulty controllers the one with the lowest number will be indicated. Message 16 is read by the module and transferred into data block DB-B.

As long as a group error is present, the error messages will be updated every five cycles.

When no more errors are present the function block automatically resets the SFEH parameter and clears the error bytes.

### 3.4 Data Storage Area Allocation

Two data blocks are occupied in the data storage area: data block DB-A and the following data block DB-B.

The data block DB-A contains the controller messages 0 to 12 and the messages 13 and 14. This is the data which is written into the module.

The data block DB-B contains message 15 and the data which is read by the module (messages 16 to 25).

With indirect parameterization, the user enters the parameters BEF, T-NR, BGAD, DB, and ADRA into the data words DW1 to DW4 of the data block DB-A (see 'Use of the Function Block').

Data block DB-A has the following contents:

From DW	Contents
0	Work area of function block
16	Data for controller 0
32	Data for controller 1
48	Data for controller 2
64	Data for controller 3
80	Data for controller 4
96	Data for controller 5
112	Data for controller 6
128	Data for controller 7
144	Data for controller 8
160	Data for controller 9
176	Data for controller 10
192	Data for controller 11
208	Data for controller 12
224	Message 13
240	Message 14

Data block DB-B has the following contents:

From DW	Contents
0	Work area of function block
16	Message 15
32	Message 16
48	Message 17
64	Message 18
80	Message 19
96	Message 20
112	Message 21
128	Message 22 (internal use)
143	Message 23 (internal use)
158	Message 24 (internal use)
173	Message 25 (internal use)
188	Free for user

**Structure of a message (no. 0 to 12) in data block DB-A**

Changes in the data words DWn to DWn+6 must be transferred using the instruction 'AS'.

Changes in the data words DWn+7 to DWn+15 must be transferred using the instruction 'AE'.

Instruction			Recommended data format
AS	DW n	Temperature setpoint	KF
	DW n+1	1st positive tolerance   1st neg. tolerance	KY
	DW n+2	Lowering setpoint	KF
	DW n+3	2nd positive tolerance   2nd neg. tolerance	KY
	DW n+4	Control byte 1   Control byte 2	KM
	DW n+5	Manually manip. variable   Limiting value (K)	KY
	DW n+6	Weighting factor (K)	KH
AE	DW n+7	Sampling interval (SE)	KF until $T_A = +32767$ KH with $T_A > +32767$
	DW n+8	Gain (SE)	KF
	DW n+9	Reset time $T_N$ (SE)	KF
	DW n+10	Deriv. action time $T_D$ (SE)	KF
	DW n+11	Automatic setting	KM
	DW n+12	Upper zone limit/Setpoint value rounding (SE)	KF
	DW n+13	Lower zone limit (SE)	KF
	DW n+14	Heating/cooling ratio (SE)   Response value	KY
	DW n+15	-   (Message no.) *)	KY

\*) The user does not have to enter the message number.

(K) Only required in the case of cascaded control.

(SE) Parameters are only valid for controllers without automatic setting functions.

**Structure of the message no. 0 in data block DB-A with cascaded control**

		Recommended data format
DW 16	Temperature setpoint (master controller)	KF
DW 17	1st pos. tolerance	KY
DW 18	-	KF
DW 19	-	KY
DW 20	Control byte 1	KM
DW 21	-	KY
DW 22	-	KH
DW 23	-	KH
DW 24	Gain KR	KF
DW 25	Reset time TN	KF
DW 26	-	KF
DW 27	-	KY
DW 28	Upper zone limit	KF
DW 29	Lower zone limit	KF
DW 30	-	KY
DW 31	-	KY

\*) The user does not have to enter the message number.

**Structure of a message (no. 13 or 14) in the data block DB-A**

			Recommended data format
DW n	Setpoint value		KF
DW n+1	Pos. tolerance	Neg. tolerance	KY
DW n+2	-		
DW n+3	-		
DW n+4	-		
DW n+5	-		
DW n+6	-		
DW n+7	-		
DW n+8	-		
DW n+9	-		
DW n+10	-		
DW n+11	-		
DW n+12	-		
DW n+13	-		
DW n+14	-		
DW n+15	-	(Message no.) *)	KY

\*) The user does not have to enter the message number.

**Structure of the message no. 15 in the data block DB-B**

If the master control bytes 1 and 2 have been subject to a change message 15 must be transferred using the instruction 'AE'.

If a value other than the above mentioned has been changed, it is sufficient to transfer message 15 using the instruction 'AS'.

Recommended  
data format

DW 16	Switching value for comparator		KF
DW 17	Observation time for emergency program		KF
DW 18	Internal use		KF
DW 19	Internal use	Start-up time **)	KY
DW 20	Start-up manip. value **)	Start-up zone **)	KY
DW 21	Start-up setpoint		KF
DW 22	Max. temp. difference	-	KY
DW 23	Internal use		KF
DW 24	-		KF
DW 25	-		KF
DW 26	-		KF
DW 27	-		KY
DW 28	-		KF
DW 29	-	Master control byte 1	KM
DW 30	Master control byte 2	Master control byte 3	KM
DW 31	Master control byte 4	(Message no.) *)	KM

\*) The user does not have to enter the message number.

\*\*) Only in the case of hot channel control.

The entries into the right-hand data byte DR 30 (master control byte 3) and into the left-hand data byte DL 31 (master control byte 4) are made by the function block; these two bytes are not to be written into by the user.

**Structure of the message no. 16 in data block DB-B**

			Recommended data format
DW 32	Status byte 1	-	KY
DW 33	Controller group error/channel group error		KM
DW 34	Status automatic setting		KM
DW 35	-		KF
DW 36	-		KF
DW 37	-		KF
DW 38	-		KF
DW 39	-	Software version	KF
DW 40	Error byte 0	Error byte 1	KM
DW 41	Error byte 2	Error byte 3	KM
DW 42	Error byte 4	Error byte 5	KM
DW 43	Error byte 6	Error byte 7	KM
DW 44	Error byte 8	Error byte 9	KM
DW 45	Error byte 10	Error byte 11	KM
DW 46	Error byte 12	Error byte 13	KM
DW 47	Error byte 14	(Message no.) *)	KM

\*) The user does not have to enter the message number.

**Structure of message no. 17 in data block DB-B**

		Recommended data format
DW 48	Actual value temperature controller 0	KF
DW 49	Actual value temperature controller 1	KF
DW 50	Actual value temperature controller 2	KF
DW 51	Actual value temperature controller 3	KF
DW 52	Actual value temperature controller 4	KF
DW 53	Actual value temperature controller 5	KF
DW 54	Actual value temperature controller 6	KF
DW 55	Actual value temperature controller 7	KF
DW 56	Actual value temperature controller 8	KF
DW 57	Actual value temperature controller 9	KF
DW 58	Actual value temperature controller 10	KF
DW 59	Actual value temperature controller 11	KF
DW 60	Actual value temperature controller 12	KF
DW 61	Actual value channel 13	KF
DW 62	Actual value channel 14	KF
DW 63	- (Message no.) *)	KY

\*) The user does not have to enter the message number.



**Structure of message no. 18 in data block DB-B**

		Recommended data format
DW 64	Manip. variable contr. 0	KF
DW 65	Manip. variable contr. 1	KF
DW 66	Manip. variable contr. 2	KF
DW 67	Manip. variable contr. 3	KF
DW 68	Manip. variable contr. 4	KF
DW 69	Manip. variable contr. 5	KF
DW 70	Manip. variable contr. 6	KF
DW 71	Manip. variable contr. 7	KF
DW 72	Manip. variable contr. 8	KF
DW 73	Manip. variable contr. 9	KF
DW 74	Manip. variable contr.10	KF
DW 75	Manip. variable contr.11	KF
DW 76	Manip. variable contr.12	KF
DW 77	-	KF
DW 78	-	KF
DW 79	-	KY

(Message no.) \*)

\*) The user does not have to enter the message number.

**Structure of message no. 19 in data block DB-B**

		Recommended data format
DW 80	Minimum value controller 0	KF
DW 81	Minimum value controller 1	KF
DW 82	Minimum value controller 2	KF
DW 83	Minimum value controller 3	KF
DW 84	Minimum value controller 4	KF
DW 85	Minimum value controller 5	KF
DW 86	Minimum value controller 6	KF
DW 87	Minimum value controller 7	KF
DW 88	Minimum value controller 8	KF
DW 89	Minimum value controller 9	KF
DW 90	Minimum value controller 10	KF
DW 91	Minimum value controller 11	KF
DW 92	Minimum value controller 12	KF
DW 93	-	KF
DW 94	-	KF
DW 95	- (Message no.) *)	KY

\*) The user does not have to enter the message number.

**Structure of message no. 20 in data block DB-B**

		Recommended data format
DW 96	Maximum value controller 0	KF
DW 97	Maximum value controller 1	KF
DW 98	Maximum value controller 2	KF
DW 99	Maximum value controller 3	KF
DW 100	Maximum value controller 4	KF
DW 101	Maximum value controller 5	KF
DW 102	Maximum value controller 6	KF
DW 103	Maximum value controller 7	KF
DW 104	Maximum value controller 8	KF
DW 105	Maximum value controller 9	KF
DW 106	Maximum value controller 10	KF
DW 107	Maximum value controller 11	KF
DW 108	Maximum value controller 12	KF
DW 109	-	KF
DW 110	-	KF
DW 111	- (Message no.) *)	KY

\*) The user does not have to enter the message number.

**Structure of message no. 21 in data block DB-B**

		Recommended data format
DW 112	Setpoint value controller 0 (master contr. 1)	KF
DW 113	Group setpoint value controller 1	KF
DW 114	Group setpoint value controller 2	KF
DW 115	Group setpoint value controller 3	KF
DW 116	Group setpoint value controller 4	KF
DW 117	Group setpoint value controller 5	KF
DW 118	Group setpoint value controller 6	KF
DW 119	Group setpoint value controller 7	KF
DW 120	Group setpoint value controller 8	KF
DW 121	Group setpoint value controller 9	KF
DW 122	Group setpoint value controller 10	KF
DW 123	Group setpoint value controller 11	KF
DW 124	Group setpoint value controller 12	KF
DW 125	-	KF
DW 126	-	KF
DW 127	- (Message no.) *)	KY

\*) The user does not have to enter the message number.

#### 4 Specifications

Block number	162	
Block name	PER:TREG	
Library number	S5-135U/R	S79200-S0025-A055 package
		S79200-S0026-A255 floppy
	S5-135U/S	S79200-S0028-A055 package
		S79200-S0029-A255 floppy
	S5-150U	S79200-S0031-A055 package
		S79200-S0032-A255 floppy
	S5-115U	S79200-S0034-A055 package
		S79200-S0035-A255 floppy
Block length	S5-115U	1173
in words	S5-135UR	1039
	S5-135US	997
	S5-150U	1120
Nesting depth	0	
Subordinate blocks	None	
Allocation in data area	Two consecutive data blocks DB-A from DW0 to DW255 incl. DB-B from DW0 to DW187 incl.	
Allocation in the	S5-115U	MB200 and MB216 to MB255
flag area	S5-135UR	MB216 to MB255
(scratchpad flag)	S5-135US	MB200 to MB255
	S5-150U	MB200 to MB255
System instructions	Yes	

#### Execution time in ms:

Instruction (see Chap. 3.3)	S1,S2	T1,T2	AS,AE	AB,HB	IW	KS	PA	Direct functions
S5-115U (CPU 943)	41	4.1	6.4	4.7	6.0	1040	1040	3.9
S5-135UR	5.6	5.6	7.0	7.4	6.3	20.4	20.4	5.3
S5-135US	12.9	13.1	24.6	19.3	24.2	197	197	12.3
S5-150U	0.8	0.8	1.1	0.8	1.1	1006	1006	0.7

## 5 Use of the Function Block

Two data blocks are required for the operation of the function block 'initialize temperature controller'. The number of the first data block (DB-A) is specified in parameter DB, the following number is assigned to the second data block (DB-B).

If KF=0 is allocated to the parameter DB, the data block number of the first data block (DB-A) must be entered in data byte DL4; the following number is assigned to the second data block. In this case, data block (DB-A) must be opened before the function block is called.

The first data block contains the controller messages 0 to 12 and the messages for the voltage input channels 13 and 14. This data is written into the module. The second data block contains the data of message 15 which is also written into the module. This data block also contains the read data (actual values, maximum and minimum values, group setpoint values).

All controllers must be parameterized in the first data block (DB-A). Controllers which are not used must be referenced with zero. The messages 13, 14 and 15 must also be parameterized. The user does not have to write in the master control bytes 3 and 4 of message 15; the entry of these signals is performed by the function block.

Before calling the function block, the parameters for the temperature controller must be entered in the specified data block. At least the first data block including data word DW255 must be available. The second data block must be available at least until data word DW187 inclusive.


The structure of the individual message is specified in the Operating Instructions of the module.

### ● Calling the function block

An absolute call of the function block is possible from the cyclic program. In this case, the indirect parameterization should be used. Zero should be specified for parameter DB; the instructions to be executed must be entered in the data word DW1 of data block DB-A. The data word DW1 is set to zero after the instruction has been executed. The function block must only be called once per temperature control module and PC cycle.

Exception: KS and PA (see Chapter 2).

● Contents in the case of indirect parameterization

Recommended data format			
DW 0	-	KH	
DW 1	Instruction		KC
DW 2	Messagen no.	Direct functions	KY
DW 3	Module address		KF
DW 4	DB-no. DB-A	Addressing mode	KY

● Byte for direct functions

One byte per module (DB-A; right-hand data byte DR2) is specified for the direct access of the user program to the temperature control modules IP244. This byte gives priority to the processing of certain instructions.

The instructions of this byte are called direct functions. They are processed prior to the instruction entered in data word DW1.

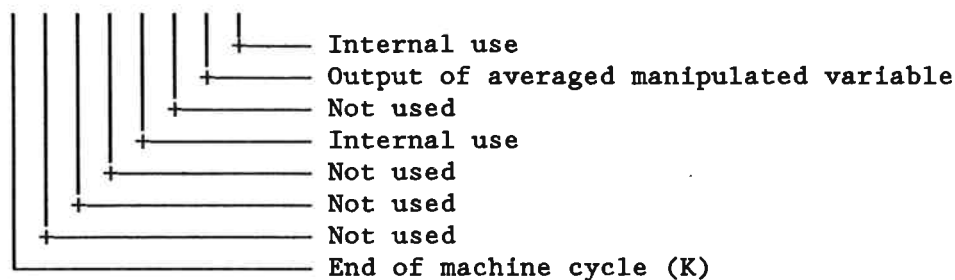
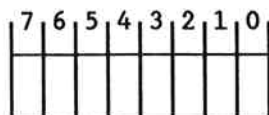
The user can set a bit of this byte 'on', thus a command word (without data) can be transferred as a direct function.

The direct functions are executed regardless from the contents of the parameter DB; i.e. they are **always** executed.

If direct functions and one of the instructions S1, S2, T1 or T2 are entered simultaneously, the direct functions and the instruction are both transferred together to the module.

After having been processed, the bits are reset by the function block. If one of the above mentioned instructions has also been transferred, the data word DW1 is also set to zero.

Allocation of the right data byte DR2 in DB-A



(K) only valid with cascaded control

The data block number of data block DB-A can be specified with parameter DB (direct parameterization) if an instruction is always to be executed or depending on a result of a logic operation. The parameters ADRA, BGAD, and T-NR must then be allocated accordingly. The function block then executes the instruction specified with parameter BEF. After execution, the instruction is not set to zero at the assignable parameter.

If both possibilities of direct and indirect parameterization are used, it should be observed that no mutual influence in the case of cyclic and interrupt controlled processing can occur.

#### ● System startup and first execution

The function block must be called absolutely in the start-up blocks OB20, OB21, and OB22 using the instructions KS (cold start) or PA (parameterization). If KS is used, all controller parameters on the module are first cleared and a re-calculation of these values is performed. The previous values of certain controller parameters are considered at the re-calculation of the control parameters if the instruction PA is used.

The function block then checks if the parameters are valid and calculates various address vectors.

The messages 0 to 15 are transferred together in one cycle to the module.



## Appendix

### A Notes on the Operation of the IP 244 with Automatic Setting

#### A.1 Requirements

- The system must physically allow a setpoint step-change of 50°C with two-position controllers or 110°C with three-position controllers.
- The system must show a low-pass response.
- The gradient of the actual value must not exceed 60°/min at full heating.
- The duration of the heating-up process must not exceed 12 hours.

#### A.2 Procedure for Single Automatic Setting

- A.2.1 In messages 0 to 12, preset all the parameters not marked with 'SE'.
- A.2.2 Select parameters for the automatic setting (byte 22) (for controllers with automatic setting function): see below.
- A.2.3 In OB 20 (with S5 135U, 150U) or OB 21 (S5 115U, 135U, 150U), execute function block FB 162 using the KS instruction in order to parameterize the IP 244.

The automatic optimization is now being executed.

- A condition code is contained in the bytes 4 and 5 of message 16. As long as the automatic optimization is being executed, the controller-specific bit remains set. It is reset by the IP when the automatic optimization is completed.
  - Closed-loop control on the basis of the entered setpoint value after the optimization has been completed.
- A.2.4 **CAUTION!** If a power failure occurs while the automatic setting function is executed, the determined parameters will be useless. A new minimum setpoint step-change is then to be provided (see Chapter A.1). This can be achieved either by cooling down the process and a restart (e.g. switchover to manual operation and cooling with three-position controllers) or by a minimum setpoint step-change from the current actual value.
  - A.2.5 **CAUTION!** If a power failure occurs after the automatic setting has been completed, following voltage recovery, the control process will be continued on the basis of the automatically determined parameters, provided that
    - the temperature control module is plugged in a location with battery backup and the backup voltage has not been interrupted;
    - during startup, after power ON, the FB 162 is executed in the start Obs OB 21 and OB 22 using the PA instruction.

### A.3 Procedure for Repeated Automatic Setting

A.3.1 As in Chapter A.2.1

A.3.2 Select parameters for automatic setting (byte 22): below.

A.3.3 As in Chapter A.2.3 (closed-loop control with an entered setpoint value).

A.3.4 As in Chapter A.2.4.

A.3.5 To ensure that the automatic setting function is automatically started following a prolonged power failure, the process must have sufficiently cooled down during the power OFF period so that, following power ON and after FB 162 (to be called with the KS or PA instruction) has been executed in the OBs 21/22, a minimum setpoint step-change is possible.  
Otherwise, the minimum setpoint step-change is to be provided either by manual operation or waiting.

A.3.6 To start a new automatic setting run without power OFF

- the process must be cooled down by the value of the minimum setpoint step-change or
- a new setpoint value must be entered which exceeds the previous one by the value of the minimum setpoint step-change.

**CAUTION!** Before the heating-up process is repeated following cooling or setpoint value changes **setpoint value 0** must be entered.

- Then wait 500 msec.
- Enter now the new setpoint value.

From now on, repeated automatic setting is being executed.

It is absolutely necessary to observe the above described procedures and to perform them without leaving out anything.

To Chapter 2.2:

$2^7$								$2^0$
0	0/1	0	1	0	0	1	0	

└ See Manual, Part 5, Chapter 2.1 (byte 22).

To Chapter 3.2:

$2^7$								$2^0$
0	0/1	0	0	0	0	1	0	

└ See Manual, Part 5, Chapter 2.1 (byte 22).

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## SIMATIC S5

### Test Program for IP 244 Temperature Controller with Function Block FB 162

Operating Instructions

Order No. C79000-B8576-C479-02

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## 1 Requirements and General Notes

The diskette contains a sample program which may be used for the function test of the IP 244 temperature control module.

In this program, the function block FB162 is indirectly parameterized, i.e. the function block uses the parameters which have been entered in the data words DW1 to DW4 of the data block DB111.

In the organization block OB1, the user can specify a flag word or any suitable input word in the assignable parameter "EING" of the function block FB99 (the test program already uses the flags M1.0 to M1.4 and the flag words MW2, MW5, and MW7). In the sample program the input word EW8 has been specified in the assignable parameter "EING" of the function block FB99. If a bit of this word is set 'on', the appertaining instruction is entered once (rising edge) in the data word DW1 of the data block DB111. After this instruction has been executed by the function block FB162 PER:TREG, the data word is set to zero by the function block. A new instruction is only entered if the data word DW1 contains a zero.

Allocation of the individual bits to the instructions, as used in the sample program:

E 8.0 --> S1	Change-over to 1st setpoint values
E 8.1 --> S2	Change-over to 2nd setpoint values
E 8.2 --> T1	Change-over to 1st tolerances
E 8.3 --> T2	Change-over to 2nd tolerances
E 8.4 -->	Must be 0
E 8.5 -->	Must be 0
E 8.6 --> AS	Change of setpoint values (controller number 0 is preset in the test program).
E 8.7 --> AE	Change of controller parameters (controller number 0 is preset in the test program).
E 9.0 --> AB	Change-over to automatic operation (controller number 0 is preset in the test program).
E 9.1 --> HB	Change-over to manual operation (controller number 0 is preset in the test program).
E 9.2 --> IW	Read actual values (message number 17 is preset in the test program).

For the module test, the following blocks must be transferred into the programmable controller after a 'PC overall reset':

Data blocks DB111 and DB112, the function blocks FB99 and FB162, and the organization blocks OB1, OB20 (not for S5-115U), OB21, and OB22.

The loop controller 0 is defined as a three-position controller (LED 17 = heating, LED 16 = cooling); the controllers 1 to 12 are defined as two-position controllers (LED ON = heating).

The controllers 0 to 12 are defined as P controllers (the D and I components are zero). The setpoint values for the analog input channels (channels 13 and 14) which are entered in data block DB111 refer to the input signals from 0 to 20 V.

## 2 Hardware

The temperature control module must be referenced to the address 128 in the I/O area. The interpretation of 8 address bits (S5 bus) must be parameterized; the PESP signal (PESP=1) must be interpreted. The jumpers for the controller-specific parameters (conversion time etc.) must be set according to the Operating Instructions.

Switch positions J76 and J77

	8	7	6	5	4	3	2	1
Off	x	x	x	x	x	x	x	x
On								

	8	7	6	5	4	3	2	1
Off			x	x	x	x	x	
On	x	x						x

24 V DC must be connected to the tab connector pin "L+". The earth connection (M) of the power supply must be connected to earth of the device. The earth potential is fed to the module via the clips in the rails.

The controllers must be switched on (LED "E" lights up), i.e. a connection must be established between the pins 1 and 20 of the connector X4 by a switch (controller ON) or by a wire jumper.

Controller inputs which are not used should be shorted and connected to 'M'. The Pt 100 resistance thermometers must be connected according to the Instructions.

### 3 How to Use the Test Program

After the specified blocks have been transferred the PC has to be restarted. The LED "R"(RUN) lights up after the parameterization of the module has been terminated.

The temperature setpoint value (1st setpoint) for the controllers 0 to 12 is specified with 30°C in data block DB111. The 2nd temperature setpoint values are entered as 10°C. If the temperature of the connected thermocouples falls below 30°C (e.g. room temperature), the LEDs light up and indicate heating operation (LED 17 = controller 0 and LEDs 15 to 4 = controllers 1 to 12). If bit 1 of the word specified in the assignable parameter "EING" of function block FB99 is set 'on', instruction "S2", change-over to 2nd setpoint values, is executed once. If the temperature of the connected thermocouple exceeds 10°C, the controller 0 starts the cooling (LED 16 ON) and the controllers 1 to 12 switch off (LEDs OFF).

If bit 10 (in test program E 9.2) of the word specified in function block FB99 is set 'on', message 17 containing the actual values of the channels 0 to 14 is read once (edge interpretation) from the module and entered into the data words DW48 to DW62 of data block DB112. If the controller inputs are shorted and connected to "M", the temperature of the connected Pt 100 resistance thermometer is displayed as actual value. Note: If this is not the case, first check the connection of the thermocouples, the resistance thermometer, and the "M" connections.

### 4 Summary

Blocks used:	OB1, OB20, OB21, OB22, FB99, FB162, DB111, DB112
Flags used:	MB1, MW2, MB5, MB6 and all flags occupied by FB162
Inputs used:	EW 8
Timers used:	T 1, T 2

# SIEMENS

## SIMATIC S5

**IP 244 Temperature Control Module  
with FB 162 Function Block**

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Check List for Commissioning

Order No. C79000-B8576-C475-02

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### **Check list for commissioning**

The following notes for hardware and software must be considered when the temperature control module is commissioned.

All items must be checked in succession on a step-by-step basis. If errors or faults occur, the check list should help to exclude mistakes made by the user.

#### **a) Hardware**

- Read IP 244 Instructions thoroughly.
- Define PC and location for IP244 in PC.
- Define module address within the system design.
- Set module address; set jumpers for PESP and system (S5 or 210) (see Technical description ... ); switches J76, 77.
- Select conversion rate and clock frequency; insert jumpers (see IP 244 Instructions, Chapter 3.4).
- Connect digital inputs and outputs to socket connector X4. Note pins of subminiature connectors type 'D' (use standard cable 6ES5-721-4xxx0).
- Connect analog signals to pin connector X3. Use only screened cables (use standard cable 6ES5-721-5xxx0).
- Shortcircuit the analog inputs which are not used and connect them to reference potential.
- Connect screens to cabinet earth after they have entered the cabinet.
- One side of floating field devices (isolated thermocouples) must be connected to reference potential (common-mode voltage between analog input and reference potential must not exceed 1 V<sub>pp</sub>).
- Connect Pt 100 element to pin connector X3 (pin assignments see Operating Instructions Chapter 2.2.1).
- Establish a thermal contact between the Pt 100 and the terminals of the thermocouples. Note air flow inside the cabinet. Pt 100 element must not lie in the direction in which fans are blowing.
- Connect L+ to connector X5.
- Plug in module and switch on at PC.

**b) Software**

- Connect programmer to processor of the programmable controller.
- Load function block 'Temperature loop control' (FB 162) from diskette into PC.
- Install data blocks for FB 162 and preset with dummies.
- Enter determined parameters (see Programming Instructions IP 244) into data block (see Programming Instructions FB 162). The following items must be noted when selecting the parameters:
  - o Choice between two-position or three-position controllers
  - o Controllers with or without automatic optimization.
  - o Cascaded control or normal operation.
- Store data blocks on diskette and transfer them to the PC.
- Install call for FB 162 in the user program. The function block FB 162 'Temperature loop control' must only be called once for each temperature control module in the user program.
- The appropriate input and output variables for the FB 162 must be made ready and processed by step 5 program. Here the test program (see Manual part 7) can be loaded into the PC to access the operation of the temperature control module. Thereafter the test program and the data blocks may be modified according to the application.
- Initiate FB 162 to transfer the parameters to the temperature control module. The functions 'cold start' and 'parameterize' must only be executed in the organization blocks OB 20, OB 21, and OB 22 (see Programming Instructions for FB 162).
- Check controller functions. Monitor the switching of the outputs.
- Start automatic optimization or optimize and correct parameters (see Programming Instructions IP 244, FB 162).
- Archive corrections.
- Operation.



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