## SIEMENS

## Compact Controller

## SIPART DR20

Project Planning Manual


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## SIPART DR20

## Project Planning Manual

This edition 1990 of the Project Planning Manual describes the SIPART DR20 compact controller in the design with software version A09 (see page 91). This device can be used to implement all functions which have already been described in earlier documents. A number of function extensions have been made compared to earlier devices; these are especially identified.

## Notice

The controller SIPART DR20 is powered by electricity. Certain components within electrical instruments are by necessity subject to very high voltages. Serious physical injury or damage to property / equipment may ensue if the hints in this manual are ignored. Only suitable qualified personnel should use this controller. The trouble-free and safe operation depends on proper transport, professional storage, as well as careful operation and maintenance.
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## 1. Fundamental Control Technology Terms

### 1.1 Control Loop

An automatic control system has the function of bringing the output variable x of a controlled system to a predetermined value and to maintain this value against the influence of disturbances $z$. With digital controller, the controlled variable x is measured cyclically and compared with the command variable w . The resulting negative deviation $\mathrm{xd}=\mathrm{w}-\mathrm{x}$ is processed in the controller to form the manipulated variable $y$ which acts on the controlled system.

w Command variable
$x \quad$ Controlled variable
xd Negative deviation
y Manipulated variable
z Disturbance variables

1 Controlled system
2 Controlling means

Fig.1/1 Block diagram of a control loop

### 1.2 Sensors and Transmitters

The controlled variable may be any physical quantity. Frequently encountered variables in process engineering are e.g. pressure, temperature, level and flow.

Certain sensors such as resistance thermometers, resistance transmitters and thermocouples can be directly connected to the controller. Otherwise, transmitters supplying an electric output variable must be connected between the sensor and the controller. Our controllers are designed for transmitters with standardized signal outputs ( 0 to $10 \mathrm{~V}, 0$ to 20 mA or 4 to 20 mA ).

### 1.3 Final Control Elements and Actuators

In most cases in heating and process engineering, the manipulated variable y acts through a valve, a damper or another mechanical positioning device on the controlled system. Three types of actuators are possible to actuate such final control elements:

- Electric actuators, consisting of electric motor and gear unit. They have an integral action and are driven by three-position step controllers. There are also electric actuators with integrated (series-connected) positioners which then have a proportional action and are driven by continuous controllers.
- Pneumatic actuators with compressed air as the supply and with electropneumatic positioner or converter. These have a proportional action and are driven by continuous controllers.
- Hydraulic actuators with electrically driven oil pump and electrohydraulic positioner. These have a proportional action and are also driven by continuous controllers.

Electric actuators with single-phase or three-phase motors are robust, economical and require practically no maintenance.

Pneumatic actuators are faster than electric actuators and are also explosion-proof. However, they are not particularly suitable for large positioning forces.

Hydraulic actuators are fast and can also be used for large positioning forces, but they are more expensive than electric or pneumatic actuators.

### 1.4 Controllers

In the input circuit, the controlled variable x is compared with the command variable W and the negative deviation xd is determined. This is processed with or without a time response into the output signal. The output signal of the amplifier can represent the manipulated variable w directly, e.g. if it controls final control elements or actuators with a proportional action. With electric actuators, the mani- pulated variable y only appears after the actuator. The positioning increments required are obtained as a PDM signal from the con- troller output by conversion.

Depending on the construction of this circuit, the controller has a proportional (P), proportional-differential action (PD), proportionalintegral action (PI) or proportional-integral-differential action (PID).

|  |  |
| :---: | :---: |
|  |  |
| control action | step response |
| P |  |
| PD |  |
| PI |  |
| PID |  |

Fig. 1/2

Step responses with different control actions

If a step function is applied to the controller input, then step responses corresponding to Fig. 1/2 are produced.

Characteristic values of the $P$ controller are the proportional gain $K p$ and the working point yo. The working point is defined as the value of the output signal at which the negative deviation becomes zero.

In contrast to the P controller, a permanent deviation is avoided in the PI controller, irrespective of the working point, the setting of the command variable and the variation in the disturbance variables, by means of an integrating component. The characteristic value of the integrating component is the reset time Tn .

The PID controller achieves an improvement of the dynamic control performance by the addition of a D component. The D component is determined by the derivative action gain Vv and the derivative action time Tv.

The controller output signals must be matched to the actuators. Two types of controllers are common for the most important kinds of actuator:
$\rightarrow$ three-position step controllers for electric actuators and
$\rightarrow$ continuous controllers for pneumatic and hydraulic actuators
The three-position step controller switches the electric motor of the actuator to clockwise rotation, stop or counterclockwise rotation by means of relays or semiconductor switches and can affect the positioning speed of the final control element by means of different on/off ratios.

w Command variable
x Controlled variable
xd Negative deviation
y Manipulated variable

1 Transmitter
2 Setpoint adjuster
3 Three-point switch
4 Feedback with time response
5 Control amplifier
6 Final control element

Fig 1/3 Three-position step controller, functional diagram

The switching performance of the three-point amplifier is reproduced in Fig $1 / 4$ as a pulse diagram.


Kp Proportional gain
Tn Reset time
xd Negative deviation
$\Delta y \quad$ Manipulated variable (controller)
y Manipulated variable (motor)

Fig. 1/4 Three-position step controller, transient function and parameters

The transient function produced at the final control element by these pulses resembles that of a continuous PI controller. Therefore the parameters Kp and Tn are also applied to the description of the transient function of three-position step controllers. This is referred to as quasi-continuous control (see Fig. 1/4).
The response threshold A is adjustable in our controllers. Thus, for example, noise suppression and a stabilizing effect can be achieved.

The main field of application of continuous controllers is in installations with pneumatic actuators. The controller output signal of 0 to 20 mA or 4 to 20 mA acts continuously on the final control element through an electropneumatic signal converter.

w Command variable
x Controlled variable
xd Negative deviation
1 Transmitter
2 Setpoint adjuster
3 Control amplifier
4 Electropneumatic signal converter
5 Pneumatic final control element

Fig. 1/5 Continuous controller, functional diagram

Two-position or three-position controllers are used to activate relays, contactors or thyristor switches for switching electric heaters or coolers. The two-position controller (Fig. 1/6) switches, if the controlled variable goes below the value x 1 or above $\times 2$. A continuous oscillation occurs whose frequency depends on the delay time of the controlled system and the switching hysteresis of the controller.

Since the control result thus obtained does not completely meet the requirements in most cases, the switching frequency is increased and the amplitude of the oscillation is thus reduced. The performance of a P or PI controller can thus be achieved in many cases using a two-position controller. In the SIPART DR20 the control amplifier is followed by a duty factor converter with adjustable period, resulting in a PID two- position controller (Fig. 1/7).


1. Controller
2. Controlled system


Fig. 1/6 Two-position controller without feedback


1. Setpoint adjuster
2. Control amplifier
3. Duty factor converter
4. Controlled system
5. Transmitter

Fig. 1/7 SIPART DR20 two-position controller
In the case of controllers with mechanical contacts, the switching frequency possibly is limited because of the contact life. However, if thyristor units are used as switching elements, the switching frequency can be increased.

The control problem often requires the controller action to be divided between various final control elements or manipulated variables, e.g. for heating and cooling. Two- position controllers are used for these problems where the manipulated variables are divided into two sections and assigned to two outputs. An adjustable dead zone is present between the two sections. A duty factor of 0 to $100 \%$ is possibly in each section.
These controllers are also referred to as three-position controllers.

## 2. The SIPART DR20 Controller

### 2.1 Application

The SIPART DR20 is a stand-alone process controller for a wide range of applications in process engineering, mechanical engineering and apparatus engineering. It is available in the following designs:

- K controller with continuous output
for connection of pneumatic or hydraulic actuators with proportional action
- S controller with step output,
programmable either as:
- three-position step controller for electric actuators
- two-position controller with two outputs for heating and cooling

Its flexibility means that SIPART DR20 is suitable for designing simple control loops as well as for solving control tasks in meshed controls. It can be used in conventional parallel wiring via its analog and digital interfaces. In addition, it can be connected to higher-level systems (process computers or control systems) via an addressable serial interface which can be retrofitted at any time or incorporated into a central operating and monitoring system with a personal computer and the SIPART software, if applicable also together with devices from the TELEPERM D range.

The SIPART DR20 can be programmed to the most common types of controller:

- Fixed setpoint controller with and without disturbance variable feedforward at input and output
- DDC backup fixed setpoint controller
- Follow-up controller with and without local/remote switchover (SPC)
- Synchronization controller for controlled variable
- Ratio controller

In addition, the device can also be used as a ratio station, manual/automatic control station (also DDC manual control station) and process indicator.

The control and display unit (front module) of the SIPART DR20 is sealed by a plastic foil so that degree of protection IP 64 is possible with a suitable installation configuration. The mounting depth of the device is very small so that it is not only suitable for panel and switchboard mounting but also for direct installation in machines and equipment.

An extremely high reliability for the device has been achieved by extensive and expensive measures during development and manufacture. In addition to appropriate selection of the components used, a worst-case design of the circuits and a 24 -hour burn-in with subsequent computer-controlled final test, special measures have been included to provide an interference-free design of the circuits and high noise immunity towards RF sources.

### 2.2 Operation and Display Functions



1 Negative deviation display
2 Replaceable label
3.1 LED for alarm A1
3.2 LED for alarm A2

4 Digital display for w-x-A2-A1 and for parameters and configurations
5.1 Manipulated variable adjustment in manual mode in direction of $0 \%$ display
5.2 Manipulated variable adjustment in manual mode in direction of $100 \%$ display
6 Digital display of manipulated variable from - 9 to $+109 \%$
7.1 Point lights up in $S$ controllers when - $\Delta \mathrm{y}$ is switched through
7.2 Point lights up in $S$ controllers when $+\Delta y$ is switched through
8 Selector for digital display 4, for activation of parameterization/configuring and for lamp test
9.1 LED lights up if $w$ is output in display 4
9.2 LED lights up if $x$ is output in display 4

10 Selector for manual/automatic mode
11 LED lights up in manual mode, flashes with remote intervention ( $\mathrm{N}, \mathrm{Si}, \mathrm{BI}$ )
12.1 Pushbutton to increase the local setpoint
12.2 Pushbutton to decrease the local setpoint

13 Selector for local/remote setpoint
14 LED lights up with local setpoint, flashes with certain SPC and DDC operating states
15 Cover for scale replacement

Fig. 2/1 Front view


1 Slot AE3, fitted with module
2 Slot AE4, unfitted, with dummy panel
3 Slot GW, unfitted, with dummy panel
4 Slot SES, module pulled out
5 Terminal block of standard controller
6 Earthing screw
7 Mains plug
8 Clamp for fixing the device in a panel; second clamp underneath device

Fig. 2/2 Rear view of SIPART DR20

## 3. Technical Description

### 3.1 Hardware

The SIPART DR20 process controller is of modular design and therefore easy to service and to convert or retrofit. It consists of a standard controller in which additional option modules can be inserted to extend the functions. These option modules are inserted into slots at the rear side of the closed controller (see Fig. 2/2).

The standard controller contains two non-floating inputs for analog currents. Since other input signals are sometimes to be processed or a floating condition is desired and the SIPART DR20 can also process three analog input signals simultaneously, two of the rear slots are designed for fitting with additional input modules. The arrangement of the fixed and optional input signal converters to the process signals is optional; the possibilities are shown in Fig. 3/1.


Fig. 3/1 Functional diagram of SIPART DR20

The standard controller comprises :

- a plastic housing with clamps for installation in switchboards, panels or machines
- a front module latched into this housing
- a basic circuit board which can be replaced towards the rear and which contains the output stage for the K (continuous) or S (step) output and the power supply unit for various operating voltages.

As already mentioned, a further four signal converter module can also be inserted into the rear of the device (also during operation). The following are present:

- two slots for analog inputs (AE3 and AE4)
- one slot for alarm outputs with relays (A1/A2)
or
alarm and S outputs via four digital outputs with an additional input for blocking programming inputs
- one slot for a serial interface module

The mains connection is via a standardized plug for low-power appliances; a special plug is used for a 24 V connection. All connections for field signals (except serial interface) consist of terminal strips which can be inserted or removed for each circuit board as a complete block. This enables prewiring and convenient replacement of modules or controllers. The terminal blocks have different number of poles and mixing up in a controller is therefore impossible (except AE3 and AE4). All additional modules are protected against incorrect insertion by mechanical coding of the circuit boards. The slots are closed by covers if additional modules are not used.

### 3.1.1 Front module

The front module consists of a plastic frame (material: Macrolon 8320), a printed, water-tight cover foil (material: Mylar D), a replaceable scale with seals and a circuit board screwed to the frame.

The front module is latched into the housing and can only be removed using a special tool. Plug connectors are arranged at the rear of the circuit board into which the basic circuit board and the additional modules are inserted from the rear.

The front circuit board contains the display and control elements and the "intelligence" of the device. LSI circuits enable a very small volume. The module contains:

- the CPU
- the non-erasable program memory
- the non-volatile data memory for the parameters and configurations entered by the user
- the time base
- the data processing of the serial interface
- the self-monitoring
- the A/D and D/A conversion for all analog variables
- the acquisition and output of digital signals
- the acquisition of input functions and control of the display elements

All display elements are designed using LEDs thus ensuring a high service life and intensity and a good viewing angle. The individual segments are driven in TDM mode. The control elements are pushbuttons with a short travel, clear point of contact and high resetting force. They are activated through the foil via a flexible switching board designed such that the foil cannot be over-stressed. They are scanned in parallel mode by the processor and several pushbuttons can therefore be activated simultaneously.

The controller has a very high number of different functions. All pushbuttons and displays are activated on the front module which are required for the specific function. Elements not required for a particular function have no effect.

### 3.1.2 Basic Circuit Board

The basic circuit board contains the power supply unit and the circuits required to match the field signals of the standard controller to the microcontroller of the front module. This results in the following function units:

- a transformer power pack for the AC 115 V and AC 230 V designs, a primary switched-mode power pack for the AC / DC 24 V design
- a highly efficient voltage stabilizer for the internally required operating and reference voltages
- a short-circuit-proof voltage output of $20 \mathrm{~V}(\mathrm{~L}+)$ for transmitters or signal contacts
- two current inputs of $0 / 4$ to 20 mA into $249 \Omega$ without electrical isolation. The start-of-scale values and the functions can be programmed (see Section 3.2)
- a digital input for 24 V logic signals. The direction of action and the function are programmable (see Section 3.2)
- a digital output for 24 V logic signals. The direction of action and the function are programmable (see Section 3.2)
- either a continuous manipulated variable signal output for $0 / 4$ to 20 mA . The start-of-scale value can be programmed
or a switching output with two relays for $230 \mathrm{~V} / 5 \mathrm{~A}$ with a spark suppressor assembly, suitable for two-position controllers with two zones (e.g. heating/cooling) or as a three-position step controller for motorized actuators.

Caution: The relays used are designed to carry a maximum switching voltage of 250 V AC I DC 240 V phase-shift motors, that generate a resonance sharpness of up to double the rated voltage on the open contact assembly, must therefore only be driven by suitable separate switching elements !

### 3.1.3 Additional Modules (Options)

### 3.1.3.1 Analog Inputs AE 3 and AE 4

As already mentioned and shown in Fig. 3/1, the standard controller can be equipped with two additional input modules. Definition of the functions and all other programming are described in Section 3.2. The following signal converters are available:

6DR2800-8J Input module with electronic isolation for standardized current signal of $0 / 4$ to 20 mA with $49.9 \Omega$ load or voltage signal of 0 to 10 V .

6DR2800-8R Input module for resistance transmitter (potentiometer); the start-of- scale and full-scale values can be adjusted during operation on the rear of the device. Three rated resistance ranges (full-scale values) can be preset on the module: 100 to $220 \Omega, 200$ to $500 \Omega$ and 470 to $1000 \Omega$. This module can also be used as a current input without electrical isolation and with adjustable start-of scale and full-scale values.

6DR2800-8P Input module for connection of a Pt 100 resistance thermometer with a two-wire, three-wire or four-wire system within a measuring range from -50 to $+850^{\circ} \mathrm{C}$. Span $\geq 50^{\circ} \mathrm{C}$; the start-of-scale and span values can be set on the module using jumpers, the fine adjustment of the start-of-scale and full-scale values is made on the rear of the device during operation. The output is linear.

6DR2800-8T Input module for mV signals or for direct connection of thermocouples. The span is $\geq 10 \mathrm{mV}$, the start-of-scale value $\leq 50 \mathrm{mV}$. The module is electrically isolated. The start-of-scale and span values are set on the module itself using jumpers. The fine adjustment is made at the rear of the module during operation. Linearization is carried out by a function generator in the standard controller. A temperature sensor fitted to the connection terminal is used for cold junction compensation; an external cold junction is possible. The following thermocouples according to the new DIN IEC 584 Section 1 can be connected:

Cu-CuNi (type T), Fe-CuNi (type J), NiCr-Ni (type K), NiCr-CuNi (type E), Pt10Rh-Pt (type S), Pt13Rh-Pt (type R), Pt30Rh-Pt6Rh (type B) as well as types $U$ (Cu-CuNi) and L (Fe- CuNi) to DIN 43710.
A further jumper setting determines whether the device input is driven to zero or full-scale in the event of a thermocouple breakage.

### 3.1.3.2 Alarm Outputs GW

The standard controller contains an adjustable alarm monitoring system with two LEDs on the front module. This circuit can be programmed such that either the controlled variable, command variable or deviation is monitored. Two additional modules are available for external signalling of the alarms which can be inserted as options into the standard controller.

6DR2801-8A Output module with two floating (relay) contacts for 24 V 5 A . The contact assignment can be set using jumpers.

6DR2801-8B Output module with four digital outputs $20 \mathrm{~V} / 30 \mathrm{~mA}$ and an additional digital input. Two of the digital outputs are for alarms, the manipulated variable signals are output via the two other outputs in the $S$ controller. In this case the output relays in the standard controller for output of the manipulated variable pulses are switched off. If the digital input of this module is connected to $\mathrm{L}+$ of the standard controller (or to another 24 V supply), the parameterization and configuring facilities via the front module of the device are blocked.

### 3.1.3.3 Serial Interface (SES)

6DR2803-8A Interface module to connect the SIPART DR20 to a serial data bus. The levels of this data bus are based on V .28 ; switching to V .28 point-to-point communication is possible using a jumper. Using this module, the device can transmit and receive process variables, operating states, parameter settings and configuring switch positions. Up to 32 SIPART DR controllers can be connected in parallel to a bus line. Combinations with TELEPERM D devices are also possible if the control of the higher-level computer allows this. A bus driver C73451-A347-B202 must be connected into the transmission line if more than three bus interfaces are to be connected together or if the transmission is to be via a line of more than 50 m . SIPART bus signals can be transmitted over distances up to $500 \mathrm{~m} ; 20 \mathrm{~mA}$ current loop signals (TTY level) are transmitted over larger cable lengths - up to 1000 m . A separate power supply ( $\pm 24 \mathrm{~V} 100 \mathrm{~mA}$ ) must be provided for the bus driver if only SIPART DR controllers are operated on a bus line. A TELEPERM $D$ device can supply the bus driver if SIPART DR and TELEPERM D controllers are connected simultaneously to the bus line.

### 3.2 Software

The program of the SIPART DR20 operates with a fixed cycle time of 100 ms . A process image is generated at the start of each routine. The analog and digital inputs and actions on the front keys are acquired and the process variables transferred which are received from the serial interface. All calculations are carried out on these input signals according to the stored functions. The data are then output to the display elements, the D/A converter and the digital outputs and the calculated variables are stored ready for the transmitter of the transmission interface. The program is interrupted every 20 ms in the S controllers in order to switch off the S outputs to obtain a good resolution. Data transfer is also executed in interrupt mode.

The ROM of the SIPART DR20 contains a large number of dedicated functions for the control of process plants, machines and apparatus. The user can program the controller by selecting the desired functions using the configuring switches. The total controller function results from the combination of individual configuring switches. Programming knowledge is not required for the settings. All settings are made on the front of the SIPART DR20 without an additional programmer. The problem-specific program produced in this manner is stored in the non-volatile part of the data memory and is therefore protected against power failure.

There are 48 configuring switches (S1 to S48). A setting corresponding to the desired function can be selected for each switch from a function table.

The factory settings of the configuring switches are always " 0 ". This corresponds to the most common setting of the individual functions so that only a few switches need be set selectively in most cases during start-up. It is always advisable, however, to compare the compatibility of the various configuring switch positions with the actual problem.

Configuring switches 1 and 2 are of fundamental importance. S1 is used to define the type of controller and thus the signal processing and linking at the input as well as the switching response of the output circuit. S2 is used to define the output configuration. The functions of the following configuring switches S3 to S40 correspond to the logical sequence of signal processing. Switches S41 to S48 are used to define general functions such as restart conditions and data transmission via the serial interface.

The complete configuring switch table (Table 3/1) follows on the next pages. Detailed information is then provided on the individual functions and links.

\begin{tabular}{|c|c|c|c|c|c|c|}
\hline \multicolumn{2}{|l|}{Structuring switches and positions} \& Function \& \multicolumn{2}{|l|}{\begin{tabular}{l}
Structuring \\
switches \\
and positions
\end{tabular}} \& Function \& \\
\hline \multirow{6}{*}{0
0
0
0
0
0
0
0
0
0} \& \multirow[t]{3}{*}{S1 \(\begin{array}{r} \\ 0 \\ 1 \\ \\ 2 \\ \\ 3 \\ 4 \\ 5 \\ \\ 6 \\ \\ 7 \\ 8 \\ 9\end{array}\)} \& \multirow[t]{3}{*}{\begin{tabular}{l}
Device type \\
Fixed setpoint controller \\
Fixed setpoint controller with disturbance \\
variable feed-forward at input \\
Fixed setpoint controller with disturbance \\
variable feed-forward at output \\
DDC back-up fixed setpoint controller \\
Slave controller without local/ remote switchover \\
Slave controller with local/remote switchover and \\
SPC via the serial interface \\
Synchronization controller without local/remote \\
switchover \\
Ratio controller \\
Ratio station (only in "K" version) \\
Manual/automatic control station and manual control device, DDC manual control device \\
Process indicator K: with setpoint value output Process indicator \(S\) with 2nd limit monitor
\end{tabular}} \& \multirow{5}{*}{\[
\begin{aligned}
\& \frac{n}{7} \\
\& \stackrel{0}{ } \\
\& \overline{0} \\
\& \frac{0}{0} \\
\& \frac{C}{4}
\end{aligned}
\]} \& S10

-2
-1
0

1 \& \multicolumn{2}{|l|}{| Allocation of the analog inputs to the auxiliary controlled variable X2/command variable X2 (ratio control) or remote setpoint WE: |
| :--- |
| AE1 (0/4 to 20 mA without electrical isolation) AE2 (0/4 to 20 mA without electrical isolation) AE3 (option for I/U, R, P, T) AE4 (option for I/U, R, P, T) |} <br>

\hline \& \& \& \& S11 \&  \& <br>
\hline \& \& \& \& S12 \& \multicolumn{2}{|l|}{No
Yes} <br>
\hline \& 0
1

2 \& \begin{tabular}{l}
K output ( $0 / 4$ to 20 mA ) <br>
S output. two-step controller with 2 outputs for heating/cooling <br>
S output. three-pos. step controller for motor-

 \& \& S13 \& \multicolumn{2}{|l|}{

No <br>
Yes
\end{tabular}} <br>

\hline \& $\begin{array}{r}3 \\ \hline 53\end{array}$ \& operated devices, internal position feedback S output. three-pos. step controller for motoroperated devices. external position feedback \& \& S14 \& \multicolumn{2}{|l|}{| Linearization of main controlled variable X1: |
| :--- |
| No |
| Yes |} <br>


\hline \& S3 $\begin{array}{r} \\ 0 \\ 1 \\ \hline\end{array}$ \& | Mains trequency suppression |
| :--- |
| For 50 Hz |
| For 60 Hz | \& \multirow{7}{*}{} \& S15 \& \multirow[t]{3}{*}{| Function of the digital input BE |
| :--- |
| BL blocking of manipulated output |
| Si safety value of manipulated variable $y=y S$ |
| $N$ tracking of the output $y=y N$ |
| CB computer ready signal |
| $B E$ on serial interface |
| BLPS Block parameterization / structuring |} \& \multirow[t]{3}{*}{} <br>

\hline \multirow{10}{*}{} \& S4 $\begin{array}{r} \\ 0 \\ 1 \\ \hline\end{array}$ \& Input signal from AE1:

$$
\begin{aligned}
& 0 \text { to } 20 \mathrm{~mA} \\
& 4 \text { to } 20 \mathrm{~mA} \\
& \hline
\end{aligned}
$$ \& \& 1

2
3 \& \& <br>
\hline \& S5 \& Input signal from AE2:

$$
0 \text { to } 20 \mathrm{~mA}
$$ \& \& 4

5 \& \& <br>

\hline \& 1 \& 4 to 20 mA \& \& 6 \& \multirow[t]{3}{*}{| BL blocking of manipulated output |
| :--- |
| Si safety value of manipulated variable $y=y S$ |
| N tracking of the output $\mathrm{y}=\mathrm{yN}$ |
| CB computer ready signal |
| $B E$ on serial interface |
| BLPS Block parameterization / |
| structuring |} \& \multirow[t]{3}{*}{} <br>

\hline \& $$
\begin{array}{r}
\text { S6 } \\
0 \\
0 \\
\hline
\end{array}
$$ \& Input signal from AE3: \& \& 7

8
9 \& \& <br>
\hline \& S7 \& Input signal from AE4: \& \& 10 \& \& <br>

\hline \& \multirow[t]{2}{*}{S8} \& \multirow[t]{2}{*}{| Allocation of the analog inputs to the main controlled variable X1 |
| :--- |
| AE 1 (0/4 to 20 mA without electrical isolation) AE 3 (option for I/U, R, P, T) |} \& \& S16 \& \multicolumn{2}{|l|}{| Sense of the digital input BE: |
| :--- |
| 13 to $30 \mathrm{~V}=$ logical 1 |
| $0 \mathrm{~V} /$ open $=$ logical 1 |} <br>

\hline \& \& \& \multirow{4}{*}{} \& S17 \& \multicolumn{2}{|l|}{x-tracking ( $w=x, w v=x v$ ) in H, N, DDC, BI and Si operation} <br>

\hline \& S9 \& | Allocation of the analog inputs to the position feedback $Y_{R}$ or position tracking $Y_{N}$ : |
| :--- |
| AE 2 (0/4 to 20 mA without electrical isolation) AE 4 (option for I/U, R, P, T) | \& \& 0

1 \& $$
\begin{aligned}
& \text { No } \\
& \text { Yes }
\end{aligned}
$$ \& <br>

\hline \& \multirow[t]{2}{*}{} \& \multirow[t]{2}{*}{AE 2 (0/4 to 20 mA without electrical isolation) AE 4 (option for I/U, R, P, T)} \& \& S18 \& | Setpoint w with CB failure: |
| :--- |
| Local w |
| Safety setpoint $\mathrm{w}_{\mathrm{s}}$ | \& <br>


\hline \& \& \& \& S19 \& | Tracking of the local setpoint wi to the setpoint w |
| :--- |
| Yes |
| No | \& ective <br>

\hline
\end{tabular}

Table 3/1 Configuring switches

| Structuring <br> switches <br> and <br> positions |  |  |
| :--- | :--- | :--- | :--- |
|  | S20 |  |


| Structuring <br> switches <br> and <br> positions |  |  |
| :--- | ---: | :--- |
|  | S29 | Priority N (DDC), BL or H: |
|  | 0 | N (DDC), BL |
|  | 1 | H |

Table 3/1 Configuring switches (continued) $\quad \begin{aligned} & \text { 1) } \\ & { }^{2)}\end{aligned} \quad \begin{aligned} & \text { Software release - A08 or greater } \\ & \text { Software release - A09 or greater }\end{aligned}$

| Stru <br> swit <br> and <br> pos | turing es ons | Function |  |
| :---: | :---: | :---: | :---: |
| $\begin{aligned} & \bar{\omega} \\ & \bar{O} \\ & \text { O} \\ & 0 \\ & 0 \\ & \dot{0} \end{aligned}$ | S39 $\begin{array}{r} -9 \\ -8 \\ -7 \\ \vdots \\ \vdots \\ -1 \\ 0 \\ 1 \\ \vdots \\ \vdots \\ 8 \\ 9 \\ 10 \end{array}$ | Minimum control pulse length te (only with S2 = 2 or 3 ) <br> 20 ms <br> 40 ms <br> 60 ms <br> 180 ms <br> 200 ms <br> 220 ms <br> 360 ms <br> 380 ms <br> 400 ms |  |
|  | S40 $\begin{array}{r} -9 \\ -8 \\ -7 \\ \vdots \\ \vdots \\ -1 \\ 0 \\ 1 \\ \vdots \\ \vdots \\ 8 \\ 9 \\ 10 \end{array}$ | Min. control pulse pause ta (function as S $\begin{aligned} & 20 \mathrm{~ms} \\ & 40 \mathrm{~ms} \\ & 60 \mathrm{~ms} \\ & : \\ & \vdots \\ & 180 \mathrm{~ms} \\ & 200 \mathrm{~ms} \\ & 220 \mathrm{~ms} \\ & : \\ & \vdots \\ & 360 \mathrm{~ms} \\ & 380 \mathrm{~ms} \\ & 400 \mathrm{~ms} \end{aligned}$ |  |
|  | S41 | Restart conditions after power failure: <br> Automatic operation, remote, with the last w or $\mathrm{wv}, \mathrm{y}$ begin, with $\mathrm{y}_{\mathrm{s}}$ with S controllers ( $\mathrm{S} 2=2$ and 3 ) with the last position Automatic operation, local, with $w=w_{s}$ or $w v=w v_{s}, y$ as $S 41=0$ Manual operation, remote, with the last or wv and $\mathrm{y}=\mathrm{y}_{\mathrm{s}}$ with S controllers (S2 = 2 and 3 ) with the last position Manual operation, local with $w=w_{s}$ or $w v=w_{s}, y$ as $\mathrm{S} 41=2$ |  |
|  | 4 5 6 | Automatic operation, remote, with the last w or $\mathrm{wv}, \mathrm{y}$ begins with $\mathrm{y}_{\mathrm{s}}$, with S controllers ( $\mathrm{S} 2=2$ and 3 ) with the last position Automatic operation, local, with $w=w_{s}$ or $w v=w_{s}, y$ as $S 41=0$ Manual operation, remote, with the last wor wv and $y=y_{s}$, with $S$ controllers ( $\mathrm{S} 2=2$ and 3 ) with the last position <br> Manual operation, local with $\mathrm{w}=\mathrm{w}_{\mathrm{s}}$ or $\mathrm{wv}=\mathrm{wv}_{\mathrm{s}}, \mathrm{y}$ as $\mathrm{S} 41=2$ |  |


| Stru <br> swit <br> and <br> pos | turing es <br> ons | Function |
| :---: | :---: | :---: |
|  | S42 <br> 0 <br> 1 <br> 2 | Serial interface, only in conjunction with optional module 6DR2803-8A: <br> Without; controller transmits all variables, receives none <br> With; controller transmits all variables, receives only parameters and structuring switches With; controller transmits all variables, receives parameters, structuring switches and $\mathrm{W}_{\text {es }}, \mathrm{Y}_{\text {es }}$, STes (CB, BL, Si and BA) |
|  | $\begin{array}{r} \mathrm{S} 43 \\ 0 \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array}$ | Data transmission rate: <br> 9600 bit/s <br> 4800 bit/s <br> 2400 bit/s <br> $1200 \mathrm{bit} / \mathrm{s}$ <br> $600 \mathrm{bit} / \mathrm{s}$ <br> $300 \mathrm{bit} / \mathrm{s}$ |
|  | $\begin{array}{r} \mathrm{S} 44 \\ 0 \\ 1 \end{array}$ | Vertical parity: <br> Even <br> Odd |
|  | $\begin{array}{r} \mathrm{S} 45 \\ 0 \\ 1 \\ 2 \end{array}$ | Longitudinal parity position: <br> Without <br> After ETX <br> Before ETX |
|  | S46 $0$ $1$ | Longitudinal parity: <br> Normal Inverted |
|  | S47 <br> 0 1 2 <br> 31 | Station number (address): $\begin{gathered} 0 \\ 1 \\ 2 \\ \vdots \\ \vdots \\ 31 \end{gathered}$ |
|  | $\begin{array}{r} \text { S48 } \\ 0 \\ 1 \\ 2 \\ 3 \\ \vdots \\ \vdots \\ 24 \\ 25 \end{array}$ | Time monitoring $\mathrm{CB}_{\mathrm{ES}}$ : <br> Without <br> 1 s <br> 2 s <br> 3 s <br> 24 s <br> 25 s |

Table 3/1 Configuring switches (continued)

The following sections demonstrate and describe hardware and software functions in the form of function diagrams. The sequence of diagrams largely corresponds to the sequence of configuring switches except that the input signal processing is handled before the diagrams of the possible settings of the configuring switch S1 (device types) to enable better understanding of the subsequent diagrams.

### 3.2.1 Input Signal Processing (Figs. 3/2 and 3/3)

Analog-to-digital conversion is carried out using a quasi-integrating measurement. All analog inputs are converted approximately 120 times within 20 or 16.67 ms and the results averaged so that the mains frequency and its harmonics can be filtered out. This adaptation to the mains frequency is made using configuring switch S3.
$\mathbf{0 / 4}$ to $\mathbf{2 0 ~ m A ~ s w i t c h o v e r : ~ T h e ~ c o n f i g u r i n g ~ s w i t c h e s ~} \mathrm{S} 4$ to S 7 are used to define whether the measuring range starts at 0 or 4 mA . The corresponding switches must be left in position 0 if nonstandardized signals (potentiometers, thermocouples, Pt100) are connected to AE3 and AE4 and with 0 to 10 V signals.

Signal assignment: Up to three analog input variables can be processed for the control tasks of the device:

- Main controlled variable $\times 1$
- Remote setpoint wE / command variable $\times 2$ with ratio controller / disturbance variable $\times 2$
- Position feedback yR / position tracking yN

The four analog inputs AE1 to AE4 are assigned to these variables using the configuring switches S8, S9 and S10. The unused inputs can be scanned via the bus interface, transmitter monitoring does not take place, however.


Fig. 3/2 Processing of analog input signals

## Transmitter monitoring:

The measured values processed in this manner can be assigned to the monitoring circuit using configuring switch S11. If one or more of the monitored variables violates the limits of -3 or $+103 \%$, the following is monitored on the four-digit display: "২1", "々2" or "২ $\uparrow$ ". This message remains until acknowledged using the pushbutton 8 (Fig. 2/1). The value which was last displayed then appears again. If several inputs are faulty simultaneously, all are monitored simultaneously. As shown, all individual signals are "OR"-ed together in addition. The fault message "MuSt" can be transmitted via the digital output or the serial interface. It is simultaneously available for programmed switchover to manual mode.

## Square-root extraction:

The position of configuring switches S12 and S13 determines whether the controlled variables x1 and $\mathrm{x} 2 / \mathrm{wE}$ are square-rooted. Negative input values are not square-rooted; in this case the output value is set to zero.

## Linearization:

The main controlled variable $\times 1$ can be linearized if required; this is selected using configuring switch S14. Linearization is carried out using a polygon characteristic with eight straight lines (see page 91 for setting and example).

The linearization circuit must always be used in the case of non-linear input values since intermediate values can only be indicated correctly on the digital display in this manner. The control response is also improved.

## Digital input BE:

The controller has a digital input which acts normally (digital signal $\geq 13 \mathrm{~V}=$ logical 1 ) or inverted (digital signal $\leq 4.5 \mathrm{~V}$ or open-circuit $=$ logical 0 ) according to the position of configuring switch S16. The function is assigned to the digital input by configuring switch S 15 which has been extended in software version A06 / A07:

| Configuring switch position of S15 | Function of digital input |  |  |
| :---: | :---: | :---: | :---: |
| 0 | BL | Blocking of manipulated variable. The last manipulated variable current is retained in the K controller, the last duty factor (heating or cooling output) is retained in the twoposition controller. A manipulated variable signal is no longer output in the three-position step controller. |  |
| 1 | Si | Safety manipulated variable. The manipulated variable assumes the parameterized safety value ( yS ) in the K controller, two-position controller and three-position step controller with external position feedback. In the threeposition step controller with internal simulation of the position, the manipulated variable tends towards zero if the parameterized safety value is less than $50 \%$, and towards $100 \%$ if the parameterized safety value is equal to or greater than 50 \%. | 3 0 들 0 0 0 0 0 3 0 0 |


| Configuring switch position of S15 | Function of digital input |  |  |
| :---: | :---: | :---: | :---: |
| 2 | N | Tracking of output. In the $K$ controller and two- position controller, the output stage is isolated from the control algorithm by this signal and directly connected to the input yN . The manipulated variable or the duty factor is then determined by this input signal. Tracking is not possible in the three-position step controller. |  |
| 3 | CB | Computer readiness. In the DDC backup controller, the controller is set to backup mode by this signal, in SPC controllers, SPC mode is then started. The CB signal can also be used for controlled two-setpoint or three-setpoint mode. |  |
| 4 | SES | A digital input signal does not trigger a function in the controller but is transmitted via the serial interface. Functions can then be triggered or displayed in a higherlevel system. |  |
| 5 | BLPS | The parameterization and configuring facility via the front module of the controller is blocked by means of a digital signal. Unauthorized adjustments to parameters or configuring switches can then be prevented. |  |
| 6 | BL | Blocking of manipulated variable, function as "Switch position 0" |  |
| 7 | Si | Safety manipulated variable, function as "Switch position 1" | $\stackrel{\text { ¢ }}{\text { ¢ }}$ |
| 8 | N | Tracking of output, function as "Switch position 2" | $\frac{0}{3}$ |
| 9 | CB | Computer enabled, function as "Switch position 3" | 은 |
| 10 | SES | The binary input only acts on the serial interface, function as "Switch position 4" | $\stackrel{\sim}{4}$ |
| 11 | BLPS | Blocking of parameters and configuring switches, function as "Switch position 5" | 0 |

Only one of these functions can be processed via the digital input BE of the controller. The non-selected functions therefore have defined signal states as follows:
$\mathrm{CB}=1$ with $\mathrm{S} 42=0$ or 1
$B L=S i=N=S E S=B L P S=0$
$C B=0$ with $S 42=2$
The digital functions $\mathrm{BL}, \mathrm{Si}, \mathrm{N}$ and CB can be addressed in parallel via the serial interface if configuring switch S 42 is in position 2.

## Acknowledgement of CB signal:

The controller is immediately switched to computer mode in positions 0 to 5 of the configuring switch S15 with a CB switchover from 0 to 1 and with the front panel key 13 in position "Remote", i.e. the controller operates "Without CB acknowledgement".

The device is switched to local mode with configuring switch positions 6 to 11, a CB switchover from 0 to 1 and with front switch 13 in position "Remote". The computer coupling is only achieved again by manual switching back to remote mode. The controller operates "With CB acknowledgement".


Fig. 3/3 Digital functions via digital input/output and the serial interface (including status signals)

### 3.2.2 Input Signal Processing and Switchover

The following functions are explained in this section:

- Manual setpoint input $w_{i}$ or setpoint ratio $w_{v}$
- $x$-tracking
- Setpoint limiting and setpoint ramp
- Formation of negative deviation
- Alarm monitor
- Digital display of setpoint and actual value or the setpoint and actual ratio factor and the limits
and, depending on the possible types of devices:
- Switchover and calculation of the setpoint $w$ or the setpoint ratio factor
- Calculation of the controlled variable $x$


## General, repeatedly encountered functions:

## Manual setpoint input $w_{i}$ or setpoint ratio $w_{v}$ :

The setpoint wi can be adjusted using the $\boldsymbol{\Delta}$ and $\boldsymbol{\nabla}$ push buttons (12) in the controller types with a facility for local setpoint adjustment providing the green LED next to the local/remote selector (13) indicates "local mode" and the green LED next to the display selector (8) indicates "Display of setpoints". The adjustment is made every 0.1 s in steps with $0.01 \%$. The step size is increased linearly with time so that larger ranges of adjustment can also be covered in a reasonable time. If the adjustment is interrupted by releasing the pressed pushbutton, it can then be started again with the smallest rate of adjustment. An adjustment over the complete measuring range lasts approx. 7 s.

## x-tracking:

It is possible to provide x -tracking for all types of controllers using configuring switch $\mathrm{S} 17=1$. This means that the setpoint is made equal to the actual value and the setpoint ratio to the actual ratio and tracked as soon as, and also as long as, the control loop is isolated in the output of the device by manual, tracking, DDC backup mode or by y-blocking or a safety manipulated variable (identified by $/ \mathrm{A}=$ no automatic mode in the function displays). Thus when returning to automatic mode, the control loop can be closed without bumps and drift with $\mathrm{xd}=0$. The setpoint may have changed in the process.

## Setpoint limit and setpoint ramp:

In all controller types the setpoint or the setpoint ratio can be limited by the parameters wa and we within the measuring range adjusted. In the ratio controller and ratio station, the range of adjustment of the ratio factor is defined by these parameters (page 38).

The rate of change can be adjusted using the parameter Tw (tS). The time Tw refers to a change in setpoint over the complete measuring range. The setpoint ramp is always effective except with $x$-tracking.

The setpoint ramp can be adjusted between 1 and 9984 s , but only between 1 and 100 s in the ratio controller and ratio station (S1 = 7 and 8 ).

## Formation of negative deviation:

The negative deviation is calculated from the effective setpoint $w$ and the effective actual value $x$ :

$$
x d=w-x
$$

and is the negation of the deviation $\mathrm{x}_{\mathrm{w}}$. Further processing is described in Section 3.2.3 (page 43).
Alarm monitor: This can be used to monitor the minimum and/or maximum values of a variable. The variable to be monitored is selected using configuring switch S22, the type of monitoring is selected using configuring switch S23. Configuring switch S24 defines whether the alarms are to be set only in the parameterization level or also in the operation level of the device.

The alarms A1 and A2 are indicated on the four-digit display (4) in the same engineering units as the setpoint and actual value. The hysteresis is $1 \%$ of the measuring range.

Caution: In addition to monitoring on the instrument, alarm signals can also be output externally using an additional module (page 80). It should be noted that only one external alarm signal is output at a time.
For example, if the alarm monitors have been programmed for max./max. signalling (preliminary alarm and main alarm), the preliminary alarm signal is cancelled when the main alarm signal appears. This only applies to external alarms via an optional module and not to LED signals on the front panel of the controller.

Digital display of setpoint and actual value or setpoint ratio and actual ratio and limits: The setpoint, actual value and limits are indicated in engineering units where the start-of-scale value is scaled by parameter LA and the full-scale value by LE. The factory setting is LA = 0.0 and $\mathrm{LE}=100.0$ corresponding to a percentage scale. Configuring switch S20 can be used to adjust the position of the decimal point, S21 the repetition rate of the displays.

With software version A06 / A07 it is also possible to set the full-scale value LE below the start-ofscale value LA, i.e. to operate the controller with falling characteristic of the actual value.

The setpoint ratio, actual ratio and limit setting are displayed with ratio controllers and ratio stations. The decimal point is fixed at $x . x x x$ so that ratio factors are possible between 0.000 and 9.999 (cf. S1 = 7 and 8).

## Functions which depend on the configured type of controller:

## - $\quad$ S1 = 0 Fixed setpoint controller (Fig. 3/4)

In this type the controller only processes the main controlled variable $x 1$ as an analog input signal. The setpoint can be adjusted using the setpoint pushbuttons (12) if the two green LEDs (9.1 and 14) light up on the front of the device, i.e. with local mode and setpoint display. It is thus possible to block the intentional or unintentional adjustment of the setpoint by pressing pushbutton (13) (LED 14 then does not light up). The x-tracking function (with manual or tracking mode or with blocking of the manipulated variable or safety manipulated variable) is independent thereof, i.e. x-tracking (with S17 = 1) is effective with and without LED 14).
In line with the definition of the fixed setpoint controller, the device does not accept an external setpoint with this programming.


Fig. 3/4 Processing of command variable and formation of the negative deviation with a fixed setpoint controller

- $\quad$ S1 = 1 Fixed setpoint controller with disturbance variable feed-forward at the input (Fig. 3/5)

The constant c1 (zero offset) and the disturbance variable $\times 2(r)$ which can be apportioned using c2 are added to the main controlled variable $x 1(r, 1)$ which can be processed further as the controlled variable x :

$$
x=x 1+c 1+c 2 * x 2
$$

The calculation is made between 0 and $100 \%$. The constants c 1 and c2 can be set as parameters between -199.9 \% (corresponds to number -1.999 ) and $+199.9 \%$ (corresponds to number 1.999).

The effective controlled variable x is displayed in the selected measuring range LA to LE.
If only "dynamic disturbance variable feed-forward" is required, the constant c 2 is set to 0 and the input variable x 2 applied directly to the D element via configuring switch S 27 (see Section 3.2.3 - D element).


Fig. 3/5 Processing of command variable, calculation of controlled variable and formation of negative deviation with fixed setpoint controller and disturbance variable feed-forward at the input

- S1 = 2 Fixed setpoint controller with disturbance variable feed-forward at the output

Fig. $3 / 3$ also applies to processing of the command variable and formation of the deviation. The evaluation and the addition of the disturbance variable to the output signal are described in Section 3.2.3 (page 44).

- $\quad$ S1 = 3 DDC backup fixed setpoint controller (Fig. 3/6)

In the case of direct digital control (DDC) all control functions are transferred directly from a process computer (control system), but individual loops, or all loops, are frequently protected by parallel hardware controllers. Their function is to take over control of the respective loop in a hitchless manner if the computer fails. During DDC mode (non-faulty), the backup controllers are at standby, i.e. their outputs are made to track the respective computer manipulated variable. The negative deviation can also be set to zero in the individual controllers by $x$-tracking so that control is continued in a hitchless manner as well as drifffree following switchover.


Fig. 3/6 Processing of command variable and formation of negative deviation with DDC backup fixed setpoint controller

DDC mode corresponds to tracking mode of other types of controller except that the switchover to tracking mode is not made via the control signal $N$ but as a function of the CB signal (also possible via the serial interface) and the local/remote selector pushbutton:

DDC mode $=\mathrm{RC}=\mathrm{CB} * / /$
(with S29 $=0$, see Fig. 3/7)
DDC mode $=\mathrm{RC}=\mathrm{CB} * / \mathrm{I} * / \mathrm{H}$
(with S29 = 1, see Fig. 3/8)

No status LED lights up on the controller in DDC mode. The value which becomes effective upon computer failure is always indicated as the setpoint. If the computer fails ( $\mathrm{CB}=1 \rightarrow 0$ ), the green LED of the "Local" display (14) flashes and the controller continues to operate with the displayed, internal setpoint. After switching over to local mode (green LED 14 steady), the setpoint can be adjusted manually. A clear display of the optical signals is shown in Fig. 3/34 on page 59. The switchover in the output circuit is explained in the description of section 3.2.4. The following tables (Figs. 3/7 and 3/8) provide a complete summary of the signals and the effective setpoints and manipulated variables depending on the front-panel signals, control signals and configuring switches S17, S18 and S29. The version in Fig. 3/7 is used if manual mode is to be selected directly following a computer failure.


Fig. 3/7 DDC backup controller / DDC manual control station DDC mode or BL has priority over manual mode ( $\mathrm{S} 29=0$ )
*) $y E$ is either $y N$ or $y E S(S 42)$. In DDC mode the manipulated variable current of the $K$ controller can be switched off with S36 = 1 (operation with two output stages). The external y source must be made to track the effective variable $y$, if DDC mode is not present.
${ }^{* *}$ ) When using the digital input BE , only one of the control variables $\mathrm{CB}, \mathrm{BL}$ or Si is possible as defined by S15.
${ }^{* * *}$ ) The data on "Signals front LED" (e.g. 0.5) refer to the flashing frequency (see 3.2.6).
( n ) The variable is made to track the last value effective before switchover, thus ensuring hitchless switchover.

NOT $(R C)=\operatorname{NOT}\{N O T(I N T)$ AND CB) $\}$

$$
\text { NOT }(R B)=I N T \text { OR H } \quad I=\text { adjustable }
$$

Programming according to the following Fig. $3 / 8$ is used if automatic mode is to be selected directly following computer failure.


Fig. 3/8 DDC backup controller/DDC manual control station
Manual mode has priority over DDC mode or BL (S29 = 1)
*) yE is either yN or yES (S42). In DDC mode the manipulated variable current of the K controller can be switched off with S36=1 (operation with two output stages). The external y source must be made to track the effective variable $y$, if DDC mode is not present.
${ }^{* *}$ ) When using the digital input BE , only one of the control variables $\mathrm{CB}, \mathrm{BL}$ or Si is possible as defined by S15.
${ }^{* * *}$ ) The data on "Signals front LED" (e.g. 0.5) refer to the flashing frequency (see 3.2.6).
(n) The variable is made to track the last value effective before switchover, thus ensuring hitchless switchover.
$\operatorname{NOT}(\mathrm{RC})=\operatorname{NOT}\{\mathrm{NOT}(\mathrm{INT})$ AND CB AND NOT(H)\}NOT(RB) $=\operatorname{INT}$ OR H $\quad I=$ adjustable

- S1 = 4 Follow-up controller without local/remote switchover (Fig. 3/9)

This type of device is for use as a follow-up controller in a cascade or for remote setpoint control of the SIPART DR20. In the case of a cascade control, the follow-up controller can only be separated from the master controller by switching the latter to manual mode.

The controller obtains the remote setpoint in this mode via input $x 2$, the local setpoint push buttons on the front of the controller have no effect. The local/remote selector pushbutton 13 is also ineffective and the green LED 14 does not light up. The device can be switched to manual mode as before or switched to one of the functions BL, Si or N via the digital input and according to the position of the configuring switch S15.


Fig. 3/9 Formation of the negative deviation in a follow-up controller without local/remote switchover

- $\quad$ S1 = 5 Follow-up controller with local/remote switch over (Fig. 3/13)

This controller type is suitable for SPC mode and operation with two or three setpoints (wi, wE, $w S$ ). The remote setpoint can be entered either via an analog input as a variable wE or via the serial interface as wES.

In SPC mode the setpoint is tracked by a higher-level computer (control system). SPC mode is present if the device is switched to remote setpoint and the signal CB is present simultaneously:

$$
\text { NOT(H) AND CB AND NOT(I) = RC = } 1
$$

A status LED does not light up in this (normal) case. The green LED 14 flashes with a duty cycle of 0.5 if the computer fails ( $\mathrm{CB}=1 \rightarrow 0$ ) and further control is made either with the local setpoint wi which tracked the last valid setpoint $(\mathrm{S} 18=0)$ or with the parameterized safety setpoint wS ( x -tracking is also possible if automatic mode is not present $=/ \mathrm{A}$ ). If the setpoint selector 13 is activated (INT = 1), the green LED becomes steady and the setpoint can be adjusted manually. The green LED flashes with a duty factor of 0.9 if the CB signal reappears during local mode but this mode is retained until a remote setpoint is again selected using pushbutton 13.
The following table (Fig. 3/10) provides a summary of signals and effective setpoints depending on control signals and the configuring switches S17, S18 and S19.

| Control commands front and digital inputs **) |  |  | Signals |  |  |  | Effective output | Effective setpointS19=0 |  |  |  | Explanations |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | $\begin{aligned} & \text { Front } \\ & \text { LED }^{* * *)} \end{aligned}$ |  | Digital output |  |  |  |  |  |  |  |  |
| $\mathrm{H}+\mathrm{N}+\mathrm{Si}+\mathrm{BL}$ | CB | INT | INT | H | /RB | /RC | Y | $\begin{aligned} & \hline \text { S17 }=0 \\ & \text { S18 }=0 \\ & \hline \end{aligned}$ | $\begin{aligned} & =1 \\ & =0 \end{aligned}$ | $\begin{aligned} & =0 \\ & =1 \end{aligned}$ | $\begin{aligned} & =1 \\ & =1 \end{aligned}$ |  |  |
| 0 | 1 | 0 | 0 | 0 | 0 | 0 | $\mathrm{yA}(\mathrm{n})$ | $\mathrm{wE}(\mathrm{n})$ *) | wE(n) *) | $\mathrm{wE}(\mathrm{n})$ *) | wE(n) *) | Automatic mode, SPC-mode |  |
| 0 | 0 | 0 | 0,5 | 0 | 0 | 1 | $\mathrm{yA}(\mathrm{n})$ | wi(n) | wi(n) | wS | wS | Automatic mode, computer switched OFF, controller at SPC standby |  |
| 0 | 1 | 1 | 0,9 | 0 | 1 | 1 | yA(n) | wi(n) | wi(n) | wi(n) | wi(n) | Automatic mode, computer at standby, controller not at SPC standby |  |
| 0 | 0 | 1 | 1 | 0 | 1 | 1 | yA(n) | wi(n) | wi(n) | wi(n) | wi(n) | Automatic mode, computer switched OFF, controller not at SPC standby |  |
| 1 | 1 | 0 | 0 | $>0$ | 1 | 1 | yH or | wE(n) *) | x | wE(n) *) | x | Manual, tracking, safety mode |  |
| 1 | 0 | 0 | 0,5 | $>0$ | 1 | 1 | yE or | wi(n) | x | wS | X | or blocking of output, |  |
| 1 | 1 | 1 | 0,9 | $>0$ | 1 | 1 | yS or | wi(n) | x | wi(n) | x | controller not at SPC standby |  |
| 1 | 0 | 1 | 1 | >0 | 1 | 1 | yBL | wi(n) | x | wi(n) | x |  |  |

Fig. 3/10 Follow-up controller with local/remote switchover, SPC controller with tracking of local setpoint $(\mathrm{S} 19=0)$
*) Sources for wE are wEA (remote analog value, e.g. from master controller) or wES (remote value via serial interface). Only wES can be tracked, of course, not wEA (see Fig. 3/13).
${ }^{* *}$ ) When using the digital input BE , only one of the control variables $\mathrm{CB}, \mathrm{Si}, \mathrm{BL}$ or N is possible as defined by S15. The priority is Si before BL before $N$ (DDC) when applied via the serial interface.
${ }^{* * *}$ ) The data on "Signals front LED" (e.g. 0.5) refer to the flashing frequency (see 3.2.6).
(n) The variable is made to track the last value effective before switchover.

$$
\mathrm{NOT}(\mathrm{RB})=\mathrm{INT} \text { OR H }
$$

The configuring switch S19 = 1 suppresses tracking of the local setpoint wi and wES of the serial interface. Thus operation is possible with two or three setpoints. If the switchover via CB is not required, the digital input should be connected to one of the other control signals via S15 and CB is then fixed at 1. The following table (Fig. 3/11) provides a summary of the changed conditions.

| Control commands front and digital inputs **) |  |  | Signals |  |  |  | Effective output$Y$ | Effective setpoint$\mathrm{S} 19=0$ |  |  |  | Explanations |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | $\begin{aligned} & \hline \text { Front } \\ & \text { LED }{ }^{* * *)} \\ & \hline \end{aligned}$ |  | Digital output |  |  |  |  |  |  |  |
| H+N+Si+BL | CB | INT | INT | H | /RB | /RC |  | $\begin{aligned} & \hline \text { S17 }=0 \\ & \text { S18 }=0 \end{aligned}$ | $\begin{aligned} & =1 \\ & =0 \end{aligned}$ | $\begin{aligned} & =0 \\ & =1 \end{aligned}$ | $\begin{aligned} & =1 \\ & =1 \\ & \hline \end{aligned}$ |  |
| 0 | 1 | 0 | 0 | 0 | 0 | 0 | $\mathrm{yA}(\mathrm{n})$ | wE | wE | wE | wE |  |
| 0 | 0 | 0 | 0,5 | 0 | 0 | 1 | yA(n) | wi | wi | wS | wS | Automatic mode |
| 0 | 1 | 1 | 0,9 | 0 | 1 | 1 | yA(n) | wi | wi | wi | wi |  |
| 0 | 0 | 1 | 1 | 0 | 1 | 1 | $\mathrm{yA}(\mathrm{n})$ | wi | wi | wi | wi |  |
| 1 | 1 | 0 | 0 | $>0$ | 1 | 1 | yH or | wE | x | wE | x |  |
| 1 | 0 | 0 | 0,5 | $>0$ | 1 | 1 | yE or | wi | X | wS | X |  |
| 1 | 1 | 1 | 0,9 | $>0$ | 1 | 1 | yS or | wi | x | wi | x | blocking of output |
| 1 | 0 | 1 | 1 | $>0$ | 1 | 1 | yBL | wi | X | wi | X |  |

Fig. 3/11 Follow-up controller with local/remote switchover without tracking of the local setpoint (S19=1), operation with several setpoints
${ }^{* *}$ ) When using the digital input BE , only one of the control variables $\mathrm{CB}, \mathrm{Si}, \mathrm{BL}$ or N is possible as defined by S15. The priority is Si before BL before $N$ (DDC) when applied via the serial interface.
${ }^{* * *}$ ) The data on "Signals front LED" (e.g. 0.5) refer to the flashing frequency (see 3.2.6).
(n) The variable is made to track the last value effective before switchover.

NOT(RC) = NOT\{NOT(INT) AND CB AND NOT(H)\} NOT(RB) = INT OR H

From software version A06 onwards it is also possible to set two different setpoints on the front of the SIPART DR20 and to select one of the values by switching over or by using a setpoint ramp.

Settings required when used as:

| Strs | Fixed setpoint <br> controller | Process variable indicator with <br> setpoint transmitter (K version) |
| :--- | :--- | :--- |
| S1 | 5 | 10 |
| S15 | $\neq 3$ | $\neq 3$ |
| S18 | 1 | 1 |
| S19 | 1 | 1 |
| S24 | 1 | 1 |
| S42 | 2 | 2 |

This configuration extends the function of selector 8 (Fig. 2/1, page 11) as follows:

| Selector key 8 | Output in display 4 | Signalling by |
| :--- | :--- | :--- |
| Position 1 | wi | LED 9.1 |
| Position 2 | x | LED 9.2 |
| Position 3 | A2 | "A2" in display 6 |
| Position 4 | A1 | "A1" in display 6 |
| Position 5 | wS | "SH" in display 6 |

This results in the following possible settings:

| Control commands front and digital inputs **) |  | Signals |  |  |  |  | Effective setpoint |  | Explanatio |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | $\begin{aligned} & \text { Front } \\ & \text { LED }{ }^{* * *)} \end{aligned}$ |  | Digital output |  | output |  |  |  |
| $\mathrm{H}+\mathrm{N}+\mathrm{Si}+\mathrm{BL}$ | INT | INT | H | /RB | /RC | Y | S17=0 | S17=1 |  |
| 0 | 1 | 1 | 0 | 1 | 1 | yA(n) | wi | wi | Automatic mode with setpoint 1 |
| 0 | 0 | 0,5 | 0 | 0 | 1 | $\mathrm{yA}(\mathrm{n})$ | wS | wS | Automatic mode with setpoint 2 |
| 1 | 1 | 1 | $>0$ | 1 | 1 | $\mathrm{yH}, \mathrm{yN}$ | wi | x |  |
| 1 | 0 | 0,5 | $>0$ | 1 | 1 | yBL, ySi | wS | x | Manual, tracking, safety mode or blocking of output |

Fig. 3/12 Follow-up controller with local/remote switchover Operation with two setpoints adjustable on front panel


Fig. 3/13 Processing of command variable and formation of negative deviation in follow-up controller with local/remote switchover

- S1 = 6 Synchronization controller without local/remote switchover (Fig.3/14)

In the case of synchronization control, a common command variable is applied to several control loops. The command variable can be shifted by the constant c1 and apportioned with the factor c2 in each controller individually.


Fig. 3/14 Processing of command variable and formation of negative deviation in synchronization controller

## - $\quad$ S1 = 7 Ratio controller (Fig. 3/15)

In a ratio controller the command process variable $x 2$ is weighted by the ratio factor $v$ and forms the setpoint for the controlled process variable $\times 1$ :

$$
w=v * x 2
$$

When $\quad x d=w-x$ then $x d=v * x 2-x 1$
With $x d=0$ this results in $v=x 1 / x 2$, i.e. in the settled state $x 1 / x 2$ corresponds to the ratio factor $v$.
A basic value (parameter c1) can be applied in addition:

$$
w=v * x 2+c 1
$$

In the settled state:

$$
x 1=v * x 2+c 1
$$

In the following, the defined (adjustable using the pushbuttons 12) ratio factor is referred to as the setpoint ratio $w_{v}$ and indicated as the setpoint on the digital display. The range of adjustment of the ratio factor $v$ is defined by the parameters $w_{a}$ and $w_{e}$ within the limits 0.000 and 9.999 where $L A<W_{a}$ and LE $>W_{\text {e }}$.

The current ratio is referred to as the actual ratio xv and is obtained by reversing the ratio formula:

$$
x_{v}=(x 1-c 1) / x 2
$$

It is indicated as the actual value in the digital display and used for $x$-tracking if applicable.
The display range for ratio factors is 0.000 to 9.999 (negative values are suppressed) The negative deviation display indicates $\mathrm{xd}=\mathrm{w}-\mathrm{x}$ as with the other controller types.

The setpoint ramp Tw is only effective at OFF or from 1 to 100 s . The alarm function enables monitoring of the actual ratio or the setpoint ratio.


Fig. 3/15 Processing of command variable and formation of negative deviation in ratio controller


Fig. 3/16 Characteristics of a ratio controller

- $\quad$ S1 = 8 Ratio station (Fig. 3/17)

The ratio station can only be implemented with a standard controller with continuous output (6DR2004)!

Signal processing is exactly the same as in the ratio controller except that the processed command variable $w$ is processed further directly as the output signal $y A$ :

$$
y A \longrightarrow w=v * x 2+c 1
$$

This signal is indicated in the two-digit display in percent. The four-digit display indicates, as with the ratio controller, the ratio factor $w_{v}$ which can be adjusted using the setpoint pushbuttons with selector 8 in position "SP-w". As with the ratio controller, the range of adjustment for the ratio factor is determined using the parameters $w_{a}$ and $w_{e}$ within the limits 0.000 and 9.999 where LA $<w_{a}$ and LE > $\mathrm{w}_{\mathrm{e}}$.

The actual ratio $x_{v}$ is only indicated in position "PV-x" of selector 8 if the controlled process variable $x 1$ is also applied to the controller. In this case the negative deviation $x d=w-x 1$ is also displayed on the 21-part LED bargraph.

A follow-up controller connected in series to the ratio station can then display the variables $w$ and $x$ in addition so that a complete process image is available. The ratio station also has the automatic (w)/manual (yH) switchover (which can be switched off by S31=1). Switchover to manual is always hitchless, switching back to w is only hitchless if the ratio factor is tracked accordingly with S17 = 1 ( x -tracking ).


1) $\mathrm{S} 22=0$, effective starting with software version A09

Fig. 3/17 Processing of command variable as an output signal of the ratio station

- $\quad$ S1 = 9 Manual/automatic control station, DDC manual control station (Fig. 3/18)


## Manual control station S31 = 2

In this type of circuit the device outputs a signal which can be adjusted using the manipulated variable pushbuttons. It is output directly in percent in the two-digit display in a standard K controller and a standard S controller with three-position step output if the position signal is fed back to the device via the input yR .

Manual/automatic control station, DDC manual control station S31 $=0$
When configuring the digital input with the CB function or when operating via the serial interface, the SIPART DR20 can also be used as a DDC manual control station in this mode. The manipulated variable is made to track yN or yES during DDC mode with a K output, with an S output / two-position controller and only yES with an S output / three-position step controller with external feedback of the manipulated variable. The output is blocked during DDC mode with an S output / three-position step controller with internal feedback.

Switchover of the output, is as with the DDC controller. "Automatic mode" with the DDC manual control station causes the manipulated variable to be held constant by the connection yA = y '. (Details on the output structures are shown in Section 3.2.4).

The four-digit display of the device can be used to indicate any process variable $\times 1$. The setpoint output on the same display can be used in conjunction with the setpoint pushbuttons to display a characteristic value.
This characteristic value and the process variable $\times 1$ are compared together and the result can be read on the 21-part LED bargraph as the difference $x d$. $x$-tracking and wS following computer failure must be switched off $(\mathrm{S} 17=0, \mathrm{~S} 18=0)$.


Fig. 3/18 Manual/automatic control station, DDC manual control station, DDC manual control station, x and w display and alarm monitor

See Section 3.2.4 for diagrams of output circuit (page 46)

## - $\quad$ S1 = 10 Process indicator (Fig. 3/19)

The switchover configuration of the follow-up controller is used for signal processing. The four-digit display either indicates a remote variable applied to input WE or a local value adjustable using the setpoint pushbuttons as the setpoint $w$ is depending on the position of the local/remote selector. If an interface module is equipped, the remote setpoint wES received via the serial interface can also be displayed.

The variable applied to input $x 1$ is indicated as the actual value $x$. The limit monitors A1/A2 can be configured to the mentioned variables.
The two-digit display can also indicate a further process variable in \%. The associated input signal is $y R / y N$.

The station provides further facilities in this mode:

- If the basic device is a K controller, the variable displayed on the four-digit display as setpoint w is output as a current signal of 0 or 4 to 20 mA via the analogue output. It is a setpoint transmitter with local/remote switchover in addition.
- If the basic device is an S controller, the signals of a second alarm monitor can be output via the $\pm \Delta \mathrm{Y}$ outputs. The switching thresholds of this alarm monitor are set by parameters ya (min.) and ye (max.) with a hysteresis of $1 \%$. The associated input signal is $\mathrm{yR} / \mathrm{yN}$.


Fig. 3/19 Functional diagram of process indicator (K-version)

### 3.2.3 Control Algorithm

This section describes the following functions:

- Filtering of negative deviation xd
- Display of negative deviation
- Response threshold of negative deviation
- Matching to direction of action
- D element
- P/PI control algorithm
- Hitchless switchover to automatic mode
- Limitation of controller output signal yA

Filtering of negative deviation: A 1st order filter with the time constant $t \mathrm{~F}$ acts on the negative deviation xd. The filter is switched on when the display of parameter tF jumps from OFF to 1 s and can be adjusted within wide limits. The time tF should only be set so large that the control loop does not oscillate (tF < recovery time Tg).

Display of negative deviation: From software version A08 onwards the display 1 can be configured to indicate either the negative deviation $\mathrm{xd}(\mathrm{w}-\mathrm{x})$ or the deviation $\mathrm{xw}(\mathrm{x}-\mathrm{w})$. Therefore the following details are valid for the negative deviation or the deviation, depending on the selection of configuring switch S25 (see page 20). The filtered negative deviation is indicated on display 1. This display has a total of 21 vertical LEDs; the factory setting enables a deviation of max. $\pm 10 \%$ to be displayed referred to the measuring range. The display range can be modified using configuring switch S25 between $\pm 2.5 \%$ and $\pm 40 \%$ negative deviation. The 21 LEDs are divided as follows:

10 red LEDs to display a positive deviation, i.e. the setpoint is larger than the actual value. In the factory setting, the 1st LED lights up with $\mathrm{xd} \geq 0.5 \%$, the 2nd LED above $x d \geq 1.5 \%$ up to the 10th LED above $9.5 \%$. The result is a red column which becomes longer as the negative deviation increases and thus as the danger increases.

1 green LED lights up in the center of the 21-part LED string if $|x d|$ is $<1 \%$ in the factory setting.

10 red LEDs to display a negative deviation, i.e. the actual value is larger than the setpoint. The display function corresponds to that of the positive deviation display but in the negative range.

This function (based on the factory setting) means that the following range has a very fine resolution:

| xd | +1.0 | to $<+1.5 \%$ | only 1st red LED (pos.) lights up |
| :--- | :--- | :--- | :--- |
| xd | +0.5 | to $<+1.0 \%$ | green LED and 1st red LED (pos.) light up |
| xd | $>-0.5$ | to $<+0.5 \%$ | only the green LED lights up |
| xd | $>-1.0$ | to | $-0.5 \%$ |
| xd | $>-1.5$ | to | $-1.0 \%$ |

The replaceable scale label (2) is printed on the front with the standard range $\pm 10 \%$ for $x d$. The free area can be labelled individually with additional information:

```
e.g. - Measurement point
    - Measuring range
    - Dimension of measured variable
    - Alarm monitoring
```

The rear of the label is unprinted and can be used for any divisions, including engineering units. A dimensional drawing of the scale label and information on a suitable labelling unit are included in the operating instructions.


Fig. 3/20 PID controller structure

Response threshold for xd (dead-zone element): If the controller output is to be dampened in addition to the effect of the filter, it is possible to set a response threshold for the negative deviation (parameter A). See adjacent Fig. 3/21. It is essential to set A>0 in the case of S controllers (twoposition controllers with 2 outputs and three-position step controllers). The gain is zero in the case of small negative deviations, the parameterized Kp is reached in the case of large deviations.


Fig. 3/21 Dead-zone element

## Matching to direction of action:

The basic setting of the controller applies to systems with a normal action. In the case of reversed systems, the sign of the proportional gain Kp can be inverted using configuring switch S26. As can be seen in Fig. 3/20, this applies to the P and I components as well as to the D element to which a disturbance variable can also be applied.

D element: The input signal for the D element can be selected using configuring switch S27. Xd is differentiated with the factory setting. S27 must be set to 1 if modifications in the setpoint are not to be differentiated as well. If the input signal $x 2$ is to be applied as a dynamic disturbance variable, configuring switch S27 must be set to 2 or 3 .
The D element can be switched off in the control level if the parameter Tv ("d-element") is set below 1 s to "OFF".
As long as the controller is ineffective as a result of an intervention in the output circuit, the D element is automatically tracked such that its output is held at zero.

P/PI control algorithm: The $P(D)$ and $\mathrm{PI}(\mathrm{D})$ control algorithms are implemented in the same manner independent of the output configuration (S or K). Configuring switch S 28 is used to select P or PI control. As can be seen in Fig. 3/20, the algorithm has a parallel configuration with interaction-free parameter setting. The following controller equations apply to a normal-action system if the cycle time, filter time constant tF and response threshold A are neglected:

P controller

$$
y A=K p * x d+y_{0}
$$

PI controller

$$
y A=K p *\left(x d+1 / T n \int x d * d t\right)+y_{o}(t)
$$

Switch over to automatic mode: If automatic mode is not present, the I component or the working point $\mathrm{y}_{0}$ is tracked so that switchover to automatic mode is hitchless with PI and P controllers. Any D component which may still be effective is set to 0 . This tracking results in automatic setting of the working point $y_{0}$ in the $P$ controller in manual, tracking (DDC) and safety mode and with blocking of the manipulated variable. The following applies if the controller is started up in manual mode:
or

$$
\begin{aligned}
& y_{0}=y H-K p *(w-x H) \\
& y_{0}=y H-K p *(w-x H)-c 2 * x 2
\end{aligned}
$$

If xH is driven to the desired setpoint in the process, the following applies:

$$
y_{0}=y H \quad \text { or } \quad y_{0}=y H-c 2 * x 2
$$

With software version A06 and greater, it is also possible to adjust the working point $\mathrm{y}_{0}$ by manual setting in the parameterization level (see table 6/1, page 90).

Limitation of controller output signal yA: (only possible with K controllers and three-position step controllers with external position feedback, i.e. with $\mathrm{S} 2=0$ and $\mathrm{S} 2=3$ ) Manipulated variable limitation with parameters ya and ye is only possible in automatic mode. The limits of these parameters are -10 and $+110 \%$. It should be noted, however, that the controllers do not output negative manipulated variable currents and cannot measure negative position feedback signals.

If the manipulated variable yA reaches one of the limits ya or ye in automatic mode, further integration is suppressed to prevent integral saturation. This ensures that a change in manipulated variable can be followed immediately if the polarity of the deviation is reversed.
The manipulated variable y can be driven outside the range limits in manual, tracking (DDC) or safety mode. The last manipulated variable is then transferred in a hitchless manner when switching back to automatic mode, but only changes to the manipulated variable in the direction towards the range ya to ye are subsequently executed.

With a two-position controller ( $\mathrm{S} 2=1$ ), yA is limited to 0 and $100 \%$. The parameters ya and ye have a different meaning in this case (see Section 3.2.4).

Manipulated variable limitation is not possible with three-position step controllers with internal simulation of the position ( $\mathrm{S} 2=2$ ).

### 3.2.4 Output Signal Processing and Switchover

The following functions are described in this section:

- Possible operating modes
- Priority switchover of manual and tracking mode/blocking
- Manual manipulated variable yH
- Position feedback
- Position display and matching to direction of action
- Function and direction of action of digital output
- Special functions of alarm output module
and, depending on the possible output configurations:
- K output, switchover and switch-off facilities
- $\quad$ S two-position output with two zones (heating/cooling)
- S three-position step output for motor-driven actuators with internal position feedback, minimum positioning pulse length and pause
- $\quad$ S three-position step output for motor-driven actuators with external position feedback

If controllers are referred to in the following explanations, the ratio station (only as K version), the manual/automatic control station and the DDC manual control station are included unless special reference to these devices is specifically made. All information for the $K$ version applies to the process indicator with setpoint transmitter. Only the information on the special functions of the alarm module are of interest for the $S$ version.

## General, recurring functions :

## Possible operating modes:

(The optical signals are shown in Section 3.2.6)

- $A=$ Automatic operation with $y=y A$. This mode can be interrupted by digital signals (see also page 23) as well as by manual interventions.
- BL = Blocking of output. The last manipulated variable signal ly or the duty factor is retained with K controllers and S two-position controllers, no manipulated variable signal is output anymore with three-position step controllers.
- $\mathrm{Si}=$ Safety manipulated variable: $\mathrm{y}=\mathrm{yS}$ is preset as the output signal. yS can be set as a parameter. The manipulated variable therefore assumes the parameterized safety value according to its set speed except with a three-position step output with internal position feedback. The output - $\Delta \mathrm{y}$ has a continuous contact if yS is configured $<50 \%$ with this output configuration, output $+\Delta y$ has a continuous contact if yS is parameterized larger than $50 \%$.
- $N=$ Tracking or DDC backup mode: $y=y N$ or $y=y E S$. This operating mode can only be implemented with K controllers or with S controllers with a two-position output. Threeposition step controllers with external position feedback, the tracking signal can be tracked via the serial interface (yES). No tracking of the manipulated variable is possible in three-position step controllers with internal position feedback.
- $\mathrm{H}=$ Manual operation: $\mathrm{y}=\mathrm{yH}$. The manipulated variable is adjusted using the two keys 5.1 and 5.2.

Only one control signal can be defined via the digital input BE according to the position of switch S 15 . The priority is Si before BL before N when entering the control signals via the serial interface SES. Si always has priority over H , but the priority between $\mathrm{H}, \mathrm{N}$ and BL can be changed depending on the position of S29.

If transmitter monitoring is set using configuring switch S11, the monitored signal can be used to switch to manual mode depending on S30, when the range limits are violated.

The switchover facility between manual and automatic operation can be suppressed by configuring switch S31:

| S31 = 1 | Automatic operation only <br> S31 = 2Manual operation only <br> Activation of the manual/automatic pushbutton in this mode causes blocking <br> of the manipulated variable adjustment and the yellow LED 11 is <br> extinguished. This function is of interest, e.g. when using the controller as a <br> manual control station. |
| :--- | :--- |

Priority switchover of manual and tracking mode/blocking: It is possible to define the priority for all controllers with internal position feedback using configuring switch S29.

$$
\begin{array}{ll}
\text { S29 = } 0 & \begin{array}{l}
\text { The digital functions } N \text { and BL have priority over manual switchover to } \\
\text { manual operation. An N or BL signal interrupts manual mode. }
\end{array}
\end{array}
$$

S29 = $1 \quad$ Manual switchover has priority over the digital functions $N$ and BL. If e.g. the manipulated variable of a controller is blocked by the digital signal BL, direct switching to manual mode is possible using the manual/automatic selector.

Manual manipulated variable $\mathbf{y H}$ : The manual manipulated variable yH can only be adjusted in manual mode using the pushbuttons 5.1 and 5.2. The adjustment is progressive in the K controller and the S two-position controller. The adjustment is made every 0.1 s in steps which start with $0.1 \%$. The step size is increased linearly with time so that larger ranges of adjustment can also be covered in a reasonable time. If the adjustment is interrupted, it can be started again with the smallest rate of adjustment. An adjustment of the manipulated variable over the complete range from 0 to $100 \%$ lasts approx. 5 s .
Positioning commands in three-position step controllers are simulated by manipulated variable signals $<0$ and $>100 \%$ so that they act on the outputs $+\Delta y$ and $-\Delta y$ like direct positioning commands (continuous contact). All switchover functions and the minimum pulse lengths te and pulse pauses ta remain effective, however.

Position feedback yR: A feedback via input yR must be made in three-position step controllers to display the position of the final control element. This signal is used in the controller with external position feedback ( $\mathrm{S} 2=3$ ) for additional control of the position controller subordinate to the actual controller. An electronic position transmitter (ESR) should always be used since this feedback must not be interrupted. A resistance transmitter is sufficient in the case of $S$ controllers with internal position feedbacks ( $\mathrm{S} 2=2$ ).
A position feedback is not required in K controllers if the following I/P position controller operates linearly. If the manipulated variable current ly is to be directly monitored nevertheless, the input yR can also be used for this purpose providing it is not required for tracking purposes. Configuring switch S32 must then be set to 1 .

Position display and matching to direction of action: Configuring switch S32 can be used to select the display variable.

| S32 $=0$ | $y$ | (for K controllers and S two-position controllers) |
| :--- | :--- | :--- |
| S32 = 1 | $y R$ | (for three-position step controllers and K controllers with position <br> feedback) |

The direction of action of the position display is matched to the process using configuring switch S33 (see also Figs. 3/24 to 3/32). The signal to be displayed is indicated directly in the basic position S33 $=0$, a reversed display takes place with S33 $=1$ ( $100 \%$ minus value to be displayed). This display is required if the trends of the position display and the controlled variable are to be in the same direction with a reversed system. The position display has a resolution of $1 \%$ as a result of the two-digit display 6 . The display range is -9 to $+109 \%$ where values above 100 are displayed as "h0" to "h9".
The two-digit display 6 contains two points 7.1 and 7.2 (top left and bottom right) which light up if the associated manipulated variable outputs $+\Delta y$ and $-\Delta y$ are driven.

Function and direction of action of digital output: The SIPART DR20 has a digital output (see Fig. 3/3, page 25) which can be assigned to an operating mode or transmitter fault signal (S34) and whose NC or NO position can be inverted using S35.

| S34 $=0$ | /RC | Controller not in computer mode NOT(NOT INT AND CB) |
| :---: | :---: | :---: |
| S34 $=1$ | H | Manual mode (this digital signal indicates the mode "Manual" even if this has only been prepared and is not. yet effective because of a priority (e..g.: BI or N) |
| S34 $=2$ | /RB | Controller not in computer readiness (INT or H) |
| S34 $=3$ | Must | Transmitter fault (collective signal). This fault signal is only output if S11 is programmed accordingly (Fig. 3/2). |
| S34 $=4$ | SES | The digital signal is activated via the serial interface only. |

Special functions of the alarm output module: Configuring switch S36 must be set to "1" if a module 6DR2801-8B ( 4 digital outputs BA +1 digital input BE) is used for alarm output. The alarm outputs A 1 and A 2 , as well as the $: \pm \Delta y$ positioning commands with the S controller, are then output via the digital outputs of this module. The two output relays in the $S$ controller are set out of operation.

The parameterization and configuring facility can also be blocked via the digital input BLPS of this module. If this input is connected to L+, the display "PS" cannot be achieved as preparation for parameterization or configuring.

In addition to the described functions, this module also enables a controller with a stepped output (S controller) to be produced from a standard K device: The K output is effective (ly = 0/4 to 20 mA ) in the standard controller with configuring switch 2 in position 0 , the device outputs switched positioning commands via the $\Delta \mathrm{y}$ outputs of this module in all other positions of this configuring switch.

| Control commands front and digital inputs |  |  |  | Status Signals |  | Effective output | Explanations |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | Front LED | Digital output |  |  |
| Si | H | BL | N *) | H | H | Y |  |
| 0 | 0 | 0 | 0 | 0 | 0 | yA | Automatic mode |
| 0 | 0 | 0 | 1 | 0.1 | 0 | yN | Tracking mode |
| 0 | 0 | 1 | 0 | 0.1 | 0 | yBL | Blocking mode |
| 0 | 0 | 1 | 1 | 0.1 | 0 | yBL | Blocking mode |
| 0 | 1 | 0 | 0 | 1 | 1 | yH **) | Manual mode |
| 0 | 1 | 0 | 1 | 0.5 | 1 | yN | Tracking mode |
| 0 | 1 | 1 | 0 | 0.5 | 1 | yBL | Blocking mode |
| 0 | 1 | 1 | 1 | 0.5 | 1 | yBL | Blocking mode |
|  |  |  |  |  |  |  |  |
| 1 | 0 | x | x | 0.1 | 0 | ys | Safety mode |
| 1 | 1 | x | X | 0.5 | 1 | yS | Safety mode |

Fig. 3/22 Output switchover of all controller types except DDC controller/manual control station
Tracking/blocking has priority before manual operation

| Control commands front and digital inputs |  |  |  | Signals |  | Effective output | Explanations |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | Front LED | Digital output |  |  |
| Si | H | BL | N *) | H | H | Y |  |
| 0 | 0 | 0 | 0 | 0 | 0 | yA | Automatic mode |
| 0 | 0 | 0 | 1 | 0.1 | 0 | yN | Tracking mode |
| 0 | 0 | 1 | 1 | 0.1 | 0 | yBL | Blocking mode |
| 0 | 0 | 1 | 1 | 0.1 | 0 | yBL | Blocking mode |
| 0 | 1 | 0 | 0 | 1 | 1 | yH **) | Manual mode |
| 0 | 1 | 0 | 0 | 0.9 | 1 | yH **) | Manual mode |
| 0 | 1 | 1 | 1 | 0.9 | 1 | yH **) | Manual mode |
| 0 | 1 | 1 | 1 | 0.9 | 1 | yH **) | Manual mode |
|  |  |  |  |  |  |  |  |
| 1 | 0 | x | x | 0.1 | 0 | ys | Safety mode |
| 1 | 1 | x | X | 0.5 | 1 | yS | Safety mode |

Fig. 3/23 Output switchover of all controller types except DDC controller/manual control station
Manual operation has priority over tracking/blocking
*) Ineffective for S controller with internal feedback
**) Adjustable

1 Digital high signal or LED lights up
0 Digital low signal or LED does not light up
$x \quad$ Digital high or low signal
0.1 \}
0.5 \} Flashing cycle of LED, see Section 3.2.6 (page 58)
$0.9\}$

## Functions depending on the possible output configurations:

## - $\quad \mathbf{S} 2=0 \quad \mathrm{~K}$ output (Figs. 3/24 and 3/25)

With a $K$ controller the resulting manipulated variable $y$ is output as a current ly. S37 can be used to set the range to 0 or 4 to 20 mA . The output stage can only output positive currents. The signal range from 4 to 20 mA must therefore be selected if a signal less than $0 \%$ is required. Open-circuit monitoring which links the output signal ly through the final control element and the input $\mathrm{yR} / \mathrm{yN}$ (with transmitter monitoring $=\mathrm{S} 11$ ) is only possible in this signal range.

Configuring switch S38 is used to define whether the output current is to be switched off in DDC mode as long as the device is in backup mode (only with $\mathrm{S} 1=3$ and $9, \mathrm{~S} 2=0$ ). This facility is required if more than one manipulated variable output (e.g. from the controller and a computer) is to act on an actuator and only one output may apply a current. Feedback into the controller output stage is prevented by the diode in the current output. The output stage of the computer, connected in parallel, must then also be equipped with a blocking diode.

The complete $K$ output configuration including position display and all switchover facilities is shown in Figs. $3 / 24$ and $3 / 25$. The difference between the two figs. is the preselection of priority between manual mode or tracking mode/blocking by means of configuring switch S29.


Fig. 3/24 Output configuration of $K$ controller, manual mode has priority over tracking mode/blocking


Fig. 3/25 Output configuration of K controller, tracking mode/blocking has priority over manual mode

- $\mathrm{S} 2=1$ Output configuration as S two-position controller with two outputs (heating/cooling) (Figs. 3/26, 3/27,3/28 and 3/29)

The switchover facilities of this output configuration can be compared with those of the $K$ output configuration. The output variable can only assume two states for each output, however: switch-on and switch-off (Fig. 3/26). The resulting manipulated variable $y$ is determined by the duty factor between the switch-on and switch-off durations and is defined as

$$
\text { Control Ratio }=\quad \text {------------------------------------------------------- } \quad \text { Switch-on duration + Switch-off duration }
$$

The switch-on and switch-off durations together result in the period. This can be adjusted in the SIPART DR20.
The range of y from 0 to $100 \%$ can be divided into two sections. A parametrizable dead-zone (ye - ya) is present between these two sections (Fig. 3/27a and note on page 53). The slope of the output sensitivity is changed by shifting ya or ye.
A different period ( $T+(T y)$ and $T-)$ can be assigned to each section. The control ratio 0 to 1 is run through in each section, where the shortest switch-on or switch-off duration is limited to $1 \%$ of the period. The period must therefore be set such that the most favorable compromise is found between the minimum permissible switch-on time of the final control element (e.g. contactor, solenoid valve, ventilator, cooling compressor), the switching frequency and the resulting response of the controlled variable.

In section y = 0 \% to ya (cooling)
the period is set using T - and the associated output is $-\Delta \mathrm{y}$. The control ratio is then from 1 at $\mathrm{y}=0 \%$ at $\mathrm{y}=\mathrm{ya}$.

In section $\mathrm{y}=$ ye to $100 \%$ (heating)
the period is set using $T+$ and the associated output is $+\Delta y$. The control ratio is then from 0 at $\mathrm{y}=\mathrm{ye}$ to 1 at $\mathrm{y}=100 \%$

If only one output range is required with a normal-action system (e.g. heating), output $+\Delta y$ should be used and ya and ye both set to $0 \%$ (Fig. 3/27b).
With a reverse-action system (e.g. cooling), output $-\Delta y$ should be used and ya and ye both set to 100 \%.


Fig. 3/26 Switch-on duration, switch-off duration, period
The period ( $\mathrm{T}+$ and $\mathrm{T}-$ ) is adjustable. The switch-on and switch-off durations are then longer or shorter accordingly. The ratio between these two is not changed. This only depends on the negative deviation and the control algorithm.



Fig. 3/27 Response of manipulated variable with two-position controller
a) with 2 output channels,
b) with 1 output channel

Caution: The parameters ya and ye are used with other output configurations to define the limits of the manipulated variable. For this reason the factory settings are ya $=\mathbf{0} \%$ and ye $=100 \%$. It is therefore essential to reset these parameters since the device cannot output a manipulated variable signal with this output configuration.



Fig. 3/28 Output configuration of two-position controller, manual mode has priority over tracking mode/blocking



Fig. 3/29 Output configuration of two-position controller, tracking mode/blocking has priority over manual mode

- $\mathrm{S} 2=2 \mathrm{~S}$ three-position step output for motor-driven actuators with internal position feedback (Figs. 3/30, 3/31)

With this type of controller, an internally simulated position control loop is connected to the PID control algorithm. The integral response of the final control element is simulated by an integrator with an adjustable positioning time (parameter Ty) which replaces the position feedback. To prevent the internal integrator and the PID output from becoming saturated as time progresses, both variables are reset by the same amount if necessary. To prevent integral saturation, the rise rate of the I component is limited to Ty by the series-connected K controller.
The variable $y$ is only a relative manipulated variable with this output configuration. Therefore limitation of the manipulated variable using parameters ya and ye, a parametrizable safety setting yS and a pure P control are not possible.
The position controller has a minimum pulse length te adjustable using configuring switch S39 and a minimum pulse pause ta adjustable using S40. The minimum pulse length te results in a response threshold as follows:

| Switch-on: | Aee $=$ | $2 *$ te $/$ Ty |
| :--- | ---: | :--- |
| Switch-off: | Aea $=$ | te $/$ Ty |
| Hysteresis: | Aee - Aea $=$ | te $/$ Ty |

See section 7.2.2 for the setting criteria of ta and te
The switchover facilities of the three-position step controller with internal position feedback are shown in Figs. $3 / 30$ and $3 / 31$.



Fig. 3/30 Output configuration of three-position step controller with internal position feedback, manual mode has priority over blocking


Fig. 3/31 Output configuration of three-position step controller with internal position feedback, blocking has priority over manual mode

## - S2 = 3 S three-position step output for motor-driven actuators with external position feedback (Figs. 3/32, 3/33)

With this type of controller, a position controller is connected in series with the PID control algorithm. The setpoint for this position controller is $y$, the actual value is the signal $y R$ feed back by the final control element. Thus limiting of the manipulated variable is possible using parameters ya and ye and an absolute value can be entered for the safety manipulated variable yS. DDC or tracking mode via yES is also possible with $\mathrm{S} 42=2$. P controls are also possible.

Caution: Since the external feedback circuit must never be interrupted, it is highly recommendable to provide the final control element with an electronic position transmitter and to feed the feedback path with a current signal of 0 or $\mathbf{4}$ to 20 mA . If the final control element only has a potentiometer as the position transmitter, it is better to operate the controller with internal position feedback only and only to derive the position display from the potentiometer setting.

The parameters ta and te are also used with this output configuration to adjust the minimum pulse pause and length. These parameters are also used together with Ty to optimize the position control loop (see section 7.2.3).


Fig.3/32 Output configuration of three-position step controller with external position feedback, tracking mode/blocking has priority over manual mode


Fig. 3/33 Output configuration of three-position step controller with external position feedback manual mode has priority over tracking mode/blocking

### 3.2.5 Restart Conditions

Configuring switch S41 is used to define the restart conditions after a power failure or if the processor had detected a fault. If it is set to position $0,1,2$ or 3 , display 4 is flashing after a restart of the controller. This signal can be acknowledged by pressing pushbutton 8 . From software version A09 onwards configuring switch S41 has the additional positions $4,5,6$ and 7 with the same restart conditions but without flashing of display 4 (see page 21).

The SIPART DR20 does not start with the last operating states since these cannot be transferred fast enough to the non-volatile memory in the case of a power failure. However, the local setpoint wi is loaded into the EEPROM if it has not been changed for approx. 5 minutes and is available as the "last w". This means that the last setpoint entered manually or via the serial interface is present providing it was constant long enough. The last manipulated variable is not retained.

The possibilities for S41 listed in the configuring table are self-explanatory.

### 3.2.6 Optical Signalling of Functions and Operating States

Various functions and operating states can be activated either by manual interventions on the control keyboard or via a digital function depending on the various configuring switch settings, as described in the previous sections. Optical signalling of these functions and operating states is on the two LEDs 11 and 14 either as steady lights or flashing lights with different cycles. All functions which refer to setpoint control are displayed on the green LED 14, all states concerning the manipulated variable are signalled on the yellow LED 11. The associated variables can be adjusted with the flashing cycle 0.9 and with steady light 1.
The following signals are possible:


To enable better understanding of the LED signals 14 (INT) and 11 (MANUAL) already shown in the tables on pages 31, 32, 34 and 35, these are again shown clearly in the following Fig. $3 / 34$.

| Cofiguring switch $\rightarrow$ | S1 = 0, 1, 2, 7, 8 |  |  | S1 = 5, 10 |  |  | S1 = 3, 9 |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Selected function | $\quad$ /INT w-adjust- ment blocked | $\quad$ INTlocal <br> mode |  | IINT <br> remote <br> mode/SPC | INTlocal <br> mode |  | $\quad$ IINT <br> DDC <br> backup <br> mode | $\quad$ INT <br> controller <br> mode |  |
| W-LED$W_{\text {effect }}$ |  |  | CB without function | $\begin{aligned} & \text { S18=0 : wi } \\ & \text { S18=1 :wS } \end{aligned}$ |  | $C B=0$ | automatic $\square$ <br> wi | automatic $\qquad$ <br> wi | $C B=0$ |
|  | wi |  |  | $\square$ <br> wE | $\begin{aligned} & \square \square \square \\ & \text { wi } \end{aligned}$ | $C B=1$ | backup $\qquad$ $\begin{aligned} & \mathrm{S} 18=0: \mathrm{wi} \\ & \mathrm{~S} 18=1: \mathrm{wS} \end{aligned}$ |  | $C B=1$ |
|  | x-tracking: | $\begin{aligned} & \text { S17 }=1 \\ & \text { S18 }=0 \\ & \text { S19 }=0 \end{aligned}$ |  | x-tracking: $\quad$ S17=1 *) <br> wS: S18=1 effective with (IINT AND /CB) <br> wi-tracking: $S 19=0$ the inactive wi is tracked to the effective setpoint $w(w S, w E)$ |  |  | x-tracking: $\quad$ S17=1 <br> not with local operation mode <br> wS: S18=1 effective with (INT AND /CB) |  |  |

*) $\rightarrow$ not with S1=10
$\nabla$ adjustable


Fig.3/34 Optical signalling and effective variables with different functions/operating states

### 3.2.7 Bus Interface

Together with the module 6DR2803-8A/8C the SIPART DR20 can transmit and receive operating states, process variables, parameters and configuring switch positions via a serial interface. Up to 32 controllers with these interface modules can be connected in parallel to a bus. Combination with TELEPERM D devices is also permissible if the control of the higher-level computer permits this.

Data transmission is at a rate between 300 and 9600 bit/s set using configuring switch S 42 and in semi-duplex mode with asynchronous transmission of ASCII characters in a 10-bit frame (start bit, ASCII character with 7 bits, parity bit and stop bit). The error message character NAK is transmitted in full-duplex mode so that messages can be repeated rapidly in the event of a fault. The controller is passive and only reacts when requested. The complete bus must be controlled by the higher-level system (master/slave operation).

The configuring switches S42 to S48 are used to define the response of the serial interface and the station numbers in the bus (between 0 and 31). These configuring switches can only be set manually on the device and not via the interface itself.

The transmission procedure (according to DIN 66258 A or B) commences with the start character STX, followed by the station number, the data, the end character ETX and, if applicable, a crosscheck sum for additional data protection. The quantity of data to be transmitted, the start address of a list range and a code for transmitting or receiving data are first defined in the data to be sent to a controller. These are then followed, if applicable, by the data to be received. If the message is received without faults, the SIPART DR20 replies immediately with a message with exactly the same format: STX, station number, data, ETX and, if applicable, cross-check sum. The data section is omitted because no values are requested.

A particularly short procedure has been defined in addition in order to rapidly scan alarms and other status signals from all stations connected to the bus:

Request: STX, station number with code bit, ETX, cross-check sum
Reply: STX, station number with reset bit, the two status bytes STN and STA, ETX, cross-checksum

The serial interface is activated by configuring switch S42:
S42 = 0 The controller transmits all variables, i.e. parameters, configuring switches, process variables and status signals, but does not receive any variables

S42 = $1 \quad$ The controller transmits all variables, but only receives parameters and the configuring switch positions S1 to S41.

S42 = $2 \quad$ The controller transmits all variables, and receives parameters, the configuring positions S1 to S41 as well as wES, yES, STes (CB, N, Si, BL and BAes).

All received information of a message is first stored in a receiver register with max. 32 byte and checked for faults. Fault-free messages are processed further as input signals at the start of the following arithmetic cycle. The transfer of modified parameter and configuring switch positions to the non-volatile EEPROM requires several seconds, however.

All data to be transmitted are loaded into an intermediate memory at the end of each SIPART DR20 arithmetic cycle so that they can be called if required during the next arithmetic cycle without interfering with the internal data processing. Intermediate storage does not take place for the parameters and configuring switches.

In addition to the comprehensive message monitoring, time monitoring can also be selected using configuring switch S48. This is used to check whether data transfer is still taking place to the higher-level system. A computer failure is assumed if messages do not follow within the set monitoring time, and the CBes signal is set to zero. The associated controller then enters standalone mode.

The interface operating instructions C73000-B7476-128 are available for producing coupling software to higher-level systems.

Example: Setpoint W READ and WRITE
Default settings: $\mathrm{S} 1=5 ; \mathrm{S} 42=2 ; \mathrm{S} 43 . .46=0 ; \mathrm{S} 47=\mathrm{StNr}(=0) ; \mathrm{S} 48=0$

| Process values are LIN-values: | 100\%: | LIN 8000 | 38303030 |
| :--- | :--- | :--- | :--- |
| ( 2 Bytes ) | $50 \%$ | LIN 4000 | 383303030 |
|  | $25 \%$ | LIN $2000_{\text {Hex }}$ | 32303030 |

Setpoint W (value: 40\%) READ $\quad$ Address inside controller: 72 $_{\text {Hex }}$

Transmit-telegram:

| STX | StNr | N1 | Adr 1 | Adr 2 | ETX |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 02 | 40 | 61 | 37 | 32 | 03 |  |  |  |  |

Receive-telegram:

| STX | StNr | Data 1 | Data 2 | Data 3 | Data 4 | ETX |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 02 | 40 | 33 | 33 | 33 | 32 | 03 |  |  |  |

$$
\text { Setpoint } W_{\text {ES }} \text { (value: } 40 \% \rightarrow 333333 \text { 32) WRITE } \quad \text { Address inside controller: } 66_{\text {Hex }}
$$

Transmit-telegram:

| STX | StNr | N0 | Adr 1 | Adr 2 | Data 1 | Data 2 | Data 3 | Data 4 | ETX |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 02 | 40 | 41 | 36 | 36 | 33 | 33 | 33 | 32 | 03 |

Receive-telegram:

| STX | StNr | ETX |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 02 | 40 | 03 |  |  |  |  |  |  |  |

The controller has to be structured in order that $\mathrm{W}_{\mathrm{ES}}$ is accepted and monitored!

- green LED above has to be OFF
therefore it is necessary that the controller has got the signal $C B=1$ whether via
binary input BE $(\mathrm{S} 15=3)$ or
via serial interface (STSES Adr. $65_{\text {Hex }}$; Bit7 $=1 ; 80_{\text {Hex }}$ )


## 4. Technical Data ${ }^{1)}$

## General data:

Mounting position
Permissible ambient temperature
Operation
Transport and storage
Humidity class
Degree of protection
Front
Housing
Connections (when plugged in)
Safety measures

Interference emission Interference immunity

CE mark

Max. weight, equipped
Color Front module frame Front surface

Dimensions and panel cut-outs

Any

0 to $50^{\circ} \mathrm{C}$
-25 to $+75^{\circ} \mathrm{C}$
F to DIN 40040

IP 64 to DIN 40050
IP 30 to DIN 40050
IP 20 to DIN 40050
To DIN / VDE 0411 Part 1 (October 73) with consideration of:

IEC 66E (Sec. 22) and DIN / VDE 0411 Part 100 (draft August 86)

- Protection class I to IEC 536
- Isolation between main connection and field signals by means of protective screen or increased insulation to DIN / VDE 106 Part 101 (Nov. 86) (IEC 536)
- The outputs are small function voltages to DIN / VDE 0100 Part 410 (Nov. 83) (IEC 364-4-41)
- Clearances and creepage paths, if not specifically stated otherwise, for over- voltage class III and contamination class 2 to DIN / VDE 0109 (Dec. 83) (IEC 664 and IEC 664A)
- Isolation between $\pm \Delta y$ contacts of the Scontroller and the field signals by means of protective screen or increased insulation to DIN / VDE 0106 Part 101 (Nov. 86) (IEC 536) for overvoltage class II and contamination class 2 to DIN / VDE 0109 (Dec. 83) (IEC 664 and IEC 664A).
according to EN 50081-2
according to EN 50082-2, NAMUR NE21 May 1993
conforms to EMC regulation 89/336/EEC LV regulation 72/73/EEC

Approx. 1.2 kg
RAL 7037
RAL 7035
See Figs. 4/1 and 4/2

1) From hardware version 2 of the controller onwards (yellow sticker on the rear of the controller or marking on the name plate)


| Number of <br> devices | Cut-out <br> width b |
| :--- | :--- |
| 2 | $140+1$ |
| 3 | $212+1$ |
| 4 | $284+1$ |
| - | $\cdot$ |
| - | - |
| - | - |
| 10 | $716+1$ |

1) Mounting depth required to replace the signal converters
2) But mounting above each other is permissible within the permissible ambient temperature range

Fig. 4/1 Dimensions
Fig. 4/2 Panel cut-outs

- Power supply

Rated voltage

| Operating voltage range Frequency range |  | $\begin{aligned} & \text { AC } 195 \text { to } 276 \mathrm{~V} \\ & 48 \text { to } 63 \mathrm{~Hz} \end{aligned}$ | $\begin{aligned} & \text { AC } 97 \text { to } 138 \mathrm{~V} \\ & 48 \text { to } 63 \mathrm{~Hz} \end{aligned}$ | $\begin{aligned} & \text { AC } 20 \text { to } 28 \mathrm{~V} \\ & 48 \text { to } 63 \mathrm{~Hz} \end{aligned}$ | DC 20 to 35 V |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Peak voltages: |  |  |  |  |  |
| Non-periodic (VDE 160) | 1.3 ms | $\leq 780 \mathrm{~V}$ | $\leq 390 \mathrm{~V}$ | $\leq 78 \mathrm{~V}$ | $\leq 78 \mathrm{~V}$ |
|  | $10 \mu \mathrm{~S}$ | $\leq 1500$ V | $\leq 1500 \mathrm{~V}$ | $\leq 500 \mathrm{~V}$ | $\leq 500 \mathrm{~V}$ |
| Permissible voltage dips (at maximum load) | **) | $\leq 30 \mathrm{~ms}$ | $\leq 30 \mathrm{~ms}$ | $\leq 30 \mathrm{~ms}$ | $\leq 30 \mathrm{~ms}$ |

Power consumption (at maximum load):
Apparent power (inductive)
Active power

| $\leq 21 \mathrm{VA}$ inductive | $\leq 21 \mathrm{VA}$ inductive <br> $\leq 13 W$ | $\leq 21 \mathrm{VA}$ inductive |  |
| :--- | :--- | :--- | :--- |
| $\leq 13 \mathrm{~W}$ |  |  |  |
|  |  |  |  |
|  |  | AC 500 V | AC 500 V |
| AC 1500 V | AC 1500 V | DC 700 V | DC 700 V |
| AC 1500 V | AC 1500 V | DC 700 V | DC 700 V |

**) The transmitter supply can fall by up to 5 V , the max. load voltage of the manipulated variable current ly from 18 to 13 V .

- Transmitter supply L+

Rated voltage
Residual ripple (100/120 Hz) Upp
Max. permissible load current
Short-circuit current

20 to 26 V
$\leq 1 \mathrm{~V}$

60 mA , short-circuit-proof
< 200 mA , pulsed

- Analog inputs AE1 and AE2 (standard controller)

Input signal range *)

Input resistance
Filter time constant
Static destruction limit
Dynamic destruction limit

0 to 20 mA or 4 to 20 mA
$249 \Omega \pm 0.1 \%$
approx. 25 ms

- $8 /+30 \mathrm{~mA}$
$\pm 500 \mathrm{~V}$
(1.2 / $50 \mu \mathrm{~S}, \mathrm{Ri}=13 \Omega$ )


## - Digital input BE

Signal state "0"
Signal state" 1"
Input resistance
Static destruction limit
Dynamic destruction limit

$$
\begin{aligned}
& \leq 4.5 \mathrm{~V} \text { or open } \\
& \geq 13 \mathrm{~V} \\
& \geq 27 \mathrm{k} \Omega \\
& \pm+35 \mathrm{~V} \\
& \pm+500 \mathrm{~V} \\
& (1.2 / 50 \mu \mathrm{~S}, \mathrm{Ri}=13 \Omega)
\end{aligned}
$$

*) Referred to M

- Digital output BA (with wired-OR diodes)

Signal state "0"
Signal state" 1"

## *)

*)
$\leq 1.5 \mathrm{~V}$
+19 to +26 V
30 mA , short-circuit-proof
$<200 \mathrm{~mA}$, pulsed
$-1 \mathrm{~V} /+35 \mathrm{~V}$
$\pm 500 \mathrm{~V}$
$(1.2 / 50 \mu \mathrm{~S}, \mathrm{Ri}=13 \Omega)$

0 to 20 mA or 4 to 20 mA
0 to 22 mA or 2.4 to 22 mA

- 1 to 18 V
$\leq 26 \mathrm{~V}$
$\leq 0.1 \%$
0.1 H
0.1 \%
< 0.1 \%
$<0.2$ \%
$\leq 0.3 \%$
$\leq 0.1 \% / 10 \mathrm{~K}$
$\leq 0.3 \% / 10 \mathrm{~K}$
$\leq \pm 0.2$ \%
330 ms
$-1 \mathrm{~V} /+35 \mathrm{~V}$
$\pm 500 \mathrm{~V}$
$(1.2 / 50 \mu \mathrm{~S}, \mathrm{Ri}=13 \Omega)$
- Relay outputs $\pm \Delta \mathbf{Y}$ (S controller)

Contact material
Contact loading capacity

- Max. switching voltage **)
- Max. switching current
- Max. switching power

Life expectancy

- Mechanical
- Electrical (AC 230 V, ohmic)

Built-in spark suppressor
Test voltage ( 1 min )
Contacts against excitation winding
$\mathrm{Ag}-\mathrm{Ni}$

| Alternating current | Direct current |
| :--- | :--- |
| AC 250 V | DC 250 V |
| 5 A | 5 A |
| 1250 VA | 100 W at 24 V |
|  | 50 W at 250 V |

approx. $2 * 10^{7}$ switching operations approx. $2 * 10^{6} /$ l switching operations (I in Amps)

Series connection $33 \mathrm{nF} / 220 \Omega$
in parallel with a varistor $420 \mathrm{~V}_{\text {rms }}$
1.5 kV
*) Referred to M
**) Please note the warning on page 15

- CPU data

Controller cycle time
Smallest integration rate
$\mathrm{dy} / \mathrm{dt}=\mathrm{Kp} * \mathrm{xd} / \mathrm{Tn}$

- A/D conversion

Procedure

Resolution
Zero error
Full-scale error
Linearity error
Temperature influence

## - Displays

- w/x display

Color/digit height
Display range
Decimal point
Repetition rate
Resolution
Display error

- xd- display

Length of display
Display range
Resolution
Resolution around $\mathrm{xd}=0$
Repetition rate
y display
Color/digit height
Display range
Repetition rate
Resolution
Display error
$97.8 \mathrm{~ms} \pm 1$ \%
$0.1 * 0.1 . \% / 10^{4} \mathrm{~s}$

Successive approximation, > 120 conversions per input and averaging over 20 or 16.67 ms

11 bit $\cong 0.06$ \%
$\leq 0.2 \%$
$\leq 0.2 \%$
$\leq 0.2 \%$
$\leq 0.2 \% / 10 \mathrm{~K}$
four-digit, 7 -segment display
red / 7 mm

- 1999 to 9999, adjustable
can be fixed
0,1 to 5 s , adjustable together with y display
1 digit, but not better than A/D converter corresponding to A/D converter and analog inputs

20 red LEDs, 1 green LED in the center 50.8 mm $\pm 10 \%$, can be reprogrammed to $\pm 2.5$ to $\pm 40 \%$
0.1 of display range
0.05 of display range
0.1 s
two-digit, 7 -segment display
red / 7 mm

- 9 to $109 \% \quad(100 \%=h 0$
$109 \%=h 9$ )
0.1 to 5 s , adjustable together with $\mathrm{w} / \mathrm{x}$ display

1 digit = 1 \%
corresponding to A/D converter and analog inputs

- Option modules

| Signal converter for Order No. | Current 6DR2800-8J | Voltage <br> 6DR2800-8J | Resistance transmitter 6DR2800-8R | Resistance thermometer <br> 6DR2800-8P | ```c``` |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Start-of-scale value <br> min. span <br> max. zero supression <br> Full-scale value | $0 / 4 \mathrm{~mA}$ <br> *) $20 \mathrm{~mA}$ | $0 / 2 \mathrm{~V}$ or 199.6 mV *) <br> 10 V or 998 mV | $\begin{aligned} & 0 \Omega \\ & \Delta \mathrm{R} \geq 0.8 \mathrm{R} \\ & \mathrm{R}_{\mathrm{A}} \leq 0.2 \mathrm{R} \\ & \mathrm{R}=80 \text { to } 1200 \Omega \end{aligned}$ | $\begin{aligned} & \mathrm{R}_{\mathrm{tA}} \geq 80.25 \Omega \\ & \mathrm{tA} \geq-50^{\circ} \mathrm{C} \\ & \Delta \mathrm{R}_{\mathrm{t}}=19 \Omega \\ & \mathrm{R}_{\mathrm{tA}} \leq 5 \Delta \mathrm{R}_{1} \\ & \\ & \mathrm{R}_{\mathrm{tE}} \leq 390.26 \Omega \\ & \mathrm{tE} \leq 850^{\circ} \mathrm{C} \\ & \hline \end{aligned}$ | $\begin{aligned} & -5 \Delta U \ldots 0 \ldots+5 \Delta U \\ & \Delta U=10 \mathrm{mV} \\ & \|U\| \leq 5 \Delta U \\ & U_{e} \leq 60 \mathrm{mV} \end{aligned}$ |
| Input impedance Difference Common mode Permiss. Commonmode voltage Supply current Line resistance Two-wire system Three-wire system Four-wire system | $\begin{aligned} & 49.9 \Omega \pm 0.1 \% \\ & \geq 500 \mathrm{k} \Omega \\ & 0 \text { to }+10 \mathrm{~V} \end{aligned}$ | $\begin{aligned} & 200 \mathrm{k} \Omega \\ & \geq 200 \mathrm{k} \Omega \\ & 0 \text { to }+10 \mathrm{~V} \end{aligned}$ | $\begin{aligned} & 5 \mathrm{~mA} \pm 5 \% \\ & <10 \Omega \text { each } \end{aligned}$ | $\begin{aligned} & 100 \mathrm{mV} / \Delta \mathrm{R} \\ & \mathrm{R}_{\mathrm{L} 1}+\mathrm{R}_{\mathrm{L} 2} \leq 10 \Omega \\ & \mathrm{R}_{\mathrm{L} 1}=\mathrm{R}_{\mathrm{L} 2}=\mathrm{R}_{\mathrm{L} 3} \leq 50 \Omega \\ & \mathrm{R}_{\mathrm{L}} \leq 80 \Omega \end{aligned}$ | $\begin{aligned} & 2 \mathrm{M} \Omega \\ & 1 \mathrm{M} \Omega \\ & -10 \text { to }+10 \mathrm{~V} \\ & \mathrm{R}_{\mathrm{L} 1}+\mathrm{R}_{\mathrm{L} 2} \leq 300 \Omega \end{aligned}$ |
| Filter time Constant $\pm 20$ \% | 50 ms | 50 ms | 50 ms | 50 ms | 20 ms |
| Error ***) Zero Gain Linearity Common-mode Cold junction compensation | $\begin{aligned} & \leq 0.3 \% \\ & \leq 0.5 \% \\ & \leq 0.05 \% \\ & \leq 0.07 \% / \mathrm{V} \end{aligned}$ | $\begin{aligned} & \leq 0.2 \% \\ & \leq 0.2 \% \\ & \leq 0.05 \% \\ & \leq 0.02 \% / \mathrm{V} \end{aligned}$ | $\begin{aligned} & \leq 0.2 \% \\ & \leq 0.2 \% \\ & \leq 0.2 \% \end{aligned}$ | $\begin{array}{ll} \leq 0.1 \% & * * \\ \leq 0.1 \% & * *) \\ \leq 0.3 \% & \end{array}$ | $\begin{aligned} & \leq 0.1 \% \quad * *) \\ & \leq 0.1 \% \quad * *) \\ & \leq 0.1 \% \\ & \leq 0.1 \% / \mathrm{V} \\ & \leq 2{ }^{\circ} \mathrm{C} \end{aligned}$ |
| Influencing effect of temperature ***) Zero <br> Gain Cold junction compensation | $\begin{aligned} & \leq 0.05 \% / 10 \mathrm{~K} \\ & \leq 0.1 \% / 10 \mathrm{~K} \end{aligned}$ | $\begin{aligned} & \leq 0.02 \% / 20 \mathrm{~K} \\ & \leq 0.1 \% / 10 \mathrm{~K} \end{aligned}$ | $\begin{aligned} & \leq 0.1 \% / 10 \mathrm{~K} \\ & \leq 0.3 \% / 10 \mathrm{~K} \end{aligned}$ | $\begin{aligned} & \leq 0.2 \% / 10 \mathrm{~K} \\ & \leq 0.3 \% / 10 \mathrm{~K} \end{aligned}$ | $\begin{aligned} & \leq 0.3 \% / 10 \mathrm{~K} \\ & \leq 0.3 \% / 10 \mathrm{~K} \\ & \leq 0.5^{\circ} \mathrm{C} / 10 \mathrm{~K} \end{aligned}$ |
| Stat. Destruction limit across the inputs Referred to M Dyn. Destruct. limit 1.2/50 $\mu \mathrm{s}, 13 \mathrm{Ohm}$ | $\begin{aligned} & \pm 40 \mathrm{~mA} \\ & \pm 35 \mathrm{~V} \\ & \pm 500 \mathrm{~V} \end{aligned}$ | $\begin{aligned} & \pm 35 \mathrm{~V} \\ & \pm 35 \mathrm{~V} \\ & \\ & \pm 500 \mathrm{~V} \end{aligned}$ | $\begin{aligned} & \pm 35 \mathrm{~V} \\ & \pm 35 \mathrm{~V} \\ & \\ & \pm 500 \mathrm{~V} \end{aligned}$ | $\begin{aligned} & \pm 35 \mathrm{~V} \\ & \pm 35 \mathrm{~V} \\ & \\ & \pm 500 \mathrm{~V} \end{aligned}$ | $\begin{aligned} & \pm 35 \mathrm{~V} \\ & \pm 35 \mathrm{~V} \\ & \pm 500 \mathrm{~V} \end{aligned}$ |

*) Start-of-scale value by configuring
**) Measuring ranges which can be marshaled or adjusted by the user
***) Without error of A/D converter

- Alarm module with relays

Contact material
Contact loading capacity

Max. switching voltage
Max. switching current
Max. switching power
Life expectancy

- Mechanical
- $\quad 24 \mathrm{~V} / 4 \mathrm{~A}$ ohmic
- $\quad 24 \mathrm{~V} / 1 \mathrm{~A}$ inductive

Built-in spark suppressor
(6DR2801-8A)

## AG-Ni

| Alternating current | Direct current |
| :--- | :--- |
| AC 35 V | DC 35 V |
| 5 A | 5 A |
| 150 VA | 100 W at 24 V |
|  | 80 W at 30 V |

approx. $210^{7}$ switching operations
approx. $210^{6}$ switching operations
approx. $210^{5}$ switching operations
series connection $1 \mu \mathrm{~F} / 22 \Omega$
in parallel with a varistor $75 \mathrm{~V}_{\mathrm{rsm}}$

## - Alarm module with 4 digital outputs and 1 digital input (6DR2801-8B)

## Outputs

Signal status 0
Signal status 1
*)
Max. load current Short-circuit current Static destruction limit Dynamic destruction limit

Input

Signal status 0
Signal status 1
Input resistance
Static destruction limit Dynamic destruction limit

4 digital outputs, of which:
2 for alarm monitoring
2 for the outputs with an S controller The output relays of the S controller are then switched off.
$\leq 1.5 \mathrm{~V}$
+19 V to +26 V
30 mA , short-circuit-proof
$\leq 50 \mathrm{~mA}$, pulsed
$1 \mathrm{~V} /+35 \mathrm{~V}$
$\pm 500 \mathrm{~V}$
$(1.2 / 50 \mu \mathrm{~S}, \mathrm{Ri}=13 \Omega)$
1 digital input
blocks the setting of parameters and configuring switches
$\leq 4.5 \mathrm{~V}$ or open
$\geq 13 \mathrm{~V}$
$\geq 2.4 \mathrm{k} \Omega$
$\pm 35 \mathrm{~V}$
$\pm 500 \mathrm{~V}$
$(1.2 / 50 \mu \mathrm{~S}, \mathrm{Ri}=13 \Omega)$

[^0]
## - $\quad$ Serial interface(6DR2803-8A)

Communication signals
Transferable data
Communications procedure
Character format

Hamming distance d
Transmission speed
Transmission

Addressable stations
Data traffic watch-dog
Transmit output Txd
Signal level "0"
Point-to-point Bus

Signal level "1"
Point-to-point
Bus
Receive input Rxd
Signal level "0"

Signal level "1"

Electrical isolation

## V. 24 / V. 28 signals to CCITT - V. 24

Operational status, process variables, parameters and configuring switches
to DIN 66258 A or B
10 bits (start bit, ASCII character with 7 bit, parity bit and stop bit)

2 or 4
300 to 9600 bit/s
Asynchronous, half-duplex
Full-duplex for NAK
32
1 to 25 s or none
V. 28
$\mathrm{U}_{\mathrm{A}}=+5$ to +12 V
$\left.\mathrm{I}_{\mathrm{A}} \max .1 .67 \mathrm{~mA} \quad\right\}$ short-circuit$\left.\mathrm{I}_{\mathrm{A}} \max .15 \mathrm{~mA} \quad\right\}$ proof
$\mathrm{U}_{\mathrm{A}}=-5$ to -12 V
$\mathrm{I}_{\mathrm{A}} \max .1 .67 \mathrm{~mA}$
$\mathrm{UA} \leq 0 \mathrm{~V}$
V. 28
$\mathrm{U}_{\mathrm{A}}=0$ to +35 V
$\mathrm{I}_{\mathrm{E}}=\left(\mathrm{U}_{\mathrm{E}}-0.7 \mathrm{~V}\right) / 6.8 \mathrm{k} \Omega$
$\mathrm{U}_{\mathrm{A}}=-3$ to -35 V
$\mathrm{I}_{\mathrm{E}}=\left(\mathrm{U}_{\mathrm{E}}+1.5 \mathrm{~V}\right) / 6.8 \mathrm{k} \Omega$

Txd: without (referred to M (Ground))
Rxd: by opto isolator

| Cable capacitance and length at $9600 \mathrm{bit} / \mathrm{s}$ | Cable capacitance | Recommended length |  |
| :---: | :---: | :---: | :---: |
|  |  | Unscreened ribbon cable | Screened round cable |
| V. 28 point-to-point | $\leq 2.5 \mathrm{nF}$ | 50 m | 10 m |
| SIPART Bus with bus driver **) | $\leq 25 \mathrm{nF}$ | 500 m | 100 m |
| TTY point-to-point with bus driver **) | $\leq 75 \mathrm{nF}$ | 1500 m | 300 m |

*) Signal level "1" is the rest position
**) Bus driver C73451-A347-B202
An external power supply ( $\pm 24 \mathrm{~V}, 100 \mathrm{~mA}$ ) is required for the bus driver

## 5. Mounting

### 5.1 Mechanical Installation

## Selection of mounting location:

The permissible ambient temperature range of 0 to $50^{\circ} \mathrm{C}$ must not be violated, taking into consideration heat sources in the environment. Note the possibility of heat accumulation in the case of direct installation of devices one above the other. The front and rear of the controller must be readily accessible.

## Panel mounting:

SIPART DR20 controllers are fitted either in individual panel cutouts or in open tiers (dimensional drawing $4 / 2$ on page 63).

- In order to ensure adequate interference suppression, even at high frequencies, we recommend that the paint be removed from the top edge of the panel cut-out. The contact spring located on the top of the controller then produces a good HF earth connection.

Insert controller into panel cut-out or open tier from the front and attach the two clamps onto the housing from the rear so that they latch into the housing cut-outs.

- Align controller and tighten clamps. The clamp range is from 0 to 40 mm


### 5.2 Electric Connection

Caution: The regulations for the installation of power systems with rated voltages below 1000 V must be observed (VDE 0100). A protective earth connection has to be made and must not be disconnected, while the controller is powered!

The arrangement of the connection elements is shown in Fig. $2 / 2$ (page 12).

## Protective earth connection:

The protective earth connection is made via grounding screw 6 at the rear. When connected to 115 V or 230 V power supplies, the protective earth connection can also be made via the mains plug 7.

## Power supply connection:

Power to the controller is supplied via a three-pin plug (IEC 320 V / DIN 49457 A) on 115 and 230 V AC systems, or by a special two-pole plug (polarity irrelevant) on 24 V AC/DC systems. Power plugs are supplied with the controller.
Connect the lead via a switch and fuse (switch and fuse not included in scope of delivery). Check the mains voltage specified on the rating plate of the device!

## Connection of measuring and signal lines:

The standard controller K and S have 8-pin or 10-pin plug-in terminal blocks, the option modules for analog inputs have 4-pin terminal blocks, those for alarm outputs have 5 -pin terminal blocks.

Measuring leads should be twisted and must be routed separately from power cables or screened. The screen must be connected to one of the M (Ground) connections.

The max. permissible conductor cross-section for the plug-in screw terminal blocks is $1.5 \mathrm{~mm}^{2}$ (AWG 14).

The SIPART DR20 is designed with a large EMC to ensure interference free operation. To maintain a high degree of reliability, we recommend that all inductances (e.g. relays, motors, contactors) in the vicinity of, or that are connected to the controller, be connected to suitable suppressors (e.g. RC combinations).

## Connection of serial interface and bus driver

The bus side of the driver is connected to the controller by a ribbon cable attached to a 9 -way subminiature D-plug (x1). Parallel interfaces can therefore be implemented cheaply. V. 28 point-topoint connections are established by a 9 -way round cable socket connector. A round cable attached to a 25 -way subminiature D-plug connects the point-to-point side of the bus driver to the remote system. D-plugs are not supplied with the modules.

Power for the bus driver is supplied via a 10-way terminal block (x2). Jumpers on the 10 -way block (and also on an additional 8-way block (x3)) allow the supply to be configured as required. The 8way block $x 3$ is connected in parallel to the 25 -way jack $x 4$, which allows the remote system to be connected to $x 3$ if necessary. The 10-way and 8 -way terminal blocks are supplied with the driver.

9-way D-plug for round cable (soldered)
9 -way D-plug for ribbon cable (i.p.c.d.)
25-way D-plug for round cable (soldered)
Recommended cables
10 core ribbon cable AWG 26
core unscreened round cable

> C73451-A347-D35
> C73451-A347-D36
> C73451-A347-D38

FLi-Y10 x $1 \times 0.14 \mathrm{~mm}$
JE-LiYY $4 \times 1 \times 0.5$ BdSi

## Zero volt system:

The SIPART DR20 controller has just one zero-volt conductor $M$ at the field end which is lead out twice to terminals 6 and 7 of the standard controller. All input and output signals refer to this point.

The power supply connection is electrically isolated from the device. The SIPART DR20 controllers need not be connected together in the case of systems with non-meshed control loops. In the case of meshed loops, the M connections of all controllers must be connected individually to a central star point. This star point may be connected at one position to the protective earth conductor of the system.

### 5.2.1 Wiring

## Standard controllers:

The connection circuits of the standard controller 6DR2001 (S output) and 6DR2004 (K output) are shown in Fig. 3/1 (page 13).

It should be mentioned again that the two analog inputs AE1 and AE2 of the standard controller are non-floating and can only accept current signals of 0 or 4 to 20 mA . The load of these inputs is $249 \Omega$ in contrast to the load of the option modules. A voltage drop of max. 5 V occurs across this load when powering 2 -wire transmitters by the SIPART DR20 so that only 15 V are available in the most unfavorable case as the supply voltage for the transmitter (connection circuits in Fig. 5/2).


Fig. 5/1 SES and bus driver interfaces


Connection circuit of AE1 or AE2 with a non-floating current source


Connection circuit of AE1 or AE2 with a floating current source


Connection of a two-wire transmitter to AE1 or AE2 with power from L+ of controller

Fig. 5/2 Wiring of analog inputs AE1 and AE2

## Optional modules for analog inputs AE3 and AE4:

## 6DR2800-8J see wiring diagram, Fig. 5/3

The current input is connected across the input terminals AE + and AE - and terminated internally with a resistance of $49.9 \Omega \pm 0.1 \%$. The subsequent differential amplifier with a high commonmode suppression allows a common-mode voltage up to +10 V . It is therefore possible to connect further loads up to a total value of $500 \Omega$ between AE - and M (see Fig. 5/3). The negative terminal of the transmitter circuit must be connected to M . Note with two-wire transmitters and with power supply from the SIPART DR20 that the additional external loads correspondingly reduce the supply voltage available to the transmitter.

The module is set to process current signals by means of jumpers on the module itself and an appropriate connection. The measuring range ( 0 to 20 mA or 4 to 20 mA ) is set by configuring.

Connection examples for current signals are shown in Fig. 5/4.
The voltage input is also connected across the input terminals AE + and AE -. As with the connection to current signals, the common-mode suppression by the differential amplifier input is max. +10 V .

The module is set to process voltage signals by means of jumpers on the module and an appropriate connection circuit. Jumpers are also used to set the full-scale value of 1 V or 10 V , The start-of-scale value is configured.

Connection examples for voltage signals are shown in Fig. 5/5.


0 ... 10 V
$0 / 0.2$... 1 V
$\mathrm{x} 4=\mathrm{x} 5$
$x 8=x 9$


0/4 ... 20 mA
$\mathrm{x} 4=\mathrm{x} 5$
$\mathrm{x} 7=\mathrm{x} 8$

Fig. 5/3 Wiring of module 6DR2800-8J


Connection of a two-wire transmitter to a signal converter 6DR2800-8J. The transmitter is powered by L+ of the controller:


Connection circuit of signal converter 6DR2800-8J as current input with a non-floating current source of 0 to 20 or 4 to 20 mA .


1) The common-mode voltage may be up to +10 V . A total resistance against the reference potential is therefore permissable up to $500 \Omega$ at this position. Note the minimum operating voltage of the two-wire transmitter.

Series connection of 2 current inputs with signal converter 6DR2800-8J. Both controllers must be connected to a common ground. Controller 2 could also be an analog input AE1 or AE2.

Fig. 5/4 Wiring of module 6DR2800-8J for current signals


Connection circuit of signal converter 6DR2800-8J as voltage input for a non-floating voltage source of 0 to +10 V . The possible drop on the M bar enters the measurement as an error.


Connection circuit of signal converter 6DR2800-8J as voltage input for a non-floating voltage source of 0 to - 10 V whilst avoiding voltage drops on the M bar


Connection circuit of signal converter 6DR2800-8J as voltage input for a floating voltage source of 0 to +10 V .

Fig. 5/5 Wiring of module 6DR2800-8J for voltage signals

Potentiometers with rated values from 80 to $1200 \Omega$ can be connected as resistance transmitters. A constant current of 5 mA is applied to the wiper of the potentiometer. Resistors are connected in parallel to the potentiometer by means of a slide switch on the module in order to carry out coarse selection of the measuring range. The start-of-scale and full-scale values are set using the two resistors accessible from the rear.
This module can also be used as a current input with adjustable start-of-scale and full-scale values. The load is $49.9 \Omega$, the module is not electrically isolated.



$$
R=R_{A}+\Delta R+R_{E}
$$

Fig. 5/6 Wiring of module 6DR2800-8R for current signals/resistance transmitter

## 6DR2800-8P see wiring diagram, Fig. 5/7

Pt 100 resistance thermometers can be connected using a two-wire, three-wire or four-wire system. The selection is made using jumpers on the module. The following conditions apply:

Two-wire circuit

$$
\mathrm{R}_{\mathrm{L} 1}+\mathrm{R}_{\mathrm{L} 4} \leq 10 \Omega
$$

Three-wire circuit

$$
\mathrm{R}_{\mathrm{L} 1}=\mathrm{R}_{\mathrm{L} 3}=\mathrm{R}_{\mathrm{L} 4} \leq 50 \Omega
$$

Four-wire circuit

$$
\mathrm{R}_{\mathrm{L}} \leq 80 \Omega
$$

The type of circuit is fixed using marshalling and the connection technique. The measuring range $R_{t A}$ to $R_{t E}$ is set using jumpers on the module (the start-of-scale value $R_{0}$ and the span $\Delta R=R_{t E}$ $R_{t A}$ are set). The lead resistance can be balanced if necessary using the start-of-scale value ( $R_{0}$ ). The required programming is listed in table 5.1. The fine adjustment is carried out using the two resistors at the rear of the module. The circuit contains a linearization function so that the output is temperature-linear.


Table 5/1
Marshalling of start-of-scale value $R_{0}$ and span $\Delta R$
A single character means that only one jumper pole should be attached.


Fig. 5/7 Wiring of module 6DR2800-8P for Pt 100 resistance thermometer

## 6DR2800-8T see wiring diagram, Fig. 5/8

All common types of thermocouples and $\mathbf{m V}$ sources can be connected to this module, As the low-drift input amplifier has a very high common-mode suppression, a DC or low-frequency AC voltage up to $\pm 10 \mathrm{~V}$ may occur between the transmitter and the controller ground. Thus nonisolated thermocouples (welded-on, earthed in undefined manner) can also be connected if two SIPART DR20 controllers are provided with a thermocouple input and connected together via the ground lead. If this is not the case, it is recommendable to connect terminal 3 to M (terminal 6 of standard controller). Electrical isolation is then provided via the mains transformer. Fine adjustment with a mV transmitter must also be carried out with this connection.

Thermocouples can be connected either via thermostats/compensation boxes or directly to the internal cold junction via the temperature sensor fitted on the terminal block (terminals 1 and 2). This compensation circuit is referred to $0^{\circ} \mathrm{C}$ and only necessary for thermocouples with internal cold junction. Only in this case the type of thermocouple must be selected by jumper marshalling on the module.

The jumper marshalling must be left open (connect one pole to E) in the case of thermocouple type $B$, thermocouples with an external cold junction or with mV signals which do not come from a thermocouple.

For calibration set jumper from NORM to TEST position. Refer to thermocouple table DIN 43710 or DIN IEC 584 for value of $\mathrm{U}_{\text {tA }}$ and $\mathrm{U}_{\mathrm{tE}}$. Calculate $\mathrm{U}_{0}$ according to location of cold junction:
internal $0^{\circ} \mathrm{C}$ :

$$
\begin{aligned}
& \mathrm{U}_{0}=\mathrm{U}_{\mathrm{tA}} \\
& \mathrm{U}_{0}=\mathrm{U}_{\mathrm{t}}-\mathrm{U}_{\mathrm{tB}} \\
& \mathrm{U}_{0}=\mathrm{U}_{\mathrm{A}}
\end{aligned}
$$

external $\mathrm{t}_{\mathrm{B}}$ :
mV transmitter:
Set appropriate jumpers additive to value of $\mathrm{U}_{0}: 0,5+1+2+4+8$ $+16+32 \mathrm{mV}$ and polarity of $\mathrm{U}_{0}: \mathrm{P}$ (positive) or N (negative).
Calculate $\Delta \mathrm{U}=\mathrm{U}_{\mathrm{tE}}-\mathrm{U}_{\mathrm{tA}}$ and set jumpers according to table $5 / 2$.
Further jumpers on the module determine whether the input signal moves towards $0 \%$ or $100 \%$ in the event of a thermocouple breakage. Tables with the required jumper settings are included in the SIPART DR20 instructions.
Fine adjustment of the measuring range (start-of-scale value and span) is carried out using a mV transmitter via the adjustable resistors accessible at the rear. For operation set jumper to NORM position for thermocouples using the internal cold junction. Leave it on TEST for thermocouples using external compensation or mV transmitters.

The output signal of the module is voltage-linear. The linearization required with thermocouples to achieve a temperature-linear signal is carried out using the linearizer which is already included in the standard controller (see Section 6 for settings).

| $\Delta \mathrm{U}$ (mV) |  | 1 | 2 | 3 | 4 | 5 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 9.7 | 10.3 | AB | AB | A | BC | AB |
| 10.1 | 10.7 | AB | A | AB | BC | AB |
| 10.6 | - 11.2 | A | AB | AB | BC | $A B$ |
| 11.0 | - 11.7 | AB | AB | BC | AB | $A B$ |
| 11.5 | - 12.0 | AB | A | A | A | BC |
| 11.8 | 12.4 | A | AB | AB | BC | A |
| 12.2 | 13.0 | AB | AB | BC | A | $A B$ |
| 12.7 | 13.3 | A | AB | A | BC | $A B$ |
| 13.2 | 13.9 | AB | A | BC | AB | $A B$ |
| 13.8 | 14.6 | A | AB | BC | AB | AB |
| 14.4 | 15.0 | A | AB | A | BC | A |
| 14.9 | 15.7 | AB | A | BC | A | AB |
| 15.5 | 16.4 | AB | AB | AB | BC | BC |
| 16.1 | 17.1 | AB | BC | A | AB | AB |
| 16.7 | 17.3 | A | A | A | BC | $A B$ |
| 17.1 | 18.1 | AB | BC | AB | A | A |
| 18.0 | 19.2 | AB | AB | BC | AB | BC |
| 18.9 | 20.0 | BC | AB | AB | AB | A |
| 19.6 | 20.6 | A | BC | AB | AB | A |
| 20.3 | 21.3 | AB | BC | A | A | A |
| 21.2 | 22.5 | AB | AB | BC | BC | A |
| 22.0 | 23.2 | BC | AB | A | AB | A |
| 23.0 | 24.2 | BC | A | AB | AB | A |
| 23.9 | 24.9 | A | BC | A | AB | A |
| 24.5 | 26.0 | AB | BC | AB | BC | A |
| 25.8 | 27.5 | BC | AB | AB | BC | AB |
| 27.3 | 29.0 | AB | BC | BC | AB | A |
| 28.4 | 30.2 | BC | AB | BC | AB | $A B$ |
| 30.1 | 31.6 | A | BC | AB | A | BC |
| 31.4 | 33.4 | BC | BC | AB | AB | AB |
| 33.2 | 35.0 | A | AB | BC | BC | BC |
| 34.8 | 36.9 | BC | BC | AB | A | AB |
| 36.8 | 39.2 | BC | A | BC | BC | AB |
| 38.4 | 40.8 | BC | BC | AB | AB | BC |
| 40.5 | 43.1 | AB | BC | BC | BC | BC |
| 42.6 | - 45.2 | BC | BC | AB | A | BC |
| 44.1 | 46.6 | BC | BC | A | AB | BC |
| 46.2 | - 49.0 | BC | BC | BC | AB | A |
| 48.8 | 51.4 | BC | A | BC | BC | A |
| 50.9 | 54.1 | BC | BC | BC | BC | AB |
| 53.8 | 56.9 | BC | BC | A | BC | BC |
| 55.4 | 58.8 | BC | BC | BC | BC | A |
| 57.9 | 61.6 | BC | BC | BC | BC | BC |



Fig. 5/8 Wiring of module 6DR2800-8T for thermoelectric voltages / mV

## Optional modules for alarm monitoring

Please refer to the note on signalling on page 27.

## 6DR2801-8A see connection diagram, Fig. 5/9

This module is equipped with two relays for external signalling of the alarms A1/A2. The contact configuration can be set according to the connection diagram using soldered jumpers on the module.
The RC combinations of the spark suppression elements are connected via the NO contacts when delivered. The capacitors must be resoldered accordingly if the load is to be connected to the NC contacts.
Consumers with a very low power may be influenced by the spark suppression capacitors ( $1 \mu \mathrm{~F}$ ). These must be replaced by smaller capacitors.
Only switching voltages up to AC/DC 35 V may be connected to the relay contacts!

## 6DR2801-8B see connection diagram, Fig. 5/10

If this module is fitted for alarm monitoring, configuring switch S36 must be set to 1 . The external signalling of alarms is then made via the digital outputs A1/A2. With an $S$ controller, the manipulated variable signal is also output at the same time via this module ( $\pm \Delta \mathrm{Y}$ ) and the output relays in the standard controller are switched off. This module can be used to convert a K controller into an S controller by setting configuring switch $\mathrm{S} 2 \neq 0$.

The adjustment facility for parameter and configuring switch settings via the front panel keyboard is suppressed by the additional digital input if this input (BLPS) is connected to $24 \mathrm{~V}(\mathrm{~L}+)$.


Fig. 5/9 Connection diagram of module 6DR2801-8A for alarm monitoring


Fig. 5/10 Connection diagram of module 6DR2801-8B for digital outputs A1 / A2 and $\pm \Delta y$ as well as digital input BLPS

### 5.2.2 Wiring the Serial Interface and the SIPART Bus Driver 6DR2803-8A (V. 28 point-to-point serial interface)

Insert in slot 4. Use configuring switches S42 to S48 to establish communications procedure.


Fig. 5/11 Wiring of V. 28 point-to-point SES module 6DR2803-8A

- SIPART Bus


Fig. 5/12 SES / bus driver / remote system wiring diagram

## - SIPART bus wiring principles



Fig. 5/13 Wiring of SES bus driver to SIPART bus

1) marshalling SES on bus ( $x 1=x 2$ )

- Bus driver C73451-A347-B202 wiring principles and interface to remote system


Fig. 5/14 V. 28 point-to-point to a remote system with no isolation between the SIPART bus and the remote system


Fig. 5/15 V. 28 point-to-point to a remote system with the SIPART bus and the remote system isolated


Fig. 5/16 TTY to remote system with SIPART bus and remote system isolated. Txd on the remote system is an active current source that is not isolated from Rxd.


Fig. 5/17 TTY to remote system with the SIPART bus and the remote system isolated. Txd on the remote system is an active current source isolated from Rxd.


Fig.5/18 TTY to remote system with the SIPART bus and the remote system isolated. Txd on the remote system is a passive switch, Txd and Rxd are isolated.

## 6. Adjustment and Operation

Operation of the SIPART DR20 controller is carried out at three modes:

- Process operation
- Parameterization
- Configuring

The pushbuttons and displays on the front of the controller sometimes have different functions in these three modes.

The adjacent photo of the SIPART DR20 front panel corresponds to Fig.2.1 on page 11.


### 6.1 Process Operation

Operation of the controller in process mode is self-explanatory as a result of the arrangement and colors of the front panel, the controls and the inscriptions.

The negative deviation display 1 consists of 21 LEDs; the center LED is green and 10 red LEDs each light up for the display of $+x d$ or $-x d$. The sensitivity of the display can be selected in several stages from $\pm 2.5 \%$ to $\pm 40 \%$.

The associated label 2 can be replaced. The sealing plug 15 at the top of the front frame should be levered out using a pointed tool and the label can then be pulled out.
Condition on delivery: inscription for scale range $\pm 10 \%$.
The rear is not printed and can be inscribed with any scale ranges. The vacant area can be used for further information, e.g. TAG-number, measuring range, dimension etc.

The LEDs 3 signal downward or upward violation of alarms A1 and A2.
The four-digit, 7 -segment display 4 outputs either the setpoint w (green LED 9.1 lights up), the actual value $\times$ (red LED 9.2 lights up) or one of the two alarm values. Output of alarms is signalled by "A1" or" A2" in display 6 . The two variables can be selected using key 8 (see page 35 for information on a special function of pushbutton 8).

The manipulated variable y is adjusted in manual mode using pushbuttons 5 . The rate of adjustment with $K$ controller increases the longer the button is pressed. In the case of $S$ controllers, the associated output relay is activated and the point 7 located next to the respective key lights up in display 6 . The two-digit display 6 indicates the output or feedback manipulated variable. The display range is -9 to $+109 \%(100 \%=$ display "h0", $101 \%=$ display "h1"; etc.). The points 7 signal the output of manipulated variable signals in the case of $S$ controller.

Selector 10 is used to switch the controller from automatic mode to manual mode and vice versa (hitchless). The yellow LED 11 lights up continuously in manual mode and flashes with other operating states (see page 58).

The local setpoint wi of the controller is adjusted using pushbuttons 12. The rate of adjustment increases the longer the button is pressed. Adjustment of the setpoint is only possible, however, if the green LEDs 9.1 and 14 light up.

Key 13 is used to switch between local and remote setpoint. LED 14 lights up continuously with local mode and flashes with various other functions (see page 58).

Remote setpoint means:

- With fixed setpoint controllers
- With ratio controllers and ratio stations
- With follow-up / SPC controllers
- With DDC backup controllers and DDC manual control stations
that the setpoint cannot be adjusted that the setpoint ratio cannot be adjusted that the setpoint is applied to the controller via the analog input $w E$ or the communication input (SES)
that backup mode is set

Key 13 has no function in the case of follow-up controllers without local / remote switchover and in the case of synchronization controllers and manual / automatic control stations. LED 14 then remains dark.

Caution: The following Sections 6.2 and 6.3 describe the parameterization and configuring of the SIPART DR20. Please note that all settings in these modes are stored in the RAM. The transfer into the fail-safe EEPROM only takes place after return to process operation mode and requires a few seconds. Also refer to the note on page 89 concerning the signalling of a mains failure.

### 6.2 Parameterization (on-line)

The adjustable parameters are listed in table 6/1 on page 90.
To prevent maloperations with the SIPART DR20, several actions are required to switch to the parameterization and configuring modes which must be made within 20 s . An automatic return to process operation is otherwise made.

1. Press selector 8 until the two-digit display 6 outputs "PS" (flashing). Release push-button; the display "PS" becomes steady.

The two digital displays no longer indicate any process variables. The controller is still fully functional and indicates the negative deviation xd.
2. Now press pushbutton 12.1 several times until the letters "PAr" appear in the four-digit display. The controller can now be parameterized.
3. Page through the parameter list forwards or backwards using pushbuttons 5.1 and 5.2. The display 6 indicates the selected parameter.
4. Set the selected parameter using pushbutton 12.1 or 12.2 . Its value is indicated on the fourdigit display 4.
5. Return to process mode by pressing pushbutton 8 once.

### 6.3 Configuring (off-line)

The configuring switch list can be found in Table 3/1 on page 19.
To select and set the configuration, proceed in an analog manner to parameterization

1. Press selector 8 until the two-digit display 6 outputs "PS" (flashing). Release push-button; the display "PS" becomes steady.
2. Now press pushbutton 12.1 until the four-digit display first indicates the letters "PAr" and then "Str". The controller can now be configured.

The controller now blocks its output. Display 1 outputs a strip pattern.
3. Page through the configuring switch list forwards or backwards using pushbutton 5.1 and 5.2. The two-digit display now indicates the selected configuring switch.
4. $\quad$ Set the selected configuring switch using pushbutton 12.1 or 12.2. The selected setting is indicated on the four-digit display.
5. Return by pressing pushbutton 8. The display first jumps to parameterization mode and then to process operation mode if pushbutton 8 is pressed again.

The controller is now in absolute manual mode, i.e. the control signals $\mathbf{N}, \mathrm{BL}, \mathrm{Si}$ are only effective after the automatic / manual key has been pressed once.

| Parameter | Char- <br> acter | Display <br> on (6) | Min. <br> value | Max. <br> value | Factory <br> setting | Dim. | Remarks |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Derivative-action gain | Vv | "uu" | 1.00 | 10.0 | 5.00 | - |  |
| Proportional gain | Kp | "cP" | 0.100 | 100.0 | 0.100 | - |  |
| Reset time | Tn | "tn" | 1.0 | 9984 | 9984 | s | With PI controller S28 = 0 |

Table 6/1 Parameters

### 6.4 Lamp Test

If pushbutton 8 is pressed for more than 5 s , all LEDs on the front panel of the controller light up irrespective of the current display until the pushbutton is released again. The original display setting is then reassumed.

### 6.5 Display of Software Release

In accordance with the technical developments of our products, the SIPART DR20 software is matched to new knowledge as required. The software release is stored in a number (A..) in the PROM and can be called as follows:

Press pushbutton 8 until lamp test is carried out. During the lamp test, press push-button 13. The software release number appears in the four-digit display 4.

### 6.6 Further Information

Signalling of mains failure: the four-digit display flashes when the controller is switched on or following a power failure, or "- - - -" flashes if the display is switched off (configuring switch S21 = OFF). The display becomes continuous when acknowledged by key 8 (the basic setting wis retained).

This signal should be observed! If parameterization or configuring was carried out immediately before, it must be checked whether the new settings have already been transferred to the fail-safe EEPROM (page 88). The controller can also start up with preset safety values depending on the configuration selected using S41.

Setting of linearizer: a non-linear physical controlled variable x1 must be linearized within its measuring range prior to display. Linearization is carried out using a polygon curve consisting of 8 straight lines within the measuring range. The axis of the electric input variable $x 1_{\text {el }}$ is divided into 8 identical intervals. The last straight-line equation is used further outside the measuring range.

The setting is described using the example of thermoelectric voltage linearization shown in Fig. 6/2:

1. Divide the electric measuring range $U_{A}$ to $U_{E}(4.234 \mathrm{mV}$ to 15.576 mV$)$ into 8 identical sections. Enter the partial voltages into a table $\left(U_{N}\right)$ :

$$
U_{N}=------------* N+U_{A} \quad(N=0 \text { to } 8)
$$

2. Determine the associated temperature (t) for every $U_{N}$ from the DIN / IEC thermocouple table and enter as parameters LA, L1 to L7, LE.

In the case of highly arced curves, it may be advantageous to improve the approximation by not applying the corner points of the polygon curve exactly on the function (but exactly on the division by 8 of the electric axis). The physical values associated with the turning points must then be entered as parameters L1 to L7. LA and LE must exactly correspond to the start-of-scale and fullscale values.


Fig. 6/2 Linearization example (thermocouple type S)

Factory setting of parameters: the parameter list (Table 6/1) also shows the factory setting of the parameters. It should be noted that some parameters (ty, SA, SE, A1, A2, yA, yE) determine values of different functions depending on the configuration of the device. The compatibility of the factory settings with the selected operating mode should always be checked (see also page 54 for example).

The output of the process variables in the four-digit display can also be made in engineering units within the setting range -1999 to 9999 as opposed to the factory setting. It must therefore be noted of course that all variables which can be output in this display during operation or which influence the setting of these variables must be set in the same unit (e.g. LA, LE, SA, SE, SH, A2 and A1). The parameter list contains two constants (c1 and c2), adjustable from $-199.9 \%$ to $199.9 \%$. The value of the additive constant c1 which can be used in various operating modes always refers to the set measuring range ( 0 to $100 \%$ ).
The constant c2 is set as a factor (arithmetic value from -1.999 to 1.999).

Factory setting of configuring switches: the factory setting of the configuring switches is always " 0 ", i.e. also with the S controller where it is essential to reset certain switches (e.g. S2). It is therefore always recommendable to check the compatibility of the settings with the desired operating mode.

### 6.7 Standard Measuring Ranges for Temperature Measurements Using Thermocouples

Settings for standard measuring ranges for thermocouples have been prepared in the following Tables 6/3 and 6/4 :

Marshalling: These settings are carried out using jumpers on the thermocouple module 6DR2800-8T.

Parameterization: These settings are carried out using parameters in the basic device.
The start-of-scale value (LA) and the full-scale value (LE) must be exactly set during commissioning using the adjustable resistors accessible at the rear of the thermocouple module.

Caution: The conditions of use and the continuous operating limits of thermocouples to DIN 43710 and DIN / IEC 584 must always be observed.


Table 6/3 Standard measuring ranges for thermocouple K (NiCr-Ni)


Table 6/4 Standard measuring ranges for thermocouples T, U, J, L, S, R

## 7. Commissioning

Most of the configuring switches and a number of parameters can already be set prior to actual commissioning. Because of missing data and unclear relationships, the remaining ones can only be determined in the system itself by "systematic trial-and-error". The following sections should be of assistance:

### 7.1 Matching to Direction of Action

### 7.1.1 Matching the Direction of Action of the Controller to the Controlled System

Definition of a normal-action system (including direction of action of final control element):

The controlled variable x increases

- in continuous controllers with an increasing manipulated variable current ly
- in two-position controllers with an increasing duty factor of output $+\Delta y$ and with a decreasing duty factor of output - $\Delta \mathrm{y}$
- in three-position step controllers with manipulated variable signals of output $+\Delta y$
- If the directions of action of the system and the final control element are known, configuring switch S26 is set according to the table:
0 with a normal-action system, 1 with a reversed-action system.
- If the directions of action of the system and the final control element are not known, set the controller to manual mode (with S26 = 1): press the right-hand manipulated variable pushbutton 5.2 briefly with the process switched off or in a safety position and observe whether the controlled variable $x$ rises or falls. A rising x means a normal-action system, a falling $x$ means a reversed-action system.

If closing of the final control element is detected during this test with three-position step controllers, the terminals $+\Delta y$ and $-\Delta y$ must be interchanged.

### 7.1.2 Matching the Direction of Action of the Position Display to the Controlled System

Configuring switch S33 is used to determine whether the manipulated variable signal y or the position feedback yR are to be displayed directly or reversed ( $100 \%-y$ or $100 \%-y R$ ). A normalaction display is selected using S33 $=0$ for a normal-action system (including final control element). There are two possibilities for reversed-action systems:

$$
\begin{array}{lll}
- & \text { S33 }=0 & \text { The manipulated variable increases with an increasing displayed value } \\
- & S 33=1 & \text { The controlled variable increases with an increasing displayed value }
\end{array}
$$

### 7.2 Matching of Step Controllers to Final Control Elements

### 7.2.1 Two-Position Controller ( $\mathbf{S} 2=1$ )

The division into two zones (e.g. heating and cooling) or only one zone (only heating or only cooling) using parameters ya and ye has already been described on pages 52/53. In addition, the parameters $\mathrm{T}+$ and T - must be matched to the period of the units connected to $+\Delta \mathrm{y}$ and $-\Delta \mathrm{y}$. The values should be selected as large as possible, the following must be observed:

- Large values of T + and T - result in low wear on the internal and external switching equipment
- Large values result in a periodic oscillation of the controlled variable x which becomes larger the faster the controlled system is.


### 7.2.2 Three-Position Step Controller with Internal Position Feedback (S2 = 2)

- The parameter Ty is used to specify the positioning time for the actuator. The factory setting of this parameter is 60 s .
- The minimum switch-on period te adjustable using configuring switch S39, should be selected at least so large that the actuator is positively set into operation, taking into account the series-connected circuit-breaker. The larger the value of te, the smoother and more resistant to wear are the switching elements and actuators. The dead band is also larger, however, in which the controller cannot control in a defined manner since the resolution of the controlled variable decreases as the minimum switch-on period increases.

Factory setting is te $=200 \mathrm{~ms}$, which corresponds with a 60 s actuator to an y resolution of

- $\quad$ This minimum possible resolution is weighted with the control loop gain Ks to the controlled variable

$$
\Delta x=K s * \Delta y
$$

- The minimum switch-off period ta adjustable using S40, should be selected so large that the actuator has positively become stationary, taking into account the series-connected circuitbreaker, before a new positioning pulse - especially in the opposite direction - arrives. The switching elements and actuators operate smoother and with less wear the larger the value of ta, but the dead time of the controller also becomes larger. The values for te and ta are normally the same.
- The response threshold (parameter A) must be set according to the set te and the resulting $\Delta \mathrm{y}$ or $\Delta \mathrm{x}$. The condition

must be satisfied, otherwise the controller will output positioning increments although the negative deviation has reached the smallest possible value as a result of the finite resolution.


### 7.2.3 Three-Position Step Controller with External Position Feedback (S2 = 3)

The position control loop is optimized using the parameters te and ta. The same relationships apply as previously for $\mathrm{S} 2=2$, except that the dynamics of the position control loop must also be considered in addition to the processing criteria of the position increments. It is usually necessary to select te and ta, and thus the resulting response threshold, somewhat larger than with S2 = 2 .

### 7.3 Optimization Guidelines

### 7.3.1 Adjustment of the control parameters without knowledge of the system response

- The parameters for optimum control of the system are not yet known. The following factory settings have been made in order to achieve stable control nevertheless:
- Proportional gain $\mathrm{Kp}=0.100$
- Reset time Tn=9984 s
- Derivative action time Tv = OFF
- $\quad$ Three-position step controller with external feedback $(\mathrm{S} 2=3)$
- First optimize the position control loop in manual mode using ta and te. If there are non-linearities, these must be in the band of greatest slope.
- Adjust te so that the actuator can process the positioning increments.
- Decrease ta until the position control loop overshoots as a result of small changes in the manual manipulated variable.
- Increase ta again until the position control loop is steady.
- $\quad P$ controller $(S 28=1)$
- Adjust the desired setpoint and control the negative deviation to zero in manual mode. In position "AUTO" of parameter yo, the working point required for a negative deviation of zero is set automatically in the process.
- Switch to automatic mode.
- Slowly increase Kp until the control loop tends to oscillate upon changes in the setpoint.
- Slightly decrease Kp until the tendency to oscillate is eliminated.
- PD controller (S28 = 1)
- Adjust the desired setpoint and control the negative deviation to zero in manual mode. In position "AUTO" of parameter yo, the working point required for a negative deviation of zero is set automatically in the process.
- Switch to automatic mode.
- Slowly increase Kp until the control loop tends to oscillate upon changes in the setpoint.
- Switch Tv from OFF to 1 s .
- Increase Tv until the oscillations are eliminated.
- Slowly increase Kp until oscillations occur again.
- Repeat the settings in the above two steps until the oscillations can no longer be eliminated.
- Slightly decrease Tv and Kp until the tendency to oscillate is eliminated.
- PI controller ( $\mathrm{S} 28=0$ )
- Adjust the desired setpoint and control the negative deviation to zero in manual mode.
- Switch to automatic mode.
- Slowly increase Kp until the control loop tends to oscillate upon changes in the setpoint.
- Slightly decrease Kp until the tendency to oscillate is eliminated.
- Decrease Tn until the control loop tends to oscillate again.
- Slightly increase Tn until the tendency to oscillate is eliminated.
- PID controller ( $\mathrm{S} 28=0$ )
- Adjust the desired setpoint and control the negative deviation to zero in manual mode.
- Switch to automatic mode.
- Slowly increase Kp until the control loop tends to oscillate upon changes in the setpoint.
- Switch TV from OFF to 1 s and increase until the oscillations are eliminated.
- Slowly increase Kp until oscillations occur again.
- Repeat the settings in the above two steps until the oscillations can no longer be eliminated.
- Slightly decrease Tv and Kp until the tendency to oscillate is eliminated.
- Decrease Tn until the control loop tends to oscillate again.
- Slightly increase Tn until the control loop is stable.


### 7.3.2 Adjustment of Control Parameters According to Transient Function

If the transient function of the controlled system is known or can be determined using a recorder, the control parameters can be set according to guidelines found in the technical literature. The transient function of the system can be recorded in manual mode by suddenly changing the manipulated variable and recording the controlled variable with respect to time.
A transient function results for controlled systems with recovery to which good average values apply from the setting data of several authors with the following rules-of-thumb:

- P controller:

Proportional gain $\mathrm{Kp}=\mathrm{Tg} /(\mathrm{Tu} * \mathrm{Ks})$

- PI controller: Proportional gain $\mathrm{Kp}=0,8 \mathrm{Tg} /(\mathrm{Tu} * \mathrm{Ks})$

$$
\text { Reset time } \quad \mathrm{Tn}=3 * \mathrm{Tu}
$$



- PID controller:
Proportional gain $\mathrm{Kp}=1.2 * \mathrm{Tg} /(\mathrm{Tu} * \mathrm{Ks})$

| Reset time |
| :--- |
| Derivative action time |$\quad \mathrm{Tv}=\mathrm{Tu}$

Tv $=0.4 \mathrm{Tu}$


Fig. 7/1 Transient function of a controlled system with recovery

### 7.3.3 Response with Controlled Variable Subject to High Interference

- Set configuring switch S3 to the mains frequency ( 50 or 60 Hz ) of the power supply in order to largely suppress interferences from the mains frequency. The factory setting is 50 Hz .
- $\quad 1^{\text {st }}$ order filter for negative deviation (parameter tF): the filter is switched on by the jump in the display from OFF to 1 s and can be matched to a low-frequency interference by increasing the value further. The filter time constant should only be set so large that the control loop would not oscillate with a large dead zone (set tF smaller than Tg ).

It is highly recommendable to switch on the filter when using the D element with $\mathrm{S} 27=0$, in order to suppress the A/D converter noise amplified by Kp and Vv .

- If the controller output is to be smoothened in addition, the response threshold A, which results in S controllers from the setting of te, can be increased or the response threshold can be switched on with K controllers. It should be taken into account that the steady-state deviation can assume the value of the set response threshold. The response threshold A can be adjusted in the range from 0 to $10 \%$ in steps of $0.1 \%$.

The dead zone element provides the controller with a progressive response; the gain is small or even zero in the case of small negative deviations, the defined Kp is reached with large negative deviations.

The factory setting of $A$ is 0 . A setting must be made for three-position step controllers (see page 89).

## 8. Abbreviations

The abbreviations used in this manual, unless already explained in the corresponding text or tables, have the following meaning:

| AE | Analog input | TF | Filter time constant for xd |
| :---: | :---: | :---: | :---: |
| A | Response threshold | Tg | Recovery time |
| IA | No automatic mode | Tn | Reset time |
| A1/2 | Alarm monitor 1/2 | Tu | Delay time |
|  |  | Tv | Derivative action time |
| BA | Digital output | Tw | Setpoint ramp |
| BE | Digital input | Ty | Positioning time of motor-driven actuators |
| BL | Control signal "Blocking of manipulated variable" | T+/T- | Period with two-position controller |
| BLPS | Control signal "Blocking of parameterization and configuring facility" | v | Ratio factor |
| c1 | Parameter "Constant 1 (zero)" | wa | Start-of-scale value ( Setpoint limitation or |
| c2 | Parameter "Constant 2 (factor)" | we | Full-scale value ( ratio factor setting range |
| CB | Control signal "Computer readiness" | wE | Remote setpoint |
|  |  | wES | Remote setpoint via serial interface |
| ESR | Electronic position transmitter | wi | Local setpoint |
|  |  | wS | Safety setpoint |
| H | Front command "Manual mode" | w | Effective setpoint |
| Int | Front command "Local setpoint" | x | Effective actual value (controlled variable) |
| ly | Current output, manipulated variable | xd | Negative deviation ( $\mathrm{w}-\mathrm{x}$ ) |
| Kp | Proportional gain | ya | Start-of-scale value (Manipulated variable |
| Ks | Transmission gain of system | ye | $\begin{array}{ll}\text { Full-scale value } & \text { (limitation or dead zone } \\ \text { (with two-position controller }\end{array}$ |
|  |  | yA | Manipulated variable in automatic mode |
| LA | Parameter "Start-of-scale value" | yBL | Blocked manipulated variable |
| LE | Parameter "Full-scale value" |  |  |
| L1 ... L7 | Parameter "Turning points of linearizer" | yE | Effective external manipulated variable |
| N | Control signal "Tracking of manipulated variable" | yES | Tracking manipulated variable via serial interface |
| /RB | Signal "No computer readiness" | yH | Manual manipulated variable |
| /RC | Signal "No computer mode" | yN | Tracking manipulated variable via analog input |
|  |  | yR | Feedback manipulated variable |
|  |  | yS | Safety manipulated variable |

## 9. Ordering Data


*) Included in scope of deliveries

## 10. SIPART controllers in higher systems

An important requirement for the safe control of process engineering plants is reliable monitoring. Therefore the functions provided by modern process control systems include central operation and monitoring using monitors. This possibility can also be implemented with the Siemens digital compact controllers.

1. Up to 32 controllers can be connected via a serial interface to a correspondingly configured personal computer (with CDOS 386, version 2.0 or CDOS XM, version 6.0 operating system). The SIPART SW PC software enables process operation and monitoring as well as parameter setting from the PC. The reliability of the single-loop controller is fully retained with this system configuration since the personal computer is only used for operation and monitoring. Failure of the PC has no effects on the process: all closed-loop controls, open-loop controls and calculations are carried out by the compact controllers in autonomous mode.
The supplementary program "BATCH" is additionally available for recipe management. Setpoints, states, parameters and structure switches of the controllers can then be stored on floppy disks and reloaded from them.
2. The Siemens digital compact controllers are highly suitable for use in higher-level automation systems both in SPC and DDC backup modes. For example, a software package "SIPART SW S5" is available for communication between the compact controllers and the SIMATIC S5115U, S5-135U, S5-150U and S5-155U programmable controllers. The interface module at the SIMATIC end is the CP 524 or CP 525-2 communication processor. A specially developed driver enables data transfer for each interface with up to 32 compact controllers of any configuration. Function blocks are also available for the above mentioned S5 programmable controllers with which the user can control the data transfer. In this manner our compact controllers can work together with the SIMATIC programmable controllers or can be connected via the CP 526 to a monitor or to COROS 2000 for central operation and monitoring.

The facilities described above can be implemented using SIPART DR20. SIPART DR22 controllers. TELEPERM D universal controllers or the multifunction unit MFE. These controllers can also be used together on one common bus providing the maximum of 32 controllers is not exceeded.

## 11. Representation of Various Setpoints

The following pages contain functional diagrams which show how the setpoints change with respect to time if

- the local / remote pushbutton (13) on the front panel is pressed
- the configured functions of the digital input BE are driven by a logical " 1 " or " 0 ".

The configuring switches listed next to the examples must be set to the defined positions for the displayed functions. Configuring switches which are not listed are of no significance. They should be set to "0" unless the controlled system requires a different setting.

Example 1: Fixed setpoint controller without setpoint ramp ( $\mathrm{Tw}=0$ ). Operation with an adjustable setpoint wi, no x-tracking.

S1 = 0
$\mathrm{S} 17=0$


Fig. 11/1 Setpoint response according to example 1

Example 2: Fixed setpoint controller with setpoint ramp (Tw>0). Operation with an adjustable setpoint wi, with x-tracking and the digital input configured to Si (safety manipulated variable $y S$ ).
With $S i=1$, the effective setpoint follows the controlled variable $x$ without a delay by means of $x$-tracking. If $\mathbf{S i}=0$, the setpoint changes with the ramp set as a time parameter to the previously fixed setpoint wi (please observe note on page 26).

S $1=0$
S $15=1$
S $16=0$
S $17=1$
S $19=1$


Fig. 11/2 Setpoint response according to example 2

Example 3: Two-setpoint mode with a synchronization controller without local / remote switchover:

1. One variable setpoint $\mathrm{w} 1=\mathrm{c} 2 * \mathrm{wE}+\mathrm{c} 1$
2. The setpoint $\mathbf{w} \mathbf{2}=\mathbf{c} 1$ defined by parameterization and not affected by the front controls

Both setpoints are thus linked by the fixed component c1; the switch-over from w1 to w2 takes place simply by external switching off of w2. A setpoint ramp Tw > 0 is provided.

S1 $=6$


Fig. 11/3 Setpoint response according to example 3

Example 4: Two-setpoint mode according to configuration described on page 33. Both setpoints can be called into the four-digit display using pushbutton 8 and adjusted using pushbutton 12 on the front of the controller. The switch over between w1 (safety setpoint wS) and w2 (local setpoint wi) is carried out by the local/remote switch 13. A setpoint ramp Tw > 0 is switched on.

S1 $=5$
S15 $=3$
S17 = 0
S18 = 1
S19 = 1
S24 = 1
$\mathrm{S} 42=2$


Fig 1/4 Setpoint response according to example 4

Example 5: Two-setpoint mode as already described in example 4, but in this case the local setpoint wi is made to track the effective setpoint $w$. The following function is then achieved: if a switch is made to local using pushbutton 13 whilst the setpoint increases, the last value is retained as wi until switched back to remote again. If necessary, wi can be changed on the front panel in local mode. Once wS has been reached, another setpoint can be reached using x-tracking if pushbutton 10 is switched to manual mode. The setpoint moves towards wS again as soon as a switch is made to automatic mode again.

$$
\mathrm{S} 1=5
$$

S15 $=3$
S17 = 1
S18 = 1
S19 $=0$
S24 $=1$
S29 $=1$


Fig. 11/5 Setpoint response according to example 5

Example 6: Three-setpoint mode with one follow-up controller where the following variables can be used:
w1 is a remote setpoint wE
w 2 is the safety setpoint wS fixed by parameterization
w3 is the local setpoint wi adjustable on the front
Switchover between w1 and w2 is carried out using the digital signal CB (local / remote pushbutton 13 must be at "Remote"). Switching between w1 / w2 on the one hand and the setpoint w3 is carried out using the local / remote pushbutton 13. Fig. 11/6 shows the setpoint response with a setpoint ramp Tw > 0, Fig. 11/7 shows the same example without a setpoint ramp ( $\mathrm{Tw}=0$ ).

S1 = 5
S10 = -1
S15 = 3
S17 = 0
S18 = 1
S19 = 1


Fig. 11/6 Setpoint response according to example 6 with Tw $>0$


Fig. 11/7 Setpoint response according to example 6 with Tw $=0$

Example 7: Four-setpoint mode with one follow-up controller with local / remote switchover and CB signal via the digital input. The controller is fitted with an optional module 6DR2800-8J as a voltage input. The four setpoints can be simulated as follows:
w1 is the setpoint wi adjustable on the front
w2 is a setpoint wa which is fixed by parameterization and cannot be influenced from the front panel
w3 is the setpoint wS adjustable on the front as "SH" (see page 33)
w4 is a setpoint we which is fixed by parameterization and cannot be influenced from the front panel

The switchover is carried out by pushbutton 13 and the CB signal as follows:
$\mathrm{w} 1=$ pushbutton 13 to local
w2 = pushbutton 13 to remote, CB signal activated by L+, input AE3 applied to ground
w3 = pushbutton 13 to remote, no CB signal
w4 = pushbutton 13 to remote, CB signal activated by L+, input AE3 applied to L+

Limitation of this circuit: w1 and w3 cannot become smaller than w2 or larger than w4.

$$
\begin{aligned}
& \text { S1 }=5 \\
& \text { S10 }=-1 \\
& \text { S15 }=3 \\
& \text { S17 }=0 \\
& \text { S18 }=1 \\
& \text { S19 }=1
\end{aligned}
$$



Fig. 11/8 Setpoint response according to example 7

## 12. Planning Examples

Common application / connection circuits of the SIPART DR20 controllers are shown below in the form of planning examples. The circuits are divided according to their output configuration S, K or Z. All input and output circuits are shown as well as the order numbers of the controllers or additional modules required in each case. A basic circuit diagram of the control loop and a short description facilitate understanding.

The simple applications have been intentionally shown in great detail to provide assistance to technicians who are only occasionally required to design such circuits.

As shown, the power supply should be fused and provided with a switch; switches and fuses do not belong to the scope of delivery of the controllers. The protective earth conductor must be connected. The permissible power supply range and controller type are defined.

## - Power supply

As shown, the power supply should be fused and provided with a switch; switches and fuses do not belong to the scope of delivery of the controllers. The protective earth conductor must be connected. The permissible power supply range and controller type are defined.

## - Alarm signalling

A module for external signalling of alarms is included in all examples. This module can be omitted if external signalling is not required. A connection circuit for the alarm module is not shown since this differs from case to case.

The relay module must only be connected to low-voltages (see page 68).

## - Input circuits

All possible input circuits are shown. Please note in the case of a power supply to a two-wire transmitter from the SIPART DR20 and simultaneous use of the analog inputs AE1 / AE2 that the supply voltage for the transmitter may be only DC 15 V in an unfavourable case (see page 73 ).

## - Output circuits

The output circuits are shown uniformly: with K standard controllers (6DR2004) for a loadindependent current signal of 0 or 4 to 20 mA , with S standard controllers (6DR2001) for relay outputs which may be loaded up to a max. of AC 250 V 5 A (see page 15 and 65). If the manipulated variable outputs of the $S$ controller are required with active, positive digital signals, the alarm module with four digital outputs (6DR2801-8B) must be used instead of the alarm module with relays (see page 80).

If inductors (e.g. positioning motors, contactors etc.) are switched via the provided relay outputs, sufficient noise suppression must be provided by connection of RC combinations.

## - Configuring

All controllers are delivered with the defined factory settings and must be configured; during commissioning. The examples show the switch positions required for the respective application, but only that configuring switches are listed, which differ from the factory setting.
Further additional settings may be necessary because of plant-specific criteria. The following planning examples always have parallel connection circuits. Therefore the configuring switches which refer to the serial interface are not listed.

## - Parameterization

Please refer to the notes on page 92.

## - Control algorithm

All planning examples (except Z1) are shown for PI or PID response. Switchover to P or PD response is possible using configuring switch $\mathrm{S} 28(=1)$. If this is necessary. it is essential to connect an electronic position transmitter (EPT) via yR in the case of a SIPART DR20 with $S$ output and to set configuring switch $\mathrm{S} 2=3$.
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| Planning example K1 | Fixed setpoint control, <br> controlled variable from four-wire transmitter |
| :--- | :--- |
|  | The controlled variable x from the transmitter is applied to <br> the analog input AE1 of the controller. The programming <br> corresponds to an input signal range of 0 to 20 mA <br> The manipulated variable output is also 0 to 20 mA. <br> The transmitter can be powered from the controller ( +to <br> terminal 5, -1 to terminal 6). <br> The alarm circuit monitors the negative deviation xd for max./ <br> min. deviations (set parameters A2 and A1!). |

Please refer to the remarks on page 108 !
Setting of configuring switches: All configuring switches in factory setting.


Planning example K2 | Fixed setpoint control, |
| :--- |
| controlled variable from two-wire transmitter |

Please refer to the remarks on page 108 !
Setting of configuring switches: $\mathrm{S} 4=1 ; \mathrm{S} 37=1$


Planning example K3 | Fixed setpoint control, controlled variable direct from |
| :--- |
| Pt 100 resistance thermometer in three-wire circuit |

Please refer to the remarks on page 108 !
Setting of configuring switches: $\mathrm{S} 8=1, \mathrm{~S} 22=1$


| Planning example K4 | Fixed setpoint control, controlled variable direct from Pt 100 <br> resistance thermometer in four-wire circuit |
| :--- | :--- |
|  | The controlled variable x from the Pt 100 is applied to the <br> analog input AE . The measuring range can be programmed; <br> the min. span is 50 K , the min. start-of-scale value $-50^{\circ} \mathrm{C}$, the <br> max. full-scale value $850^{\circ} \mathrm{C}$ (see information on page 76 ). <br> The manipulated variable output is 0 to 20 mA ; a signal range <br> of 4 to 20 mA can be set using configuring switch $\mathrm{S} 37=1$. <br> The alarm circuit monitors the controlled variable <br> (temperature) (set parameters $\mathrm{A} 2=$ min. and $\mathrm{A} 1=$ max.). |

Please refer to the remarks on page 108 !
Setting of configuring switches: $\mathrm{S} 8=1, \mathrm{~S} 22=1$


Planning example K5 | Fixed setpoint control, controlled variable direct from Pt 100 |
| :--- |
| resistance thermometer in two -wire circuit |

Please refer to the remarks on page 108 !
Setting of configuring switches: $S 8=1, S 22=1$


| Planning example K6 | Fixed setpoint control, controlled variable direct from a <br> thermocouple with internal cold junction |
| :--- | :--- | :--- |
|  | The controlled variable x from the thermocouple is applied to <br> the analog input AE3. The measuring range is <br> programmable. The controlled variable must be linearized <br> (see instructions on pages 78 and 91). <br> The manipulated variable output is 0 to 20 mA ; it can be <br> reconfigured to 4 to 20 mA (S37 = 1). <br> The alarm circuit monitors the negative deviation Xd for max. <br> / min. deviations (set parameters A2 = min. and A1 = max. !). |

Please refer to the remarks on page 108 !
Setting of configuring switches: $\mathrm{S} 8=1, \mathrm{~S} 14=1$


| Planning example K7 | Fixed setpoint control, controlled variable direct from a <br> thermocouple with external cold junction |
| :--- | :--- | :--- |
|  | The controlled variable $x$ from the thermocouple is applied to <br> the analog input AE3. The measuring range is <br> programmable. The controlled variable must be linearized <br> (see instructions on pages 78 and 91 ). <br> The manipulated variable output is 0 to 20 mA ; it can be <br> reconfigured to 4 to 20 mA (S37 = 1). <br> The alarm circuit monitors the negative deviation Xd for max. <br> I min. deviations (set parameters A2 = min. and A1 = max. !). |

Please refer to the remarks on page 108 !
Setting of configuring switches: $\mathrm{S} 8=1, \mathrm{~S} 14=1$


| Planning example K8 | Fixed setpoint control, controlled variable direct from a <br> thermocouple (internal cold junction), setpoint w adjusted <br> remotely (resistance transmitter) |
| :--- | :--- | :--- |
|  | The controlled variable $x$ from the thermocouple is applied to <br> the analog input AE3. The measuring range is <br> programmable. The controlled variable must be linearized <br> (see instructions on pages 78 and 91). <br> The manipulated variable output is 0 to 20 mA ; it can be <br> reconfigured to 4 to 20 mA (S37 = 1). <br> The alarm circuit monitors the negative deviation Xd for max. <br> I min. deviations (set parameters A2 $=$ min. and A1 = max. !). |

Please refer to the remarks on page 108 !
Setting of configuring switches: $\mathrm{S} 1=4, \mathrm{~S} 8=1, \mathrm{~S} 10=1, \mathrm{~S} 14=1$

Planning example K9

Please refer to the remarks on page 108 !
Setting of configuring switches of the ratio station:
S1 $=8, S 8=1, S 10=-1, S 25=O F F$


## Planning example K9

Ratio control with a ratio station and a slave controller

The process variable x1, also from a four-wire transmitter, is applied to the slave controller. Only for indication of the process ratio factor $x v$, it can be linked to input AE3 of the ratio station in a current loop with input AE1 of the slave controller. If this is not necessary, input module 6DR2800-8J must not be equipped and x 1 is directly connected to the slave controller.

By switchover of the ratio station to manual operation, the setpoint of the slave controller is adjusted by the manual manipulated variable: the ratio control is now changed to a fixed setpoint control. If S17 in the ratio station is set to " 1 " the switchover back to automatic mode is hitchless and droopless by x -tracking ( wv is tracked).

The alarm circuit in the slave controller monitors the negative deviation xd for max./min. deviations (set parameter $\mathrm{A} 1=\max$ and $\mathrm{A} 2=\mathrm{min}$ ).

Setting of configuring switches of the slave controller:
$S 1=4, S 10=-1$


Planning example K10 $\quad$| Cascade control |
| :--- |
| Controlled variables for both controllers from |
| four-wire transmitters |

Please refer to the remarks on page 108!
Setting of configuring switches: All configuring switches in factory setting


## Planning example K10

Cascade control
Controlled variables for both controllers from four-wire transmitters

In order to disable the cascade the master controller can be switched to manual mode, which corresponds to local mode of the slave controller. The switchover back to automatic mode of the master is hitchless. Beyond that x-tracking can be configured, so that the setpoint of the master controller is tracked during manual mode.

The alarm circuit in the slave controller monitors the negative deviation xd for max./min. deviations.

Setting of configuring switches of the slave controller: $S 1=4, S 10=-1$


| Planning example K11 | Ratio control <br> Four-wire transmitters are provided for process <br> variable and command variable |
| :--- | :--- | :--- | :--- |
| The process variable $\times 1$ is connected to analog input |  |
| AE1, the command variable $\times 2$ is linked to analog |  |
| input AE2. |  |
| Signal range of both inputs is 0 to 20 mA as well; it |  |
| can be reconfigured to 4 to $20 \mathrm{~mA}(\mathrm{~S} 37=1)$. |  |
| The alarm circuit monitors the process ratio factor xv |  |
| for max./min. deviations. |  |
| For adjustment of the ratio factor range see page 38. |  |

Please refer to the remarks on page 108 !

Setting of configuring switches: $\mathrm{S} 1=7, \mathrm{~S} 10=-1, \mathrm{~S} 22=1$


Planning example S1 | Fixed setpoint control, controlled variable from four-wire |
| :--- |
| transmitter, position feedback from electronic position |
| transmitter (EPT) |

Please refer to the remarks on page 108 and the note on page 15 !

Setting of configuring switches: $\mathrm{S} 2=2$ or $3, \mathrm{~S} 32=1$


| Planning example S2 | Fixed setpoint control, controlled variable direct from <br> thermocouple (internal cold junction), position feedback <br> from electronic position transmitter (EPT) |
| :--- | :--- | :--- |

Please refer to the remarks on page 108 and the note on page 15 !
Setting of configuring switches: $\mathrm{S} 2=2$ or $3, \mathrm{~S} 8=1, \mathrm{~S} 14=1, \mathrm{~S} 22=1, \mathrm{~S} 32=1$


Planning example S3 | Fixed setpoint control, controlled variable direct from |
| :--- |
| Pt 100 resistance thermometer, position feedback from |
| resistance transmitter |

Please refer to the remarks on page 108 and the note on page 15 !
Setting of configuring switches: $\mathrm{S} 2=2$ or $3, \mathrm{~S} 8=1, \mathrm{~S} 9=1, \mathrm{~S} 22=2, \mathrm{~S} 32=1$


Planning example S4 | Fixed setpoint control, controlled variable direct from |
| :--- |
| thermocouple (external cold junction), position feedback |
| from electronic position transmitter (EPT) |

Please refer to the remarks on page 108 and the note on page 15 !
Setting of configuring switches: $\mathrm{S} 2=2$ or $3, \mathrm{~S} 8=1, \mathrm{~S} 14=1, \mathrm{~S} 22=2, \mathrm{~S} 32=1$


| Planning example | Fixed setpoint control with disturbance variable feed- <br> forward (two-component control). Controlled variable $\times 1$ <br> direct from Pt 100, disturbance variable x2 from <br> transmitter. Position feedback from resistance transmitter |
| :--- | :--- | :--- |

Please refer to the remarks on page 108 and the note on page 15 !
Setting of configuring switches: $S 1=1, S 2=2, S 8=1, S 9=1, S 10=-2, S 32=1$

Planning example S6

Please refer to the remarks on page 108 and the note on page 15 !
Setting of configuring switches: $\mathrm{S} 8=1$


| Planning example S6 | Cascade control <br> Process variables for both controllers from resistance <br> thermometers Pt 100 |
| :--- | :--- |

In order to disable the cascade the master controller can be switched to manual mode, which corresponds to local mode of the slave controller. The switchover back to automatic mode of the master is hitchless. Beyond that x-tracking can be configured, so that the setpoint of the master controller is tracked during manual mode.

The alarm circuit in the slave controller monitors the negative deviation xd.

Setting of configuring switches of the slave controller:
$S 1=4, S 2=2, S 8=1, S 9=1, S 10=-1, S 32=1$


Planning example S7 | Ratio control, controlled variable ( $x 1$ ) and command |
| :--- |
| variable (x2) applied to controller from two-wire |
| transmitters |

Please refer to the remarks on page 108 and the note on page 15 !
Setting of configuring switches: $\mathrm{S} 1=7, \mathrm{~S} 2=2, \mathrm{~S} 4=1, \mathrm{~S} 5=1, \mathrm{~S} 9=1, \mathrm{~S} 10=-1, \mathrm{~S} 22=1, \mathrm{~S} 32=1$


The supply voltage present at the transmitters
is 15 V in the most unfavourable cases !

Planning example $\quad$| P1 |
| :--- |

Please refer to the remarks on page 108 !
Setting of configuring switches: $\mathrm{S} 2=1, \mathrm{~S} 8=1, \mathrm{~S} 14=1, \mathrm{~S} 22=1, \mathrm{~S} 28=1, \mathrm{~S} 32=\mathrm{OFF}$


## Circuit diagram K



## Circuit diagram S



Setting of SIPART -Controller No. I Tag-No.



[^0]:    *) Referred to M (Ground)

