# Process Control System

# ME 4012

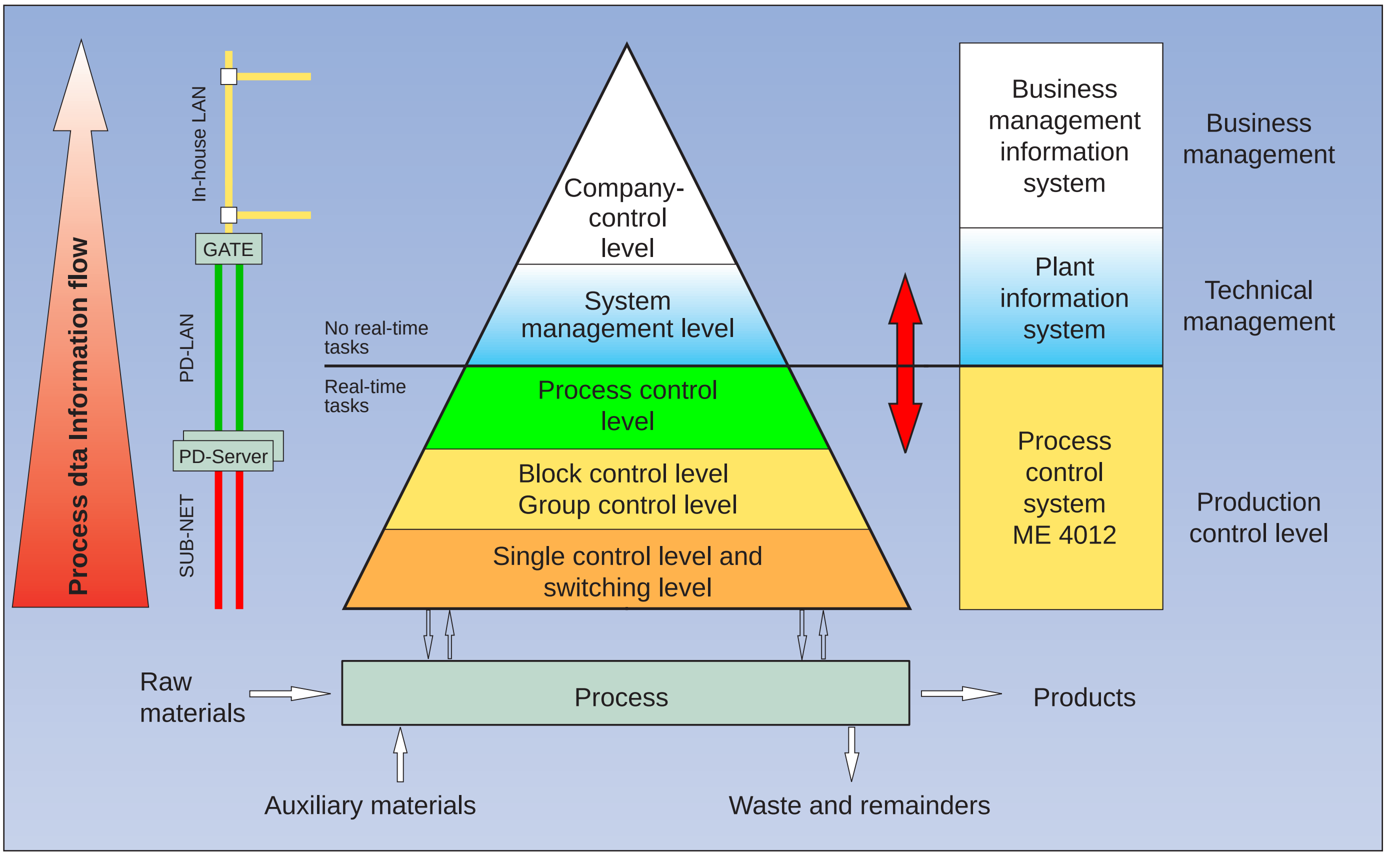
# System Overview

Efficient operator control and monitoring of the complex processes in power stations and large industrial plants is essential for economic production and safe plant operation.

ME 4012 structures the entire process in functionally-separated horizontal control levels which leads to a well-defined and clear automation architecture of the plant or process.
The vertical arrangement of the individual control levels, implemented by means of independent programmable controllers and subprocessors, results in a process-oriented distributed configuration with a hierarchical structure.

Availability and redundancy can thus be implemented according to the requirements of the process and the signal exchange between function units is minimized.

The human-process communication takes place over redundant serial communication paths and allows direct and level-independent operator access to the switching and single control level.




*ME 4012 system architecture: function levels and information flow*

**Hierarchical Levels**

**• System management level**

**- Plant information system ME-AIS**
Generation of plant-specific reports and higher-order computation of production data. ME-AIS offers a PD-LAN interface for the transmission of all relevant process signals which is also the gateway for the data transfer to the customer's office LAN.

**• Process control level**
The process control level offers the following components:

**- ME-VIEW Operator control and process monitoring system**
for centralized plant operation and process monitoring using the state-of-the-art system hardware and software. The system allows real-time operator access using one to four monitors (multi-screening) or large-screen projection. Process events/alarms are recorded in chronological order with an accuracy of 1 ms. Redundancy for all functions of the operator-process interface is achieved by means of independent, interlinked ME-VIEW workstation computers.

**- Printer server**
for producing hard copies of the ME-VIEW sreen images and the output of event and alarm lists.

**- Real-time radio clock with SUB-NET interface**
for the synchronization of all system processors with the DCF 77 radio clock time (accuracy: ±1 ms).

**- Process data servers (master computers)**
working as redundant interface between the operator interface and the programmable controllers. They are equipped with long-term memories and represent the current and historical database for all processing systems.

**- Process data LAN (PD-LAN)**
Makes the current and historical process data available throughout the system.

- **Coherent computer-aided project design ME-DRP**
  for all planning tasks, for the generation of the entire plant documentation and online configuration and fault diagnosis. The use of a DVD writer allows you to store the entire plant documentation - and also the current process data - on DVD media.

- **SUB-NET process bus (level B)**
  for the system-crossing communication between the AE 4012 programmable controllers, the process data servers as well as for the redundant communication with the ME-DRP documentation and diagnosis workstation. Bus control is distributed on the active subscribers and is based on the 'flying-master' principle.

- **Programmable controllers AE 4012**

- **SUB-NET interface**
  between level A and level B. For a high degree of availability, a double-redundant connection is implemented allowing an online changeover of the SUB-NET interface modules between the AE4012 programmable controller and the higher-level SUB-NET process bus (level B).

- **Group control level**
  for function groups and higher-level closed-loop control schemes. This enusres a high degree of automation and hence a high degree of user friendliness in the operation of the overall system. The subprocessors for the serial integration of third-party systems are also installed at this level.

- **Subscriber bus SUB-NET (level A)**
  Communication link for the individual subprocessors in the AE 4012 programmable controllers.

- **Single control level**
  with subprocessors for the implementation of drive control, closed-loop control and interlocking circuits for individual devices.

- **Switching level**
  comprising the supply, monitoring and signal conditioning modules of all binary and analog field units.

- **Hart protocol**
  Transmission protocol for the diagnosis or programming of Smart measuring transducers via the ME 4012 process control system.

- **Digital turbine control system**
  The high-performance subprocessors (high arithmetic performance, high-precision measuring value conditioning) allow the implementation of specific applications,such as digital turbine output and speed control as well as electronic, highly-available turbine overspeed protection. The implemented 1v2 turbine control and 2v3 turbine protection meet the high requirements in plant safety and availability.

- **Fail-safe control circuits**
  for tank ventilation, tank protection, burner control and output, and tank pressure protection make use of the prototype-tested control system (ME 4002S) in compliance with the applicable safety regulations. Total integration into the plant's control and instrumentation systems (operator control, diagnosis, time stamp) is ensured.

- **Control systems for auxiliary plants, ME 400 and MWR**
  The ME 400 and MWR programmable controllers can be used as independent units for local automation tasks and interlinked with the SUB-NET process bus. This makes them particularly interesting for suppliers who provide complete components inclusive of all automation to a general contractor. The ME 400 and MWR units are fully compatible with the ME 4012 system.

- **Field bus and distributed I/O stations**

- **Distributed I/O station ME 30**
  **Decentrally organized m**odular units pick up analog and binary process signals which are to be transmitted to the ME 4012 process control system with a minimum of wiring and cabling. The signals are directly connected to the modules through screw-type terminals. A CAN bus handles the serial transmission in the field. A SUB-NET interface establishes the connection to the main control and instrumentation system.

- **Profibus interface**
  Profibus DP is a bus system for interlinking digital control sensors and actuators. An interface connection to the SUB-NET process bus is in preparation.

## SUB-NET process bus

The SUB-NET process bus constitutes a uniform communication link not only inside an AE 4012 programmable controller (SUB-NET subscriber bus), but also for the interconnection of all subscribers in the plant beyond the boundary of a control cubicle (SUB-NET process bus). SUB-NET is a serial, redundant bus with line and star structure and a high net transmission rate. Access to the SUB-NET is according to the Flying Master principle. Source addressing allows the direct exchange of data across all levels.

Main features of the SUB-NET bus system:

- Fully redundant connection of all system components (AE 4012 programmable controllers and subprocessors). The AE 4012 units are arranged in double-redundant system by means of 2 independent interface modules so that one AE 4012 always remains connected to the higher-level SUB-NET process bus if the other fails or is removed.

- All nodes are active and have the same rights

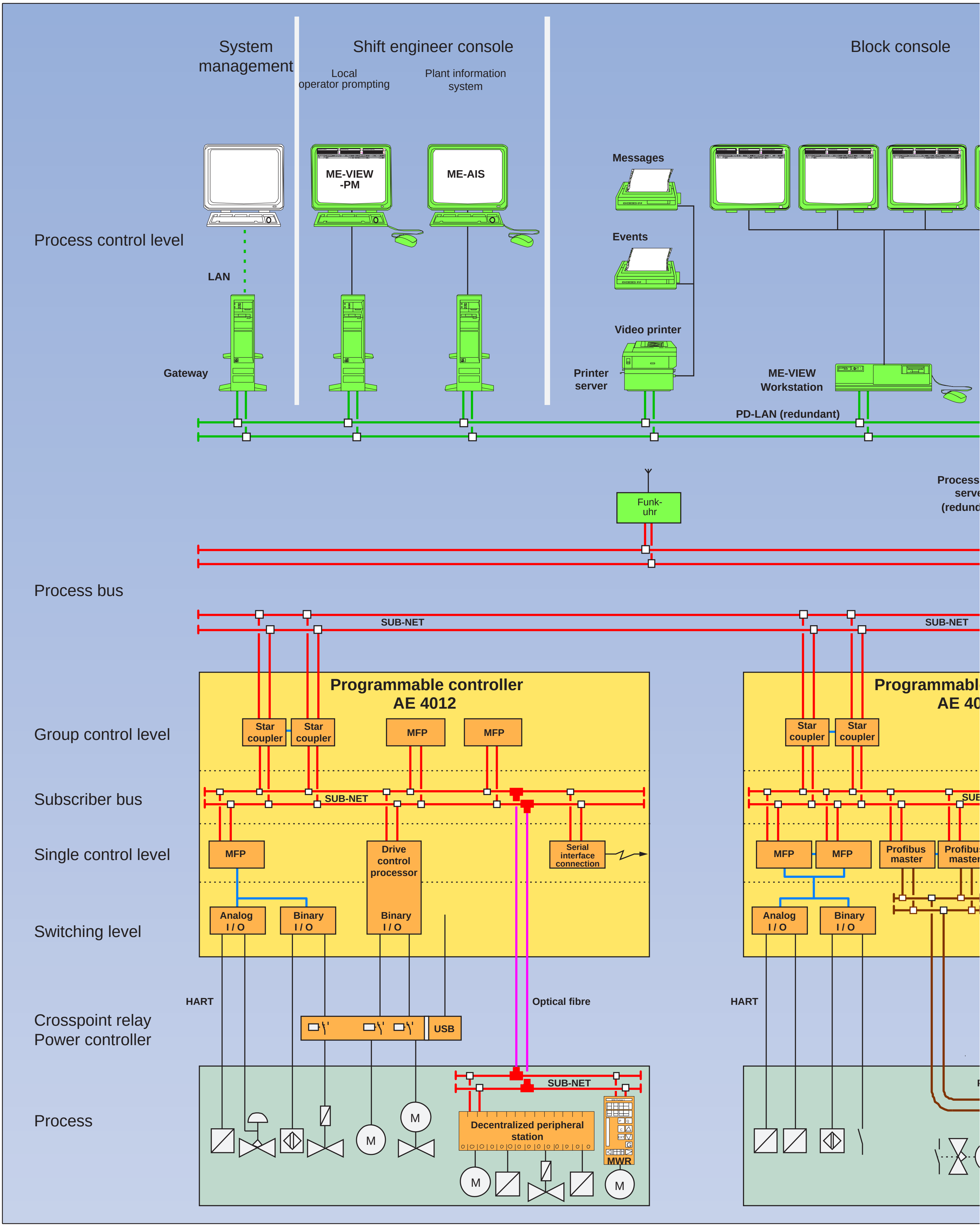
- Immune to noise, high transmission integrity (Hamming distance d=4)

- Serial transmission, asynchronous, half duplex operation

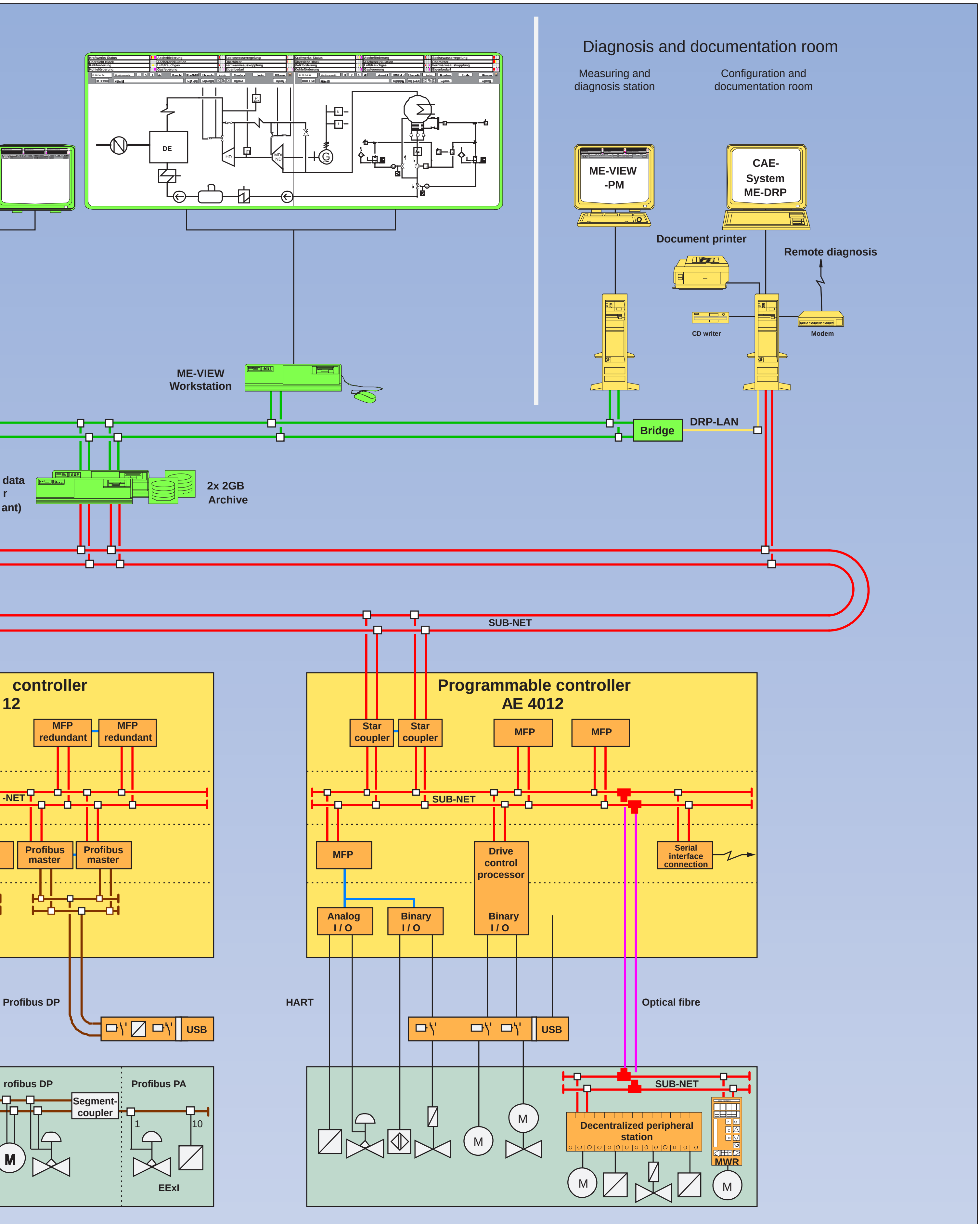
- Addressing scope

| | | |
|---|---|---|
| 122 subprocessors | (SUB-NET subscriber bus*) | Bus level A |
| 60 system subscribers | (SUB-NET process bus*) | Bus level B |
| 8 process bus areas | (SUB-NET continental bus) | Bus level C |

Note: * = Systems with more than 30 subscribers are decoupled by means of intermediate repeaters. Up to 5 repeaters can be connected in series. - Transmission distances using twisted copper lines: 200 m



System management
Shift engineer console
Local operator prompting
Plant information system
Block console
ME-VIEW -PM
ME-AIS
Messages
Events
Video printer
Printer server
ME-VIEW Workstation
Process control level
LAN
Gateway
PD-LAN (redundant)
Funk-uhr
Process bus
SUB-NET
Programmable controller AE 4012
Group control level
Star coupler
MFP
Subscriber bus
Single control level
Drive control processor
Serial interface connection
Profibus master
Switching level
Analog I / O
Binary I / O
HART
Optical fibre
Crosspoint relay
Power controller
USB
Process
Decentralized peripheral station
MWR
M


Diagnosis and documentation room
Measuring and diagnosis station
Configuration and documentation room
ME-VIEW -PM
CAE-System ME-DRP
Document printer
Remote diagnosis
CD writer
Modem
DE
ME-VIEW Workstation
Bridge
DRP-LAN
data
r
ant)
2x 2GB Archive
SUB-NET
controller
12
MFP redundant
MFP redundant
-NET
Profibus master
Profibus master
Programmable controller AE 4012
Star coupler
Star coupler
MFP
MFP
SUB-NET
MFP
Drive control processor
Serial interface connection
Analog I / O
Binary I / O
Binary I / O
Profibus DP
HART
Optical fibre
USB
USB
rofibus DP
Profibus PA
Segment-coupler
1
10
EExI
SUB-NET
Decentralized peripheral station
MWR
M
M
M
M
M

- Transmission distances using optical fibre cables: 2 000 m per single line. For additional lines, specific repeaters and line materials are available

- Easy replacement of subprocessor modules at any point in the system without any adverse effect on the other subscribers

- Target-addressed transmission of plant data that has been time-stamped at distributed points to generate a centralized event/alarm report at a resolution of 1 ms-

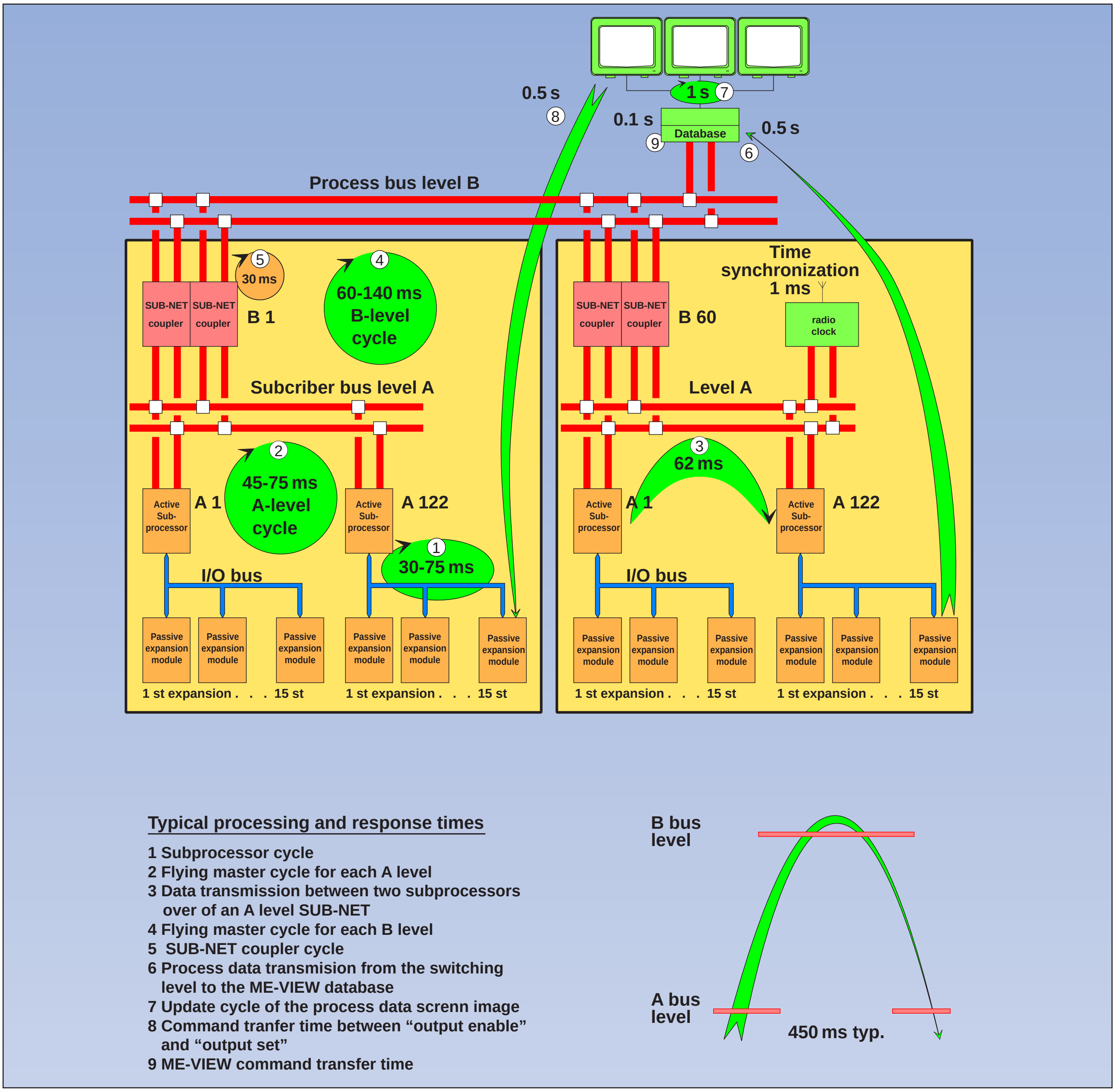
Date and time synchronization of all subscribers with an accuracy of 1 ms by means of a SUB-NET compatible radio clock

- Data consistency in the configuration data for online writing and reading through a centralized design station ME-DRP

- Target-addressed diagnosis and status data transmission for higher-level alarm message and fault diagnosis

- Connection of distributed or local subprocessors (i.e., subprocessors outside of the AE 4012 programmable controller) for the integration of black boxes with a minimum of wiring and cabling

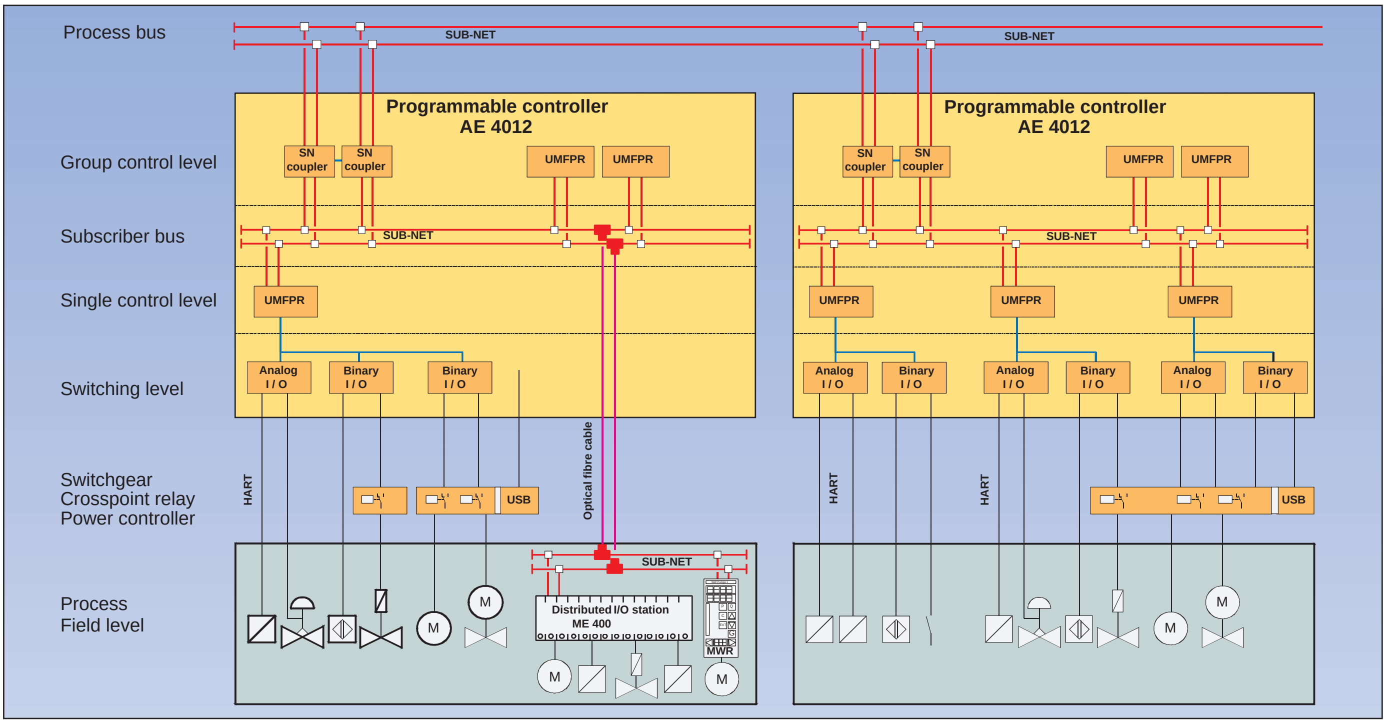
- Interface connection to other bus systems
  - CAN bus
  - Profibus DP




*SUB-NET performance data derived from plant performance tests*

The AE 4012 programmable controller takes charge of the actual automation tasks and 'talllks' directly to the distributed I/O equipment. It is capable of handling complex control sequences, closed-loop control and arithmetic functions. It also contains the modules for binary and analog signal conditioning and the interface connection of field bus systems, such as Profibus-DP or CANopen.

To ensure a high degree of availability, the AE 4012 is designed as multi-processor system of decentralized design. In addition to its simultaneous processing capability, the AE 4012 has a high arithmetic capacity and thus allows short signal scans and output update cycles.




*Multifunction processor programmable controller AE 4012*

Subprocessors and I/O modules with process bus interface can be inserted at any position in the subracks. This means that the control, arithmetic, closed-loop control, alarm and monitoring functions can be completely integrated. Each subprocessor module is equipped with a redundant SUB-NET process bus interface (subscriber bus).

In the control hierarchy, the subprocessors of the single control level implement the drive control and closed-loop control circuits.

The I/O bus connects the processors to the modules of the switching level. These are responsible for process signal conditioning and command forwarding to power controllers and switchgear.

The subprocessors are interlinked with each other and with all subscribers on the SUB-NET bus system by means of their redundant SUB-NET interfaces (multifunction processor UMFPR).

Data exchange is based on the source-addressing principle.

The distributed power supply of the modules and the non-interacting connection to the SUB-NET bus system allow each module to be replaced without interrupting the operation of the other processors.

The system can be configured during online operation. The user configuration can be documented graphically which facilitates commissioning and servicing.

The I/O modules available (some of them equipped with a preprocessing processor) are high-performance modules for special functions, such as signal conditioning, I/O diagnosis, transmitter supply and signal preprocessing (e.g., time stamp, filtering, signal compensation, etc.). They allow you to adapt the AE 4012 programmable controller to your specific automation task.

The AE 4012 programmable controllers are connected to all other subscribers of the SUB-NET process bus by means of double-redundant SUB-NET couplers.

All modules are equipped with fault indication LEDs on their front plate for easy fault diagnosis. The modules can be easily replaced without any adverse effect on the other subscribers. The use of HCMOS modules allows chopper-type transducers to be employed on the individual modules so that centralized power supply units are not required. The separate power supply for each module is connected via the subrack's backplane.

### Switching Level

The I/O modules of the switching level acquire the physical process variables in the form of binary and analog signals.

They are combined with the necessary subprocessors of the single control and group control level in common AE 4012 programmable controllers. The subrack and cubicle configuration is mainly determined by the functional scope and redundancy requirements of the function areas to be automated. All signals processed by the modules of the switching level are available in the SUB-NET bus system (direct source addressing).

The simultaneous supply of both the measuring transducers and the criterion transmitters through the modules of the switching level allows the peripheral equipment to be monitored for wire break, short circuits, signal plausibility and the presence of the supply voltage.

The modules and the process interface system are connected by means of configured cable groups with plug-in accessory allowing an easy-maintenance connection to the module front bracket.

All modules with SUB-NET interface also have an RS 232 interface for the local simulation and diagnosis with the local ME-DRP diagnostic computer. This can also be done from the centralized ME-DRP documentation station using the SUB-NET interface.

### Binary Signal Input K16IN for the Contact/Initiator Scan

These modules are used for processing important binary signals coming from the process, e.g., from pressure and temperature detectors, level detectors, etc..

Hardware structure:

- 16 contact or initiator inputs
- I/O bus interface for multifunction processor connection
- + 24 V supply with monitored electronic fusing
- - 24 V supply for increasing the contact scan voltage
- Static-dynamic 24 V group alarms, even in the event of a power supply failure
- Active generation of the N/C current circuit
- Connection of auxiliary power; SUB-NET via subrack rear panel

Input characteristics:

- Isolated electronic protection (self-healing) for each contact or initiator
- Input filter for contact debouncing, 5 ms typ.
- Transmitter simulation or disconnection via simulation pins
- Input steps and transmitter supply outputs are protected against overloading due to overvoltages at the input by means of overvoltage protection and rupture joints
- 11 discrete diode-decoupled outputs of the contact-type inputs for separate protection and interlocking
- Input contact scan 24 V or 48 V
- Wire break monitoring of the inputs with 100 kΩ resistors
- Wire break monitoring can be individually configured for each input
- Transmitter input status indication by means of one LED per channel
- Simulation indication through LED or simulation pins
- All inputs interrupt-controlled, alarm and time stamp capable, accuracy: 1 ms
- Supply and scan of 2-, 3- and 4-wire initiators of PNP design, polarized, overload and short-circuit protection
- Minimum load current at contact scan 4 mA at 24 V or 8 mA at 48 V
- 16 indirect input scans for the generation of the contact complementary signal (virtual changeover contact)
- Valence monitoring of the changeover contact inputs can be configured

### Analog Signal Input AE16V with Transducer Supply

This module is used for the input of up to 16 standardized analog signals with modulated FSK signal for HART protocol transmission.

Hardware structure:

- 16 non-floating analog signal inputs, nominal range: 0 to 20 mA
- Analog-digital converter with 12 bit signal resolution
- Separate 24 V voltage supply with monitored fusing
- Separate short-circuit proof transducer supply for each input channel, 24 V DC / 4 W, minimum current and undervoltage monitoring
- Input low-pass filter, transition frequency 24 Hz
- Load resistors (250 Ω) for the injection of FSK signals to reduce the power loss; only connected during the HART protocol transmission for the corresponding SMART measuring transducer
- CPU for signal preprocessing
- Front bracket test sockets for measuring the input signals (0/4 to 20 mA), without measuring circuit separation
- Static-dynamic 24 V group alarms
- I/O bus interface
- Redundant signal conditioning of an analog signal to different AE16V modules at signal isolation via an AV24P module

Input characteristics:

- Standard and SMART transducers can be connected
- Transducer supply 24 V, 2-wire and 4-wire
- Measuring range 0/4 to 20 mA, linear up to an overload of 11 %
- Measuring accuracy ± 0.2 % with regard to the upper range value
- Measuring value acquisition approx. 1 ms for each channel, 2 analog-digital converters, resolution: 12 bits
- Input load at normal operation 100 Ω, overload protection
- Measuring range input can be configured and standardized
- Configurable input filter PT1, average value, low pass for signal filtering
- Limit value indication and time stamp
- Remote parameter setting and diagnosis of SMART transducers using HART protocol, max. distance: 2000 m

Information exchange:

The information is transmitted both by the standardized analog signal of the transducer and the frequency-modulated digital signal of the HART protocol via the measuring circuit as the common electrical connection.

The analog signal transmits the measuring value and the information for the measuring circuit diagnosis. The measuring circuit is monitored for Information exchange:

The information is transmitted both by the standardized analog signal of the transducer and the frequency-modulated digital signal of the HART protocol via the measuring circuit as the common electrical connection. The analog signal transmits the measuring value and the information for the measuring circuit diagnosis. The measuring circuit is monitored for

- Wire break
- Overload
- Plausibility
- Failure of the auxiliary supply voltage

The digital information transmitted by the HART protocol is used for the centralized parameter definition and diagnosis of the field units via the ME-DRP system. Due to the low transmission rate (2 measuring values per second) the transmitted digital measuring value itself is not used in the process control system.

### Hart Protocol Data Transmission for Field Transducers

SMART transducers use the HART protocl for the transmission of parameter definition data. This protocol implements frequency shift keying (FSK) according to the Bell standard 202 for the communication between the transducers and the parameter definition device.

A digital signal with a nominal frequency of 1200 Hz or 2100 Hz is superimposed on the d.c. current useful signal. In order to reach the required voltage range, a shunt of 250 Ohm is integrated in the measuring circuit of the AE16V module. At parameter definition or diagnosis this shunt is looped in in the measuring circuit by a parallel transistor. During Hart protocol data transmission the AE16V module takes over the role of a master unit while the transducers 1 to 16 act as salves.

The transducer parameters are transmitted from the ME-DRP workplace to the AE16V module on the SUB-NET and passed on to the individual transducers.

A cyclic routine deposited on the AE16V scans each transducer for diagnostic data and transmits this information to the centralized ME-DRP project design station.

Pending information is furnished with a time stamp on the AE16V and passed on to the visualization interface for further processing.

To avoid having to employ numerous parameter definition interfaces for the various types of transducers, a uniform user interface based on Visual Basic for programming and monitoring all types of transducers is provided.

### Analog Signal Conditioning and Distribution AD8EA

The module is used for processing analog sensor and standard signals.

Hardware structure of the expansion module:

- 8 analog signal inputs, each of them floating
- CPU for signal preprocessing
- Front bracket measuring sockets for standard signals
- 24 V voltage supply with monitored fusing
- I/O bus interface
- Static-dynamic 24 V group alarms

Input characteristics:

- Connection possibility for: 0/4 – 20 mA — Accuracy: ± 0.2 %, ± 0.35 %
- Thermocouples (J, K, E, R, S, T, B) — Accuracy: ± 0.15 %
- PT 100 (4-wire circuit), Ni 120, Cu 10 — Accuracy: ± 1 %
- Voltage inputs 3 x mV, 3 x V — Accuracy: ± 0.2 %, ± 0.35 %

(no combination on the same module)

- Load inputs 20 Ω, overload protection
- All inputs isolated from the electronic equipment acc. to VDE 0435, Part 303, Class 1
- Measuring range input configurable and linearized
- Configurable input filter PT 1, average value, low pass, PLL
- Limit value indication and time stamp
- Isolated signal output 0/4 to 20 mA, 600 Ω load for each output

Output characteristics:

- Signal output accuracy: ± 0.25 % at 25 °C (with regard to the upper range value)

### Pulse Input IE2FZ 21AF

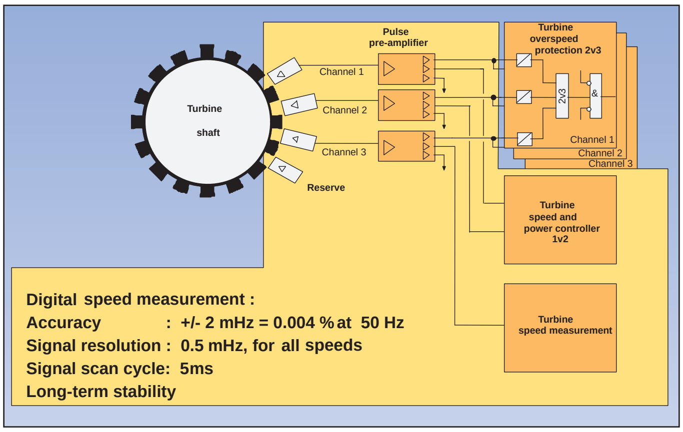
I/O expansion module for the acquisition of fast pulse sequences, logic signals or pulse signals from rotating shaft flow meters, feeding systems and positiong systems.

The module has two isolated input channels for pulses of 2 Hz to 500 kHz with an input voltage between 15 V and 24 V DC.

Fields of application:

- Pulse counting and comparison with predefined values (coincidence)
- Speed measurement (e.g., turbine speed)
- Frequency measurement
- Frequency/analog conversion

The accuracy of a turbine frequency measurement is in the range of approx. ± 2 MHz abs at nominal speed (signal resolution: 0.5 MHz).




*Pulse signal acquisition with sensor and pulse pre-amplifier (three-channel isolated outputs) and signal conditioning in the areas turbine protection and turbine speed control*

### Analog Signal Output AA08V

Module for the reactionless output of up to 8 normalized analog signals with changeover possibility for redundant configurations.

Hardware structure:

- 8 analog signal outputs, common isolation
- I/O bus interface
- CPU for output signal processing
- Separate 24 V supply with monitored fusing
- Static-dynamic 24 V group alarms
- Self-diagnosis for signal output disconnection in the event of faults
- Redundancy capability

Output characteristics:

- Signal level 0/4 to 20 mA up to 110 %
- Signal output load: 600 Ω
- 8 short-circuit proof output channels, common isolation
- Resolution: 12 bits, accuracy: ± 0.1 % with respect to the upper range value
- Outputs can be disconnected in the event of faults
- Modules can be replaced during operation

### Analog Signal Output AA16V

Module for the output of up to 16 normalized analog signals.

Hardware structure:

- 16 analog signal outputs, common isolation
- Passive I/O bus interface
- CPU for signal preprocessing
- Separate 24 V supply with monitored fusing
- Static-dynamic 24 V group alarms

Output characteristics:

- Signal level 0/4 – 20 mA
- 2 load outputs per signal (100 Ω and 250 Ω), can be combined to 350 Ω
- 16 short-circuit proof output channels, common isolation Resolution: 12 bits, accuracy: ± 0.2 % with respect to the upper range value
- Front bracket measuring sockets for each channel
- Outputs can be set to 0. 4 or 20 mA in the event of faults

### Binary Signal Input / Output DEAIN

Module for the input of 30 binary signals and output of 12 binary signals.

Hardware structure of the expansion module:

- 12 outputs, single-pole circuit
- 30 contact-type inputs ±24 V DC
- Module supply 24 V DC with monitored fusing
- I/O bus interface
- 6 supply steps + 24 V DC for the isolated, monitored transmitter supply

Output characteristics:

- Signal level + 24 V DC, 50 mA, overload and short-circuit protection, isolated for ohmic, inductive and capacitive loads

Input characteristics:

- Contact circuit ± 24 V DC; 3.3 mA for all input channels
- Time stamp resolution 1 ms
- Signal delay 5 ms typ. (debouncing)
- Interrupt-controlled, alarm capability
- Isolated
- Surge strength acc. to DIN EN 60870-2-1: 97-07, Class VW3

### Binary Signal Output DA32V

Module for the output of 32 binary signals.

Hardware structure of the expansion module:

- 32 semiconductor outputs
- Module supply 24 V DC with monitored fusing
- Interface for connection to subprocessor

Output characteristics:

- Signal level 24 V DC, 50 mA or 100 mA, overload and short-circuit protection
- Isolated groups of eight acc. to VDE 0435 Part 303 Class II
- Diode-decoupled for ohmic, inductive and capacitive loads

### I/O Interface Signal Level

**Binary signal definition** (with respect to M potential)

Inputs:

| | |
|---|---|
| Supply | 24 V or ±24 V (48 V) |
| Low signal "Zero" | 0 V to +5 V |
| High signal "One" | +15 V to +28.8 V |
| ON and OFF delay | 5 ms typ. |
| Input currents | 2 mA at 24 V (binary signal scan) |
| | 3 mA at 48 V (contact scan) |
| | 8 mA at 48 V (criterion conditioning), input loop resistance monitoring: <150 Ω (short-circuit monitoring) |

Outputs:

| | |
|---|---|
| Amplifier output | Overload/short-circuit protection |
| Output voltage | 24 V DC |
| Output currents | 0 to 50 mA / 0 to 100 mA |

**Analog signal definition** (with respect to measuring earth MZ)

| | |
|---|---|
| Input signals | 0 to 20 mA or 4 to 20 mA<br>0 to 10 V or 2 to 10 V |
| Nominal input resistance | 100 Ω at 20 mA |
| Analog-to-digital conversion | 12 bits |
| Accuracy | 0.25 % |
| Sensor inputs | Resistance thermometer, Thermocouples |

| | |
|---|---|
| Output signals | 0 to 20 mA or 4 to 20 mA |
| Nominal output load | 350 Ω |
| Digital-to-analog conversion | 12 bits |
| Accuracy | 0.25 % |

## Single Control Level

### Multifunction Processor UMFPR

The UMFPR module is equipped with a powerful processor. Its high arithmetic capability ensures very fast processing of the control and closed-loop control functions.

This allows the connection of various drive and control loops via the switching level modules to a multifunction processor in the single control level. The optimal utilization of the hardware results in a high packing density in the programmable controllers so that space requirements and heat loss are reduced.

Redundant functions can be defined and processed on separate SUB-NET subscribers which leads to a high degree of functional decentralization.

The open-loop and closed-loop controls are programmed by linking the function macros stored in the UMFPR firmware library.

The integration into the higher-level plant protection system, function groups and control loops and the connection of additional I/O signals for operation or safety interlockings is established via the multifunction processor and its redundant connection to the SUB-NET process bus.

Switching level expansion modules are available for the connection of additional binary signals as well as analog or sensor signals. The signals can be directly integrated into the interlinking and computing logic of the drive controls

Due to their complexity and the required short response times closed-loop control arrangements impose specific requirements on the automation equipment. Control loops (e.g., the direct position balancing of a servo drive) are allocated to the single switching level, all higher-level closed-loop control circuits, like cascaded controls, block controls, etc., are allocated to the group control level.

In addition to the standard P, I and D action closed-loop control functions, we also provide modern, more complex closed-loop control concepts, e.g., state controllers with observer and Fuzzy controllers.

### UMFPR Module Performance

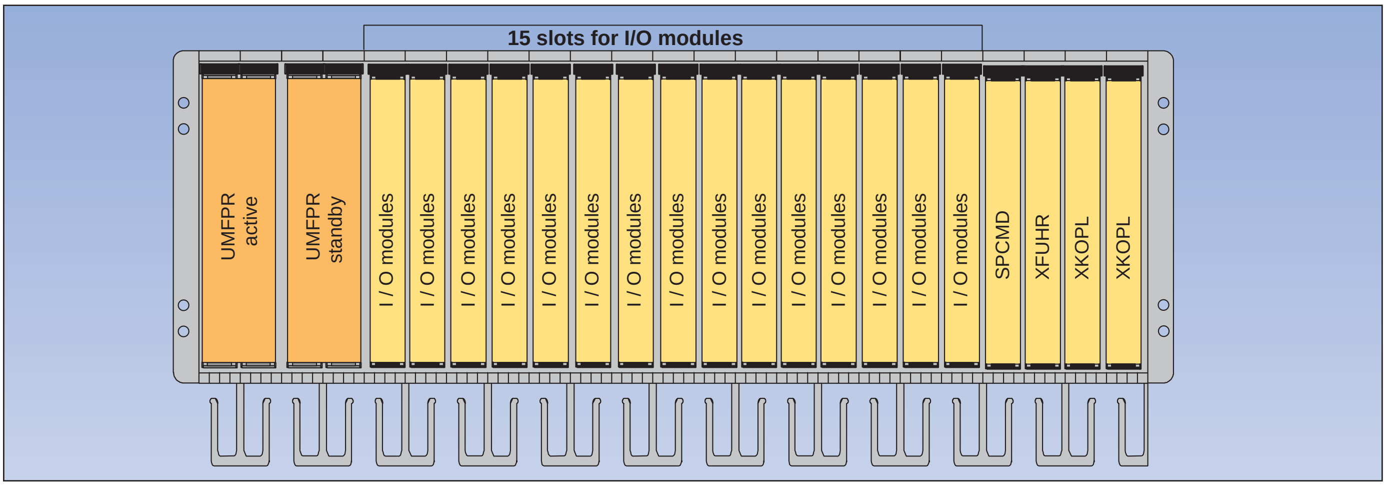
Features and performance characteristics of the UMFPR multifunction processor:

- Pentium processor, low power hardware (operation without fan)
- Unique SUB-NET address for active and standby processor module
- Online, non-interacting changeover to the standby CPU
- Online, non-interacting changeover to the I/O modules
- Automtic  starting and balancing of the standby CPU after module replacement
- Automatic, non-interacting module disconnection from the SUB-NET and I/O bus and automatic, bumpless changeover to the standby processor in case of malfunction
- Firmware memory in the form of flash disks
- Firmware updates can be carried out from the centralized ME-DRP station over the SUB-NET
- Connection of up to 15 input/output modules
- Simple plugin location planning allowing system-relevant redundancies to be observed

### Multifunction Processor Redundancy

In order to achieve a higher degee of plant availibilty, the multifunction processors of the single control level can be arranged in a redundant system.

A redundant system structure offers various advantages, like simple plugin location planning and complete utilization of the available 15 I/O bus slots. The diagram below shows a typical subrack configuration for a redundant system.




*Subrack of the ME 4012 programmable controller with redundant multifunction processor and I/O modules for the connection of peripheral signals*

**Binary Signal Input/Output for Drive and Step Controls F6ATR**

F6ATR module for various control tasks and closed-loop control tasks:

- Triple configuration for non-reversing drive (motor)
- Triple configuration for reversing or actuator drive
- Triple configuration for solenoid valve with 2 coils, or 6-fold arrangement for solenoid-operated mechanism with 1 coil
- Triple configuration for conveyor belt drive; the space assignment can be reduced depending on the required closed-circuit current signals (suitable for AK3 or AK4 applications acc. to DIN V 19250)
- Triple configuration for servo-drive (step)
- Or any thereof

The F6ATR module offers 30 binary inputs for the connection of process signals and 6 bipolar binary outputs for the transmission of control commands.

Hardware structure:

- I/O bus interface for multifunction processor connection
- 6 bipolar outputs
- 30 contact-type inputs ±24 V DC
- 24 V DC module supply with monitored fusing
- 6 short-circuit proof supply stages +24 V DC for the isolated, monitored transmitter supply
- Status indication of the outputs and supply stages by front bracket LEDs; diagnosis sockets for the connection of a commissioning test device for monitoring, diagnosis and simulation

Output characteristics:

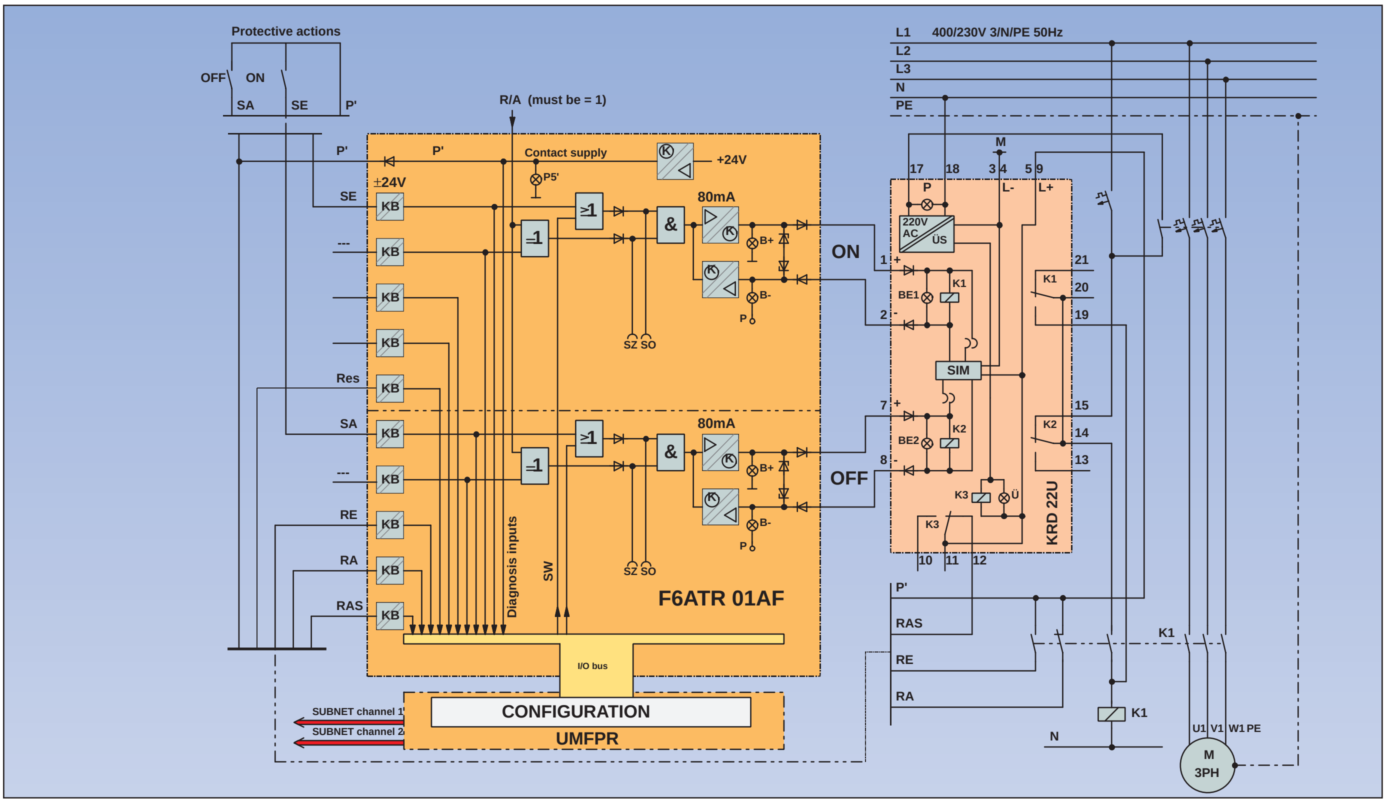
- Signal level 24 V DC, 80 mA, overload and short-circuit protection, floating
- Diode-decoupled for ohmic, inductive and capacitive loads

Input characteristics:

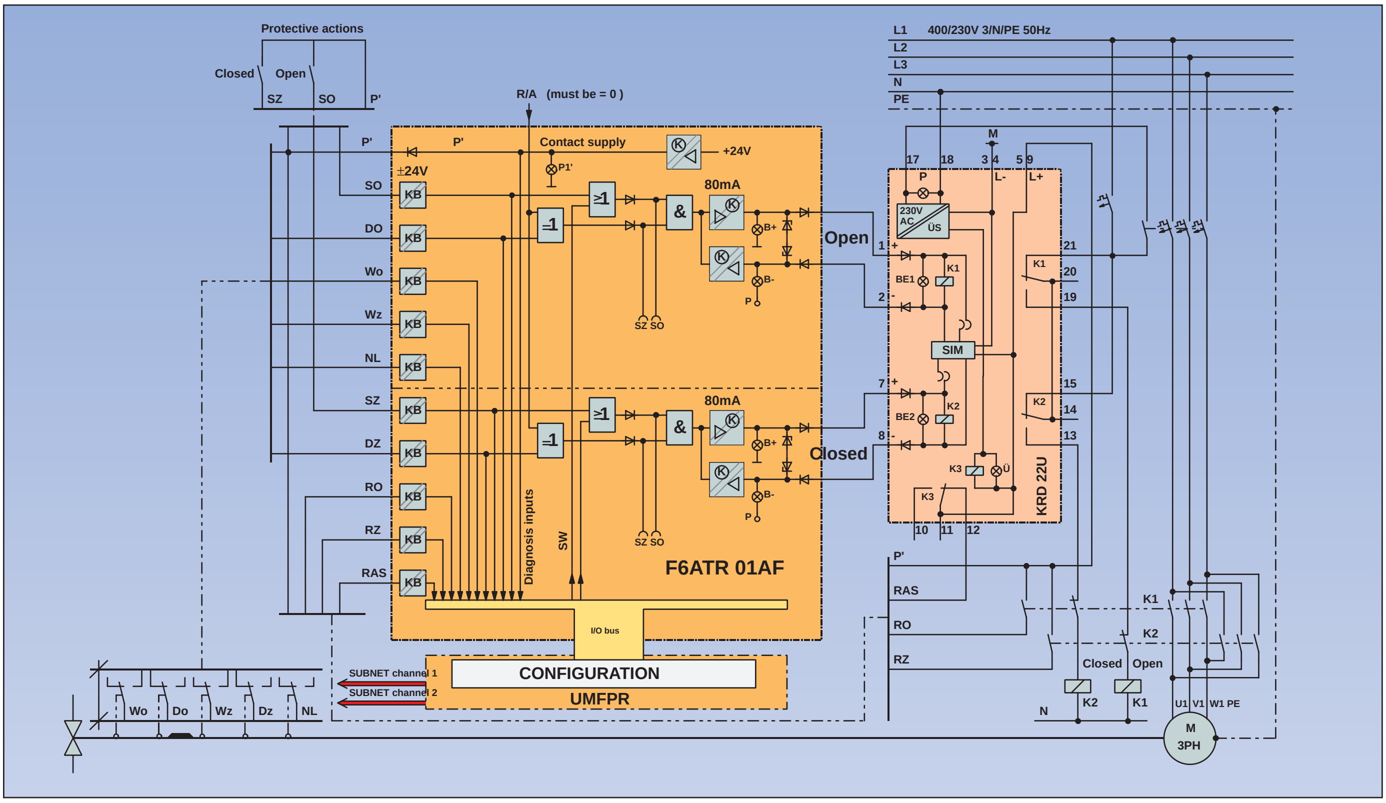
- Valence monitoring, configurable
- Signal delay, 5 ms typ. (debouncing)
- Input load for 24 V inputs: 2 mA, floating
- Input load for 48 V inputs: 4 mA, floating
- Interrupt-controlled, alarm capability, time stamp resolution: 1 ms
- Isolated
- Surge strength acc. to DIN EN 60870-2-1:97-07, Class VW3

Other main features:

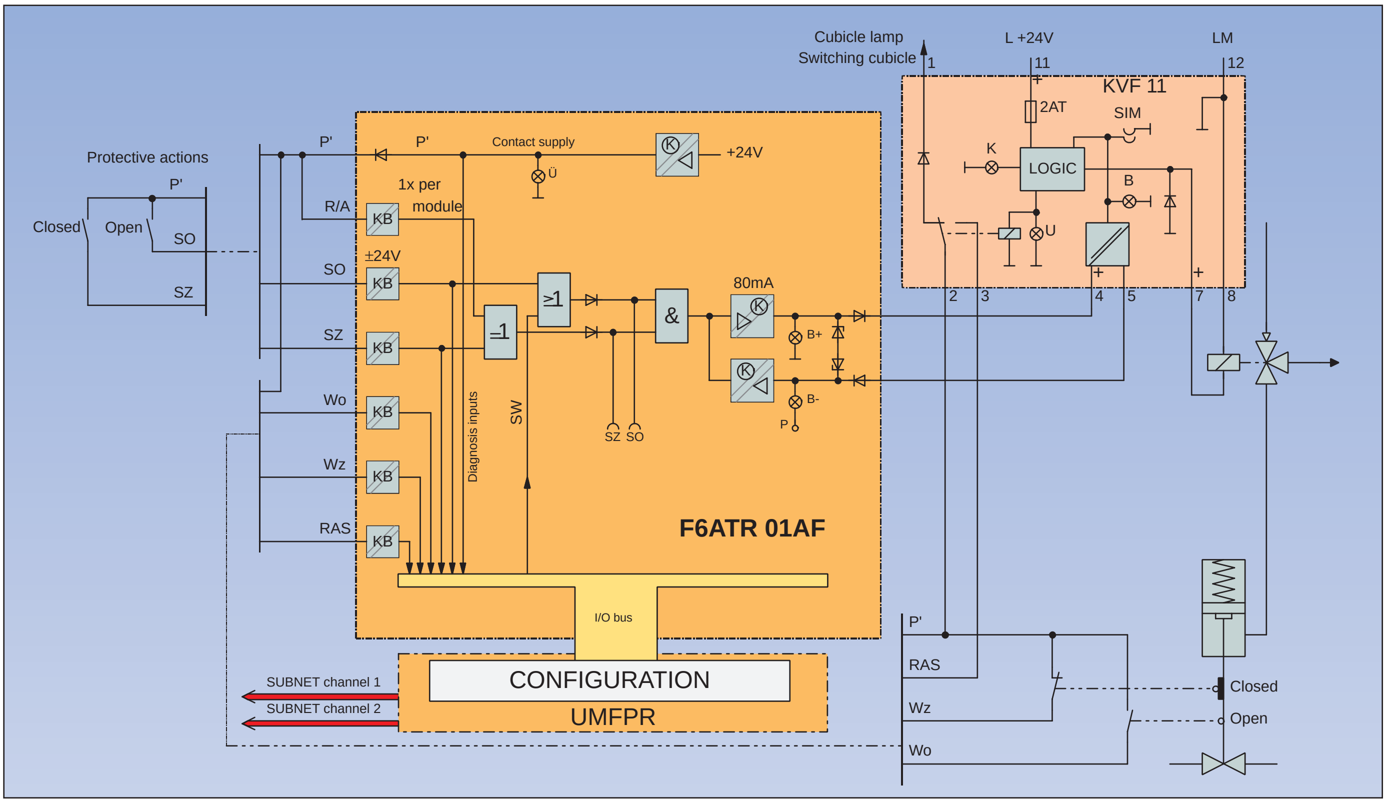
- Pump lock (torque switch)
- Differential monitoring
- Short-circuit proof outputs 24 V, 80 mA
- Separate command output for ON/OPEN and OFF/CLOSED
- The command output for the activation of the drives is handled by crosspoint relays or power controllers in the switchgear section
- All process signals directly processed on these modules (acknowledgement signals, position signals, etc.) can be transmitted to the SUB-NET bus system
- Module replacement at continuing self-blocking in the switchgear section
- Configuration data can be changed online
- Generation of the contact scan voltage (± 24 V) if additional 24 V DC is connected
- Contact processing for transient suppression
- Hardware fault indication through front panel LED
- The criteria ‘Protection ON’ and ‘Protection OFF’ can be directly directly to the outputs in the event of a CPU malfunction. This increases the safety of the drive control.
- Signal scan monitoring
  In order to further increase availability for a multiple connection with drives the module is equipped with 6 current-limiting, isolated contact supply stages which monitor the overall loop resistance in long tranmission lines. Due to the high-ohmic input stages a body contact of the contact scan loops can be safely detected (this could not be done with fine fuses). The scan of the inputs from the process and switchgear sections can thus be divided into three independent groups.
- The torque and suppressor circuits are connected by means of specific module inputs and directly affect the module’s command outputs via hardware logics (without processor action). For the contact-type inputs available on every F6ATR module (e.g., torque), N/C or N/O current operation can be selected.
- To ensure safe activation of the intermittent switchgear devices, the corresponding outputs are of bipolar design.



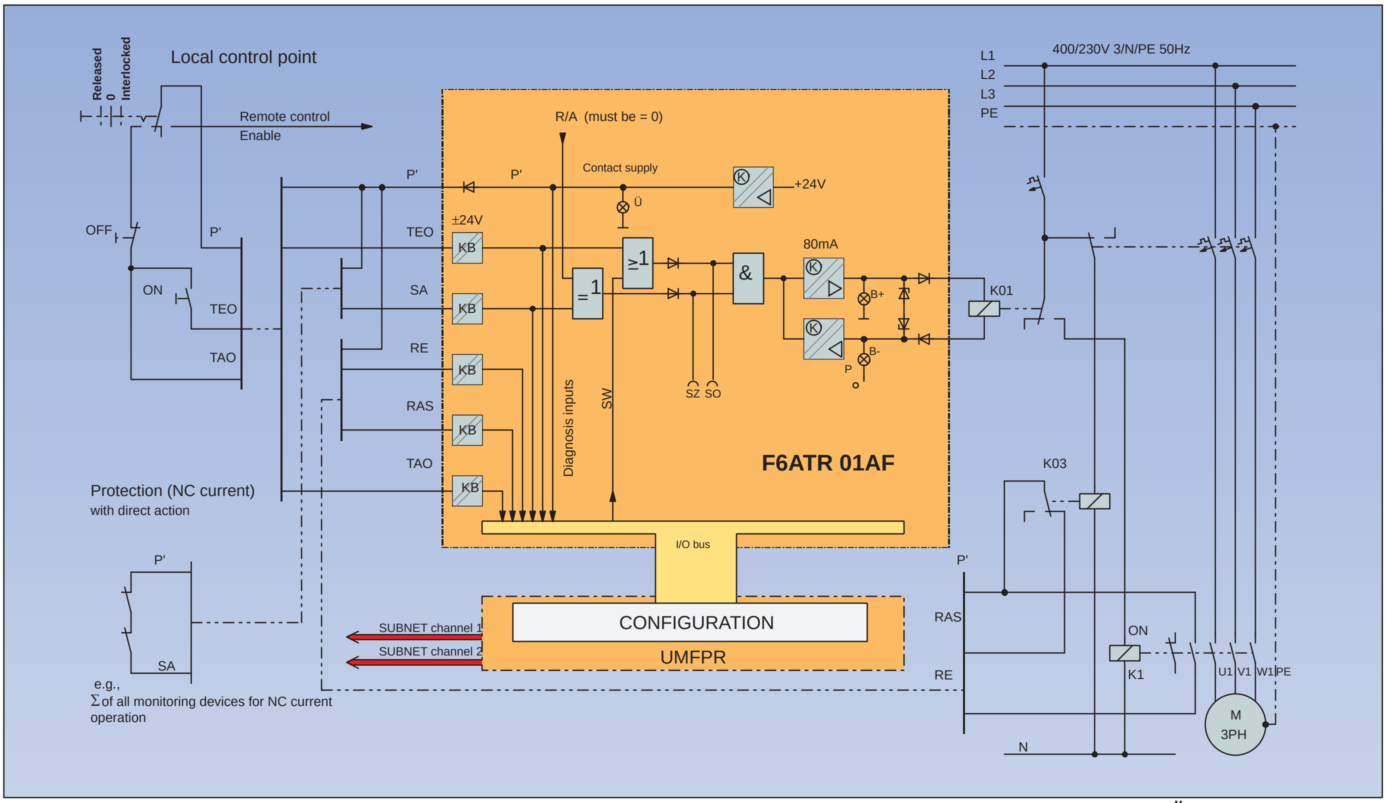
Typical arrangement for the activation of a motor drive



Typical arrangement for the activation of an actuator drive




*Typical arrangement for the activation of a solenoid valve with one coil*



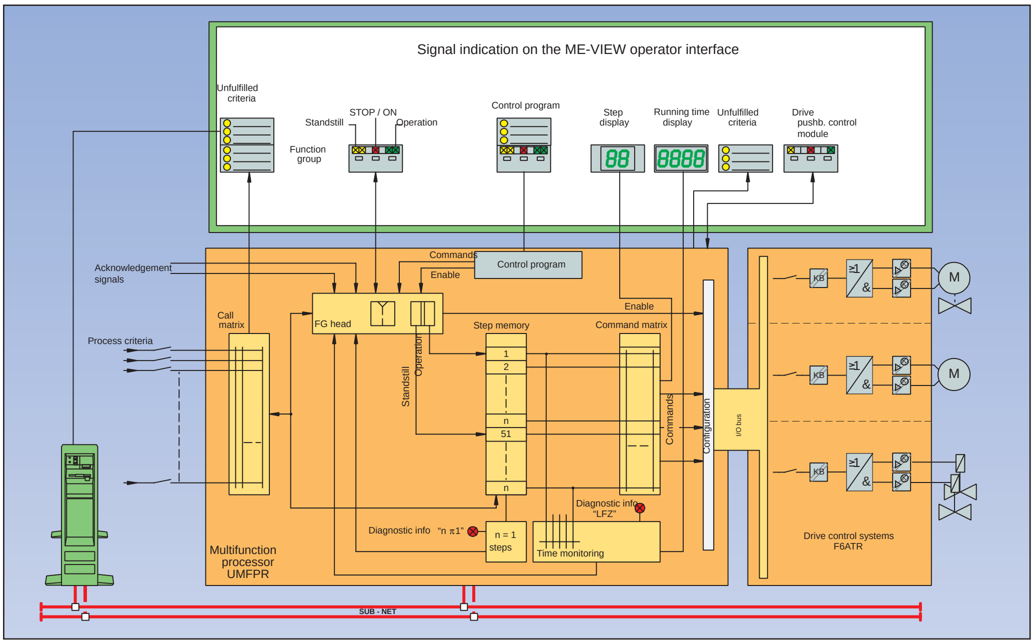

*Typical arrangement for the activation of conveyor belt drive acc. to DIN V 19250, AK3. AK 4 applications are also TÜV approved but requires a second NC current trigger channel.*

## Group Control Level

The logic and computing circuits for function groups or setpoint controllers are implemented in the multifunction processors of the AE 4012 programmable controllers.

Function group operation: The 'Start program' command for the operating and down-time program can be activated manually in the control room or by means of a higher-level program.

The following information is also read out:




*Block diagram of a function group (step program) with standard signalling in ME-VIEW*

- Starting/shutdown interlocking
- Run time exceeded
- Disconnection due to faults
- Step number

The following standard functions are provided so that the function groups can be activated at any time:

- Following-on mode at automatic operation
- OFF without command output
- Slave tracking operation

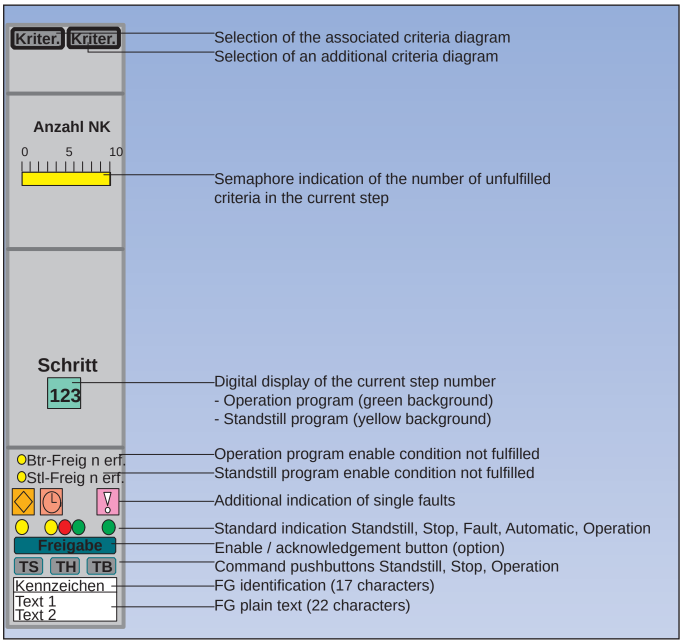
In addition to the function groups and setpoint controllers, the group control level allows the implementation of

- preselection functions
- automatic circuits
- automatic transfer on faults

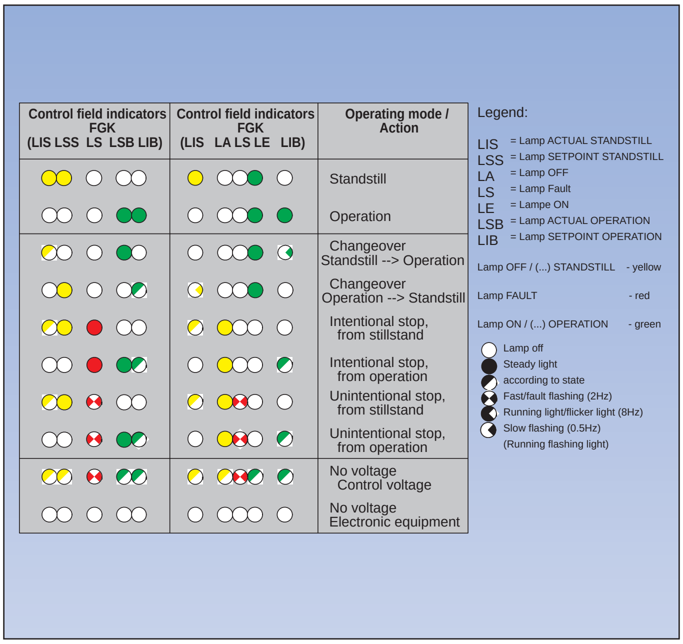
## Function Group Structures and Functionalities

All function groups designed with the standard function macros fulfil the following basic requirements:

- Automatic starting on request, for the operation and shutdown of the devices and controllers linked to the function group. The individual steps of the sequence are carried out in the technologically correct order.
- Operator prompting by indicating the unfulfilled criteria of each step

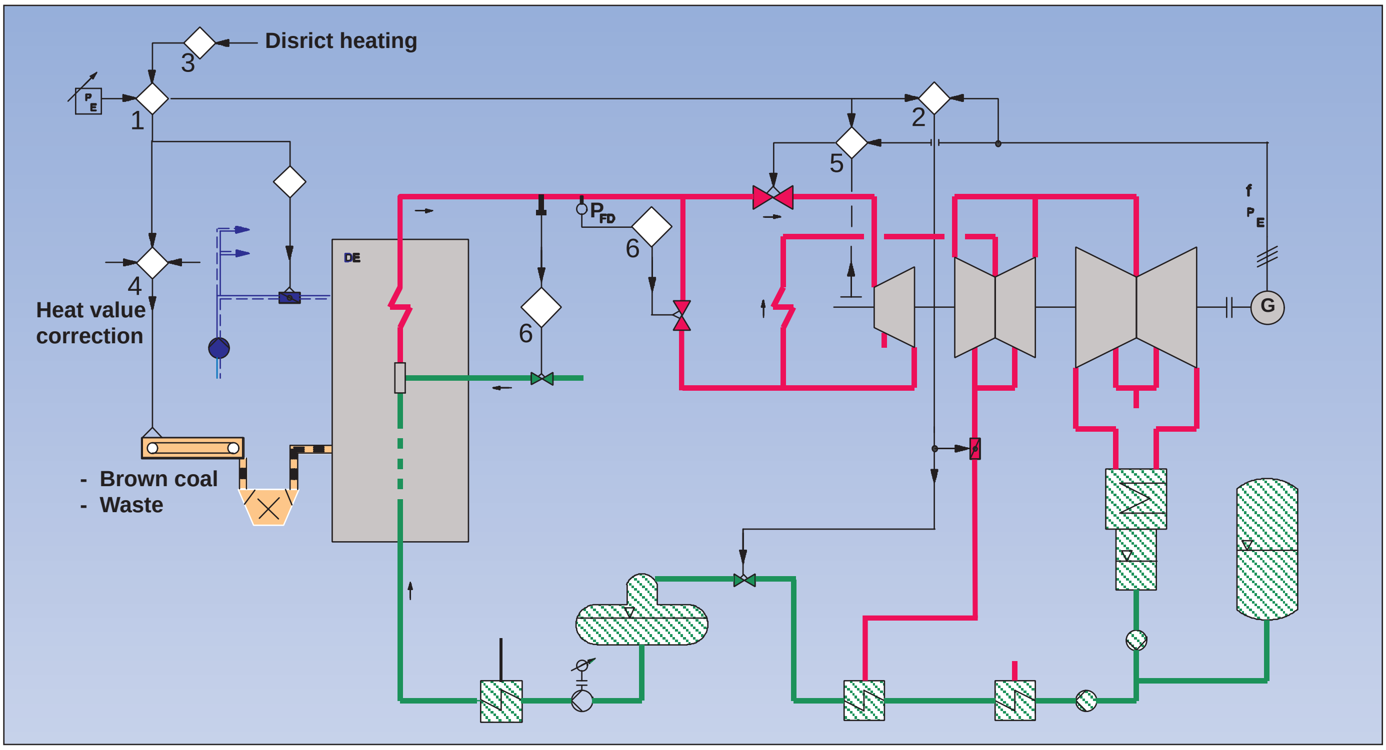



*Example of a function group control panel*




*Signalling table of a function group*

## Modern Control Algorithms in Power Station and Process Control Systems




*Block control concept and use of modern control algorithms*

### Application of Modern Control Algorithms

Fields of application of modern control algorithms in today's steam generators and their auxiliary plants:

**Calculation-guided Closed-loop Control Systems**
Application examples:

- Control of condensate build-up
- District heating supply from cogeneration

Fields of application and characteristics

Calculation-guided closed-loop controls are primarily used in complex power station heat circuits where often contrasting task definitions have to be taken into account:

- Fast and opposite load variations at the consumer end, e.g., turbines / generator and district heating system
- Slow increase of the steam generator output

Using conventional closed-loop control circuits responding to system deviations, these tasks can only be solved with a maximum effort in the planning and commissioning phases. They also hinder a dynamic operation of the plant.

The block model assigns parameters on the basis of the technological design specifications, supplies reference input variables for all control loops of the meshed system - right up to the furnace operation setpoint control. Model errors are corrected by the subordinate setpoint controllers of all major process areas, such as FD floating pressure, turbine extraction pressure, heating condenser pressure.

**State Controllers with Observer**
Application examples:

- Live steam temperature control
- Intermediate superheater temperature control
- Control loops with highly load-dependent time constants and of higher system order

Fields of application and characteristics

The state controller with observer is used for higher-level processes with self-regulation, but can also be used for processes with dead time. The process/plant-specific disturbance analysis is carried out by an internal state observer and the analysis result is taken into account when the actuating variable is generated. Actuator non-linearity, system dead time, etc. are taken into acount by internal compensation circuits so that a persisiting system deviation is avoided. An online parameter adaptation derives the optimal state controller parameters from the controlled system characteristics.

The use of a state controller results in an aperiodic and asymptotic damping of the controlled variable characteristics which leads to a smooth actuator operation and therefore a smooth response of the linked variables.

**Block Model (Steam Generator and Turbine)**
Application example:

- Anticipation of the tank and turbine output development, gradient limiting for the load balancing through the block capacity control (to avoid irregular block operation).

Fields of application

Large-scale power station components only allow certain load characteristics. A setpoint control that is not optimally adjusted to the possible actual conditions will lead to unnecessary fluctuations in the control response and thus to unauthorized controller actions. This puts unnecessary strain on the materials and reduces plant efficiency. If the time characteristics for the setpoint control of the essential components is derived on the basis of plant-specific parameters (load level setpoint gradient, storage capacity, etc.), the block model can be used to implement a specific setpoint control of all large-scale components which takes into account the actual process conditions. This will result in an optimal utilization of the dynamic performance and a higher overall efficiency at load variations. Untimely correction of the control process through the subordinate setpoint control systems can be avoided.

**Fuzzy Control Algorithms**
Application examples:

- FGD plant optimization of the deposition degree of the $SO_2$ content in the raw gas by selecting and specifying the number of the spraying levels in operation
- Correction of the furnace operation control due to fluctuations in the heat value and mass current measurement errors

Fields of application and characteristics

Plant areas producing non-consistent process variable fluctuations which cannot be measured are difficult to control satisfactorily, even if complex control loops with a high degree of intermeshing and complex feedforward control are employed. The heat value of refuse or brown coal, for example, cannot be determined satisfactorily due to the fluctuations in the composition of these fuels. The operation of incinerators in particular requires various fueling parameters to be taken into account (e.g., furnace temperature range, minimum retention time of the gaseous products at specific temperatures, air excess or starvation in the various burning zones, quality of the steam parameters) in order to achieve a high energy utilization factor. The method of multi-variable control based on a Fuzzy algorithm can be used for non-linear and linear processes. Reference setpoints are derived from the various actual values for all furnace-relevant control loops (control of the roller/ travelling grate speed, primary/secondary/tertiary air quantities, refuse feeding speed, etc.).

The described control strategies are implemented on the standard processors of the ME 4012 process control system so that the practical utilization of these modern control concepts is greatly facilitated.

**Serial Interface SPCMD for the Connection to Intelligent Third-Party Systems (Blackbox Systems)**

The SPCMD serial interface handles the data exchange between the AE 4012 programmable controller and the process control and PLC systems of other manufacturers. It consists of the SPCMD subprocessor module which can be directly inserted in the subrack. The RS 422/485 connection is established through the plug connector on the module front.

Due to its subprocessor status within the AE 4012 programmable controller, process data from the SUB-NET subscriber bus can be easily read and written (decoupled reading and writing). This allows the following functions to be implemented:

- Reading out function macro variables
- Writing process variables to function macros, e.g., for setpoint control, controller adaptation, status change, operating mode changeover, control commands

Characteristics:

- System interlinking (connection to third-party systems) by means of various messages/protocols in UART character format
- Configuration with ME-DRP or configuration PC
- SUB-NET capability with ADR area for up to 2 SUB-NET subscribers
- Processing of up to 13 500 signal connections between the ME 4012 and the remote station
- Configurable via the RS 232 configuration interface
- Monitoring, simulation and diagnosis over the RS 232 configuration interface
- Various transmission procedures, exchangable via firmware
- Signal exchange with the connected system over the RS 422 or RS 485 interface
- Minute pulse synchronization and distribution via b and d plug connectors for the system time synchronization of the connected system units
- Electrically isolated transmission equipment

**Transmission Procedures (Excerpt)**

| Protocol type | System type | Manufacturer |
|---|---|---|
| MODBUS | Procontrol P | ABB |
| MODBUS | Contronic E | ABB |
| MODBUS | Contronic M | ABB |
| MODBUS | other | andere |
| Protronic | Compact controller | ABB |
| 3964R | Simatic S5/7 | Siemens |
| 3964R | Teleperm XP | Siemens |
| 3964R | Teleperm ME | Siemens |
| 3964R | others | others |
| DIN 19 244 | various | others |
| IEC 870-5-101 | Power control systems | others |

### Radio Clock Receiver XFUHR (DCF 77 or GPS)

The radio clock module XFUHR is a SUB-NET module designed to process high-precision date and time specifications for widely distributed systems which require time synchronization and message time stamps with a time resolution of 1 ms.

Hardware structure:

- SUB-NET capability
- Time of day recognition via DCF 77 signal, optional GPS receiver module
- Time deviation: 50 µs
- Minute pulse output
- DCF signal test via the processor
- Voltage or DCF 77 signal failure backup supply: 400 hours max. (quartz-controlled)
- Ferrite or frame aerial possible
- Aerial connection via BNC plug connector
- Compensation of the signal propagation times between DCF 77 transmitter and radio clock receiver via DIP switch setting in steps of 100 km
- The change from summer to winter time is announced 1 hour before the adjustment is made

The 77.5 kHz time signal transmitted by the long-wave transmitter in the vicinity of Frankfurt/Main has a range of up to 2000 km. If used outside this service area, the XFUHR function module can be synchronized by an additional satellite receiver.

The GPS satellite receiver uses the global time signal of the 24 satellites of the Global Positioning System (GPS) to generate a high-precision time signal by carrying out an automatic, locus-dependent propagation time compensation. Simultaneous reception from at least three of the 24 satellites is required for faultless operation.

Technical characteristics:

- Internal message confirmation status indicated by 2 LEDs
- Hardware clock and CMOS-RAM battery backup
- Remote aerial unit (cable length: 100 m max.)
- Output pulse for seconds, minutes

### SUB-NET Coupler (XKOPL) for the SUB-NET Process Bus

Module for the redundant interface connection of the SUB-NET levels A, B and C. Due to its importance for the higher-level communication the module is designed as a double unit so that a standby module is always available if one of the XKOPL 10AF coupler cards should fail (both SUB-NET transmission channels are maintained). This considerably increases the MTBF time of the overall system. The module can be replaced during operation without any adverse effect on the system. The modules front bracket houses the SUB-NET interfaces and a configuration and diagnosis plug connector.

Method of operation:

- The connection between levels A, B and C is established automatically
- Configuration of the SUB-NET interface connection
  as A/B connection : by subscriber address transmissions of the A level subprocessors
  as B/C connection : by subscriber address transmissions passed on via the A/B connection
- Configuration-dependent subscriber coupling/decoupling: Depending on the configuration of the SUB-NET interface connection, the subprocessor source data is decoupled from an A bus level to the B bus level and source data from the B bus level coupled to the A bus level. The B/C connection is established in the same way.
- Time stamps and error words are passed on over the SUB-NET interface connection and relayed from the receiving SUB-NET interface to the transmitting SUB-NET interface.
- Configuration data is transmitted from the ME-DRP station to the corresponding bus level (or passed on).
- Monitoring
  - Interface monitoring
  - Supply and processor monitoring
  - Connection monitoring of the SUB-NET interfaces
- Signalling system
  - Static/dynamic error message triggering
  - Front bracket LEDs

### SUB-NET Star Coupler LWLSN

Module for the connection of a SUB-NET process bus channel over an optical fibre line.
Hardware structure:

- Connection between SUB-NET channel (RS 485) and optical fibre line (for the transmitting and receiving direction)
- Synchronization output (minute pulse) for accurate time synchronization
- Optical fibre open-circuit monitoring for the receiver end
- Module state indication by means of LEDs
- Static/dynamic signalling concept through short-circuit proof

## Intermittent Devices

In all process engineering plants, the implementation of supervisory control commands issued from the control centre down to the machine controls and feedback control loops relies on the amplification of analog and binary command signals.

The controlling equipment may be units such as:

- solenoid valves
- motors for continuous and actuator drives
- electrical step servo-drives
- electrical continuous servo-drives
- electrical frequency converters for speed-controlled motors
- pneumatic control and servo valves
- hydraulic control and servo valves

A wide range of intermittent devices ensures that the suitable signal interfacing can be employed between the programmable controller and the power section or switching plant.

For complete control and instrumentation systems, the intermittent units for continuous and actuator drives are usually provided by the switchgear supplier. The supplier of the control equipment normally provides the power amplifiers for the low-performance solenoid valves. The interface between the process control and instrumentation system and the power section can thus be implemented plant-specifically and consistently with regard to signal level, availability and diagnostic depth.

### Intermittent Device KVF 11 for Solenoid Valves, 24 V DC, 35 W max.

Compact intermittent device for solenoid valves designed for the efficient amplification of the control commands. Due to its wear-resistant semiconductor components the device can offer the following essential characteristics:

- Output voltage = supply voltage
- Electrical isolation between input and output
- Output voltage fusing
- Low-limit monitoring of the output voltage
- Short circuit and wire break monitoring
- Command simulation possible by means of test probe
- Resistance circuit of the fault signal contact

The KVF 11 components are enclosed in a 22.5 wide plastic housing suitable for mounting onto standard rail acc. to DIN EN 50022.

### Intermittent Device KRD 22U for Motors and Actuator Drives

Intermittent device for the high-magnitude power amplification. The device is installed in the proximity of the power circuit-breaker in the switchgear. The input voltage is 24 V.

Characteristics:

- Electrical isolation between control and load circuits
- Two load switching circuits with one floating changeover contact each (common root)
- Load switching circuit: 250 V AC max., 8 A, 2000 VA
- LED indication of the switchgear voltage and monitoring circuit status
- Two command inputs with LED status indication
- Fault signal output in the event of unavailable or low load circuit supply voltage, non-floating changeover contact
- Command simulation possible by means test probe

The KRD 22U components are enclosed in a 45 mm wide plastic housing suitable for mounting onto standard rail acc. to DIN EN 50022.

Two connection/application examples of the KRD 22U intermittent device are described below.

## Power Controllers

### Power Reversal Controllers for Three-phase a.c. Servo-Drives

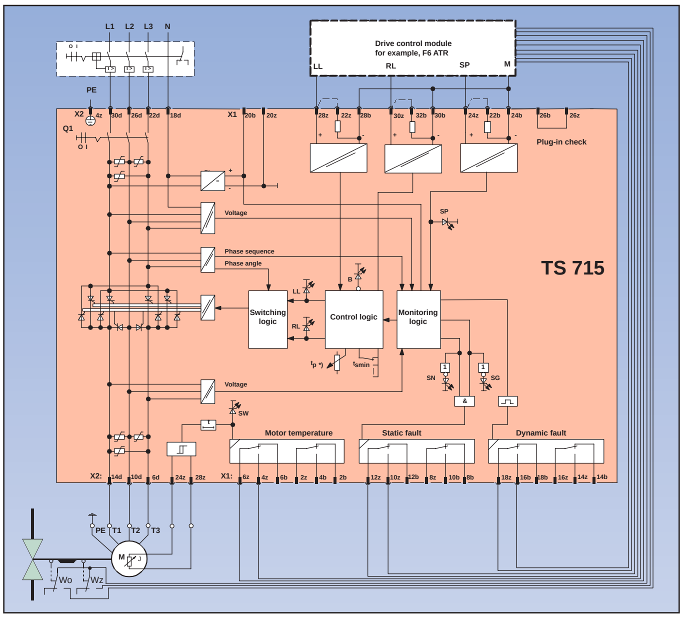
Drives with three-phase asynchronous cage motors and self-locking gear units, drive power ≤5.5 kW, are typical for most regulating inductors and servo valves. The power-rated conversion of the controller output signals is ususally established by means of contactless reversing thyristor controllers of withdrawable-unit design installed in separate cubicles.

The reversing thyristor controllers are designed for 3 x 400 V, 50 Hz three-phase systems. They are directly triggered (with +24 V, 50 mA pulses) by the subprocessors of the control level and operate asynchronous motors with capacities of up to 5.5 kW. Power controllers, switching rate (c/h) and motors are tuned to each other. The permitted switching rate is 2400 c/h max., depending on the capacity and the drive rating.

Switching is bipolar and contactless. The change of rotation is established through an internal, electronic reversal of two phases. The minimum reversing time RL/LL is 30 ms, plus the braking time of 20 ms. All values can be set.

Three-pole circuit-breakers with fast short-circuit release are used for the selective overcurrent protection of the thyristors. The reversing thyristor controllers are installed in system cubicles capable of housing 16 or 24 devices, including the 400 V, 50 Hz supply with monitoring. The auxiliary power for the electronic equipment is 24 V DC. Due to the minimal power loss, the power controllers can be operated without fan/separate ventilation.

In addition to the reversing thyristor controllers of withdrawable-unit design for 3 x 400 V AC three-phase systems, thyristor reversers of plate field design, size PG 1/2, for 3 x 400 V AC, 3 x 500 V AC or 3 x 690 V AC three-phase systems are also available.



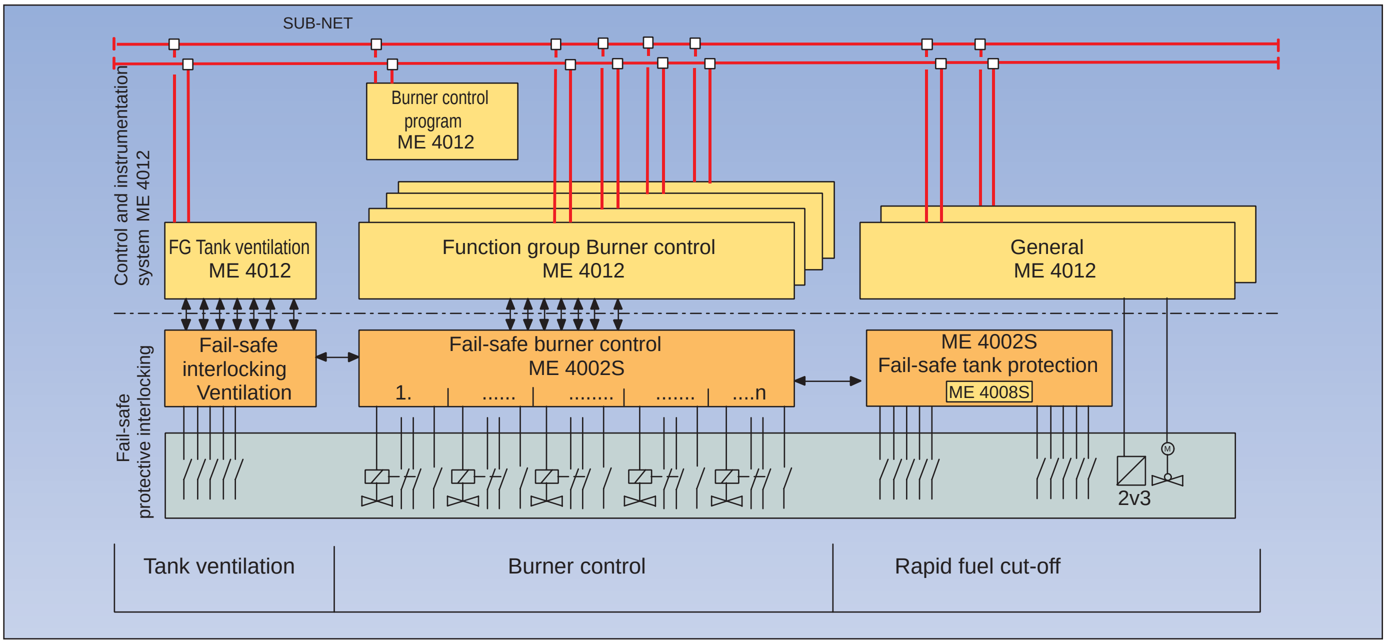

*Reversing thyristor controller for three-phase a.c. drives*

The ME 4002S fail-safe control system is primarily used in areas where plant safety has a higher priority than availability. In power stations, this first and foremost applies to the oil, gas or coal dust feeding control, but also to the overpressure control of pipelines and tanks as well as the district heating networks which must be in compliance with the TRD regulations.

The system's dual-channel, hard-wired N/C current logic and the diversity timing elements ensure fail-safe monitoring, enabling and interlocking in compliance with the applicable safety regulations (VDE 0116, TRD 411, 412, 413, 414).
A distributed and structured configuration is of course extremely especially important for the plant sections requiring fail-safe operation to ensure that the autonomous functionality of the protective interlocking circuits for the following areas is maintained:

- Tank ventilation
- Burner control
- Rapid fuel cut-off
- Pipeline and tank pressure control

The interlocking circuits are directly connected to the subprocessors of the plant's control and instrumentation system through signal-level-compatible interfacing. The resulting structure shown in the below diagram ensures consistent operator control, plant monitoring and message processing meeting the guidelines on plant safety laid down by the TÜV (a German Technical Inspectorate). Unfulfilled control criteria as well as process messages are indicated on redundant ME-VIEW stations for operator attention (operator prompting).




*Distributed structure of the fail-safe interlocking routines and their integration in the plant's control and instrumentation system*

The ME 4002S fail-safe system has been prototype-tested and approved by the TÜV Bavaria so that it is not necessary to carry out individual site tests. Tests can thus be limited to the correct installation and integration of the I/O devices at commissioning and to the mandatory inspections.

It must be kept in mind that field modifications of the protective circuits always require the approval of the local Technical Inspectorate. Repairs on prototype-tested devices may only be carried by the manufacturer using original components.

Safety modules are only used for the direct safety circuits of the interlocking and drive control level.

The protective circuits are therefore of dual-channel design with static operation which are compatible with the interface circuits of the ME 4012 process control system. Dual-channel operation is implemented for all functions. If technically feasible and sensible, the two channels can also be of different circuit logic. If required, the dual-channel basic arrangement (1v1) can be linked to higher-level evaluation circuits, e.g., 2v3.

**Interlocking circuits: Burner**

The fail-safe ME 4002S control system allows a burner-specific interlocking circuit and firing safety period monitoring to be implemented for each individual burner so that in the event of a fault in the burner interface system (e.g., flame detector failure, Fire Out, wire brake) or fail-safe control system, only the corresponding burner is switched off.

Apart from executing the burner-specific emergency tripping functions, the system also integrates signals from the tank protection and tank ventilation control.

### Interlocking Circuits: Tank Ventilation

A specific section of the ME 4002S fail-safe system is designed to provide protection against faults in the areas of tank ventilation, ventilation time counting, firing trial counting and fuel release (for the permitted firing period).

### Interlocking Circuits: Tank Protection Control

The tank protection control consists of complex interlock logics which process all relevant tank status signals. For safety reasons, the signals are conditioned at N/C current through modules for 3 changeover contacts or 6 N/O contacts and can be connected to the interlocking logics via dual-channel 2v3 selection circuits in order to increase availability. The rapid fuel cut-off control is implemented by connecting the N/C current command outputs to the quick-release valve modules of the burner control system via a dual-channel circuit.

### Automated Test System ME 4008S for the Tank Protection Control

The ME 4008S automated test system is a microprocessor system for the dynamic online monitoring (simulation test) of ME 4002S interlocking circuits for the tank protection control.

When a triggering cause is simulated, the two channels of the fail-safe control are tested one after the other across all signal processing levels. Existing faults are indicated so that preventive maintenance or repair jobs can be carried out during online operation in order to obtain the highest possible MTBF times. The results of the check run can be recorded by integrating the ME 4008S system into a message signalling system. In plants approved for unattended operation the fault messages trigger a system shutdown. The results of the tank protection control can be recorded by integrating them into the ME-VIEW message signalling concept.

To avoid unintentional triggering of the tank protection control during the test, the trigger signal is suppressed at the end of the interlock chain by means of a passive OR logic (diodes).

It is thus possible to detect faults which are normally only detected by the valence monitoring at the signal change caused by the trigger event, i.e. the automated test can be used for the systematic location of faults on the modules of the ME 4002S control system (e.g., transistor failure).

### Burner and Ventilation Program ME 4012

The area of the function group control not subjected to the stringent safety requirements is implemented on separate multifunction processors

### Burner Control Program ME 4012

The ME 4012 burner control program is implemented on an independent multifunction processor which communicates with the function groups of the burner control, ventilation program and all other relevant plant sections over the redundant SUB-NET process bus.

### Lambda Monitoring

The dual-type measuring values for the combustion air and gas or oil quantities are connected to independent multifunction processors of the ME 4012 process control system in a dual-channel circuit. Based on these measuring signals the processors compute the volume flow correction and fuel/air ratio.

The derived lambda limit values are connected (dual-channel connection) to a 2v2 N/C current circuit of the ME 4002S fail-safe system (an error triggers the system). The ”total lambda value” is measured via the tank outlet (higher-level measurement), computed on the multifunction processors and connected to the interlocking circuit of the tank protection control system.

### Special Characteristics of the Fail-Safe Control System

- N/C current transmitter conditioning
- 2v3 input circuits for a higher degree of safety and availability
- Dual-channel N/C current processing
- Independent, dual-channel diversity time elements for tank ventilation, firing enable time and firing safety period
- One autarkic interlock circuit for each burner
- Tank protection control with dynamic online test routine (automated test simulation) for preventive error location
- Signal-compatible integration into the ME 4012 process control system for consistent operator control and monitoring
- Distributed configuration of the tank ventilation and burner control (individual control circuit for each burner - and for each type of fuel, if required)
- Dual-channel computation implemented for each burner (e.g., lambda); in the event of processor faults only the corresponding area is shut down
- Integration of the event/alarm recording system, time resolution: 1ms
- Integration of conventional visual/acoustic messages
- User-friendly indication of unfulfilled stepping conditions on colour monitors
- Possible online configuration in the area of the non-fail-safe function group level
- The failure cause leading to the halt of a firing trial can be stored
- The high degree of availability and safety has been successfully proven in many large-tank applications

## Digital Turbine Control with ME 4012

As all fields of engineering, power station technology, too, has progressed enormously during the last years. Especially in the field of steam turbines, new knowledge has been gained about material strength and long-term behaviour, flow dynamics and design, and has turned the relatively simple turbine of the past into a hightec unit. This advance in technical standards in power stations increases the requirements for plant safety, improved availability and maximum turbine life. With our ME 4012 process control system a digital turbine controller is now available that meets these high demands and is capable of recording and independently controlling every single process within the specified limits, thus reliably fulfilling the DVG guidelines. Higher-level automated function groups ensure optimal interaction of the individual processes so that the entire industrial complex “Power station” with its huge capital expenditure can be operated safely and economical for a long time.

Let us take a closer look at a particular part of the power station: the turbine set. For this section alone, the ME 4012 process control system has to meet very specific requirements for safe and reliable control of the five main operating conditions

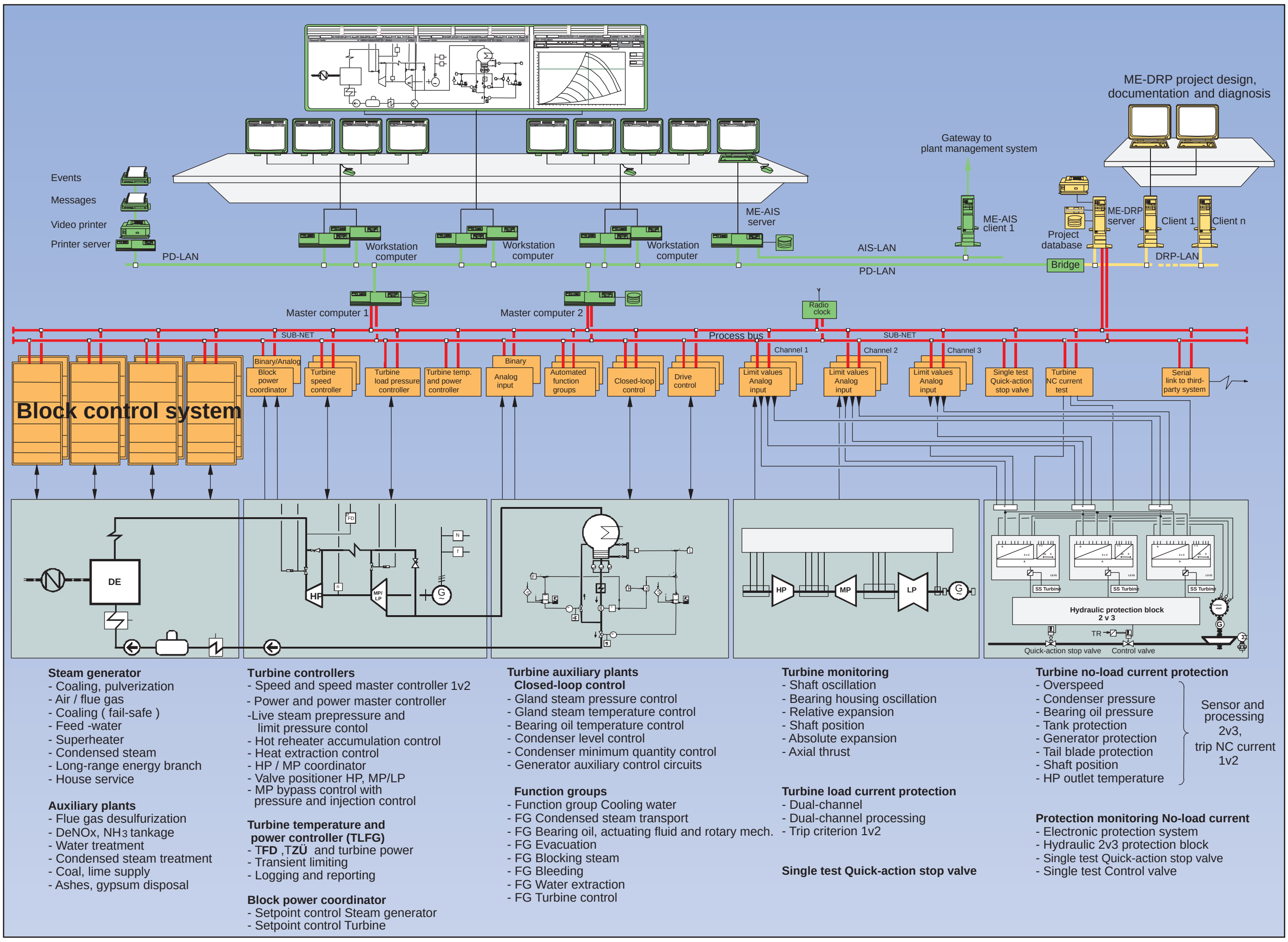
- starting and synchronization
- loading and power operation with power controller and frequency influence
- controlled deceleration at load shedding and securing the station services at load
- load ramp operation
- shut down.

Furthermore, the ME 4012 process control system continuously monitors the actual status of the plant so that the necessary conclusions for optimal plant operation can be drawn from any changes that might occur. The aim of this enhanced turbine control system is to ensure

- a high degree of operational safety
- a high degree of availability
- a low rate of wear
- extended life expectancy
- the homogenous integration into the plant’s control and instrumentation system and convenient operator control
- a high diagnostic depth and a minimum of maintenance requirements
- prolonged service intervals

### A Uniform Control Systems for all Plant Sections

The ME 4012 process control system with its uniform hardware, firmware, operator interface and documentation is open for all areas of the power station process (steam generator, turbine set, and auxiliary plants).




*The digitale turbine control system ME 4012: a uniform, consistent power station control and instrumentation system*

The ME-VIEW system is a state-of-the-art tool for informative and detailed representation of process data and for convenient operator control. The demands on a modern visual display system can be divided into two groups:

- Process monitoring:
  - Process data conditioning and management (archiving)
  - Graphic representation of plant sections (static) and processes (dynamic)
  - Display of process data and states
  - Conversion of process messages into concise graphical information (signalling)
  - Time monitoring of process values (graphs)
  - Plain text and signal display as well as fault message recording

- Operator-process communication:
  - Fault message acknowledgement
  - Changing process parameters (setpoint inputs)
  - Transmitting control commands to individual devices
  - Starting/stopping function group step programs
  - Preselections

ME-VIEW meets these requirements as an integrated part of the ME 4012 process control system. It allows clear representation of all relevant information, transparent process monitoring and safe and reliable operator control of the ME 4012 system. The connection to the AE 4012 programmable controllers is established over the SUB-NET process bus.

The possibility to create coloured process graphics of high resolution (1280 by 960 picture elements) results in an extremly high information density and lucidity.

Thanks to its modular design the ME-VIEW operator control and process monitoring system can be adapted to meet your specific requirements. The system is open-ended for future expansion to meet increased demands . Taking different availability requirements and plant sizes into account, Mauell GmbH offers two systems with different degrees of expansion:

- ME-VIEW single-station system based on an industrial PC for simple application
- ME-VIEW multistation system based on industrial PCs for medium size and large-scale plants

Due to the comprehensive logic and arithmetic functions for data preprocessing in the AE 4012 programmable controllers additional process information can be derived from the process variables. This enables the operating personnel to

- detect faults in time,
- quickly find the cause of the fault,
- and take appropriate measures to correct the fault.

## ME-VIEW System Hardware

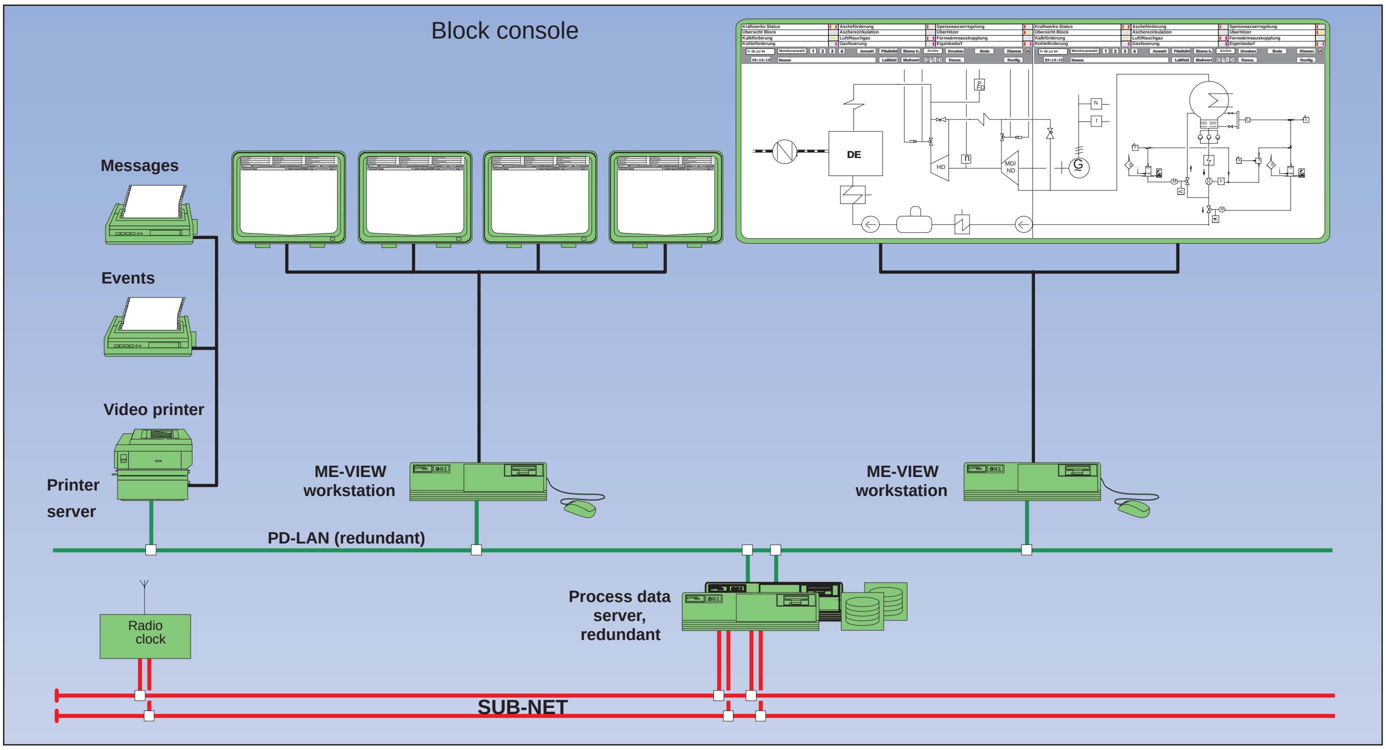
### System Structure

The ME-VIEW system comprises a process data server (of redundant design, if required) with process data/process diagram base and a workstation computer with graphics controller. Every process data server (PD server) has a redundant process bus interface for the communication with the AE 4012 programmable controllers on the SUB-NET.

The ME-VIEW single-station can have two colour monitors; operation is by keyboard and mouse.

The ME-VIEW multistation system can have up to four colour monitors connected to each workstation computer; operation is by function keyboard and mouse/track ball.

It is also possible to connect a large-screen display. The configuration of the ME-VIEW is carried out on the central ME-DRP project design station .




*ME-VIEW multistation system, 2 operator stations for 1 to 4 monitors and large-screen projection. Process data server and workstation computer in redundant configuration, if required.*

### Process Data Server

The process data server stores all relevant process data, irrespective of whether this data is currently displayed or not. In this way, process information is instantly available for presentation in flow diagrams or graph windows and does not have to be called up from the programmable controllers each time it is required.

The data is processed on modern component industrial computers (32-bit computers with 128 MB RAM). The supraregional time synchronization with an accuracy of 1 ms is established over the SUB-NET process bus.

Two serial printer ports and one parallel printer port are provided for the output of the various standard reports.

For further processing bulk information for the long-term storage of process data for graphs and reports, the process database can be transferred to an archive server. The connection to the process diagram database is established over the PD-LAN network with a clock rate of 10 MHz. The archive server can be designed as a RAID system (redundant data management) in order to meet more strict safety requirements.

### Graphics Controller

The ME-VIEW graphics controllers have been especially designed to handle fast changing process graphics. The vector-based graphic design interface allows you to create high-resolution images which require only little storage space.

Video characteristics:

| | |
|---|---|
| • Vector graphics | |
| • Picture elements | 960 x 1280 pixels in the matrix memory of each video channel |
| • Colour set | 256 colours |
| • Refresh frequency | 74 Hz (for a flickerfree display) |
| • Flashing frequency | 0.5 Hz, 2 Hz, 8 Hz, synchronous for all system monitors |
| • Video frequency | 125 MHz |
| • Refresh memory | 2 MB |

- Multiscreening function for all 4 video channels connected to the process diagram database

An internal bus establishes the connection to the process diagram database.

### Printer Server

The selected screen image is directly transmitted to the printer server for digital output. Main features:

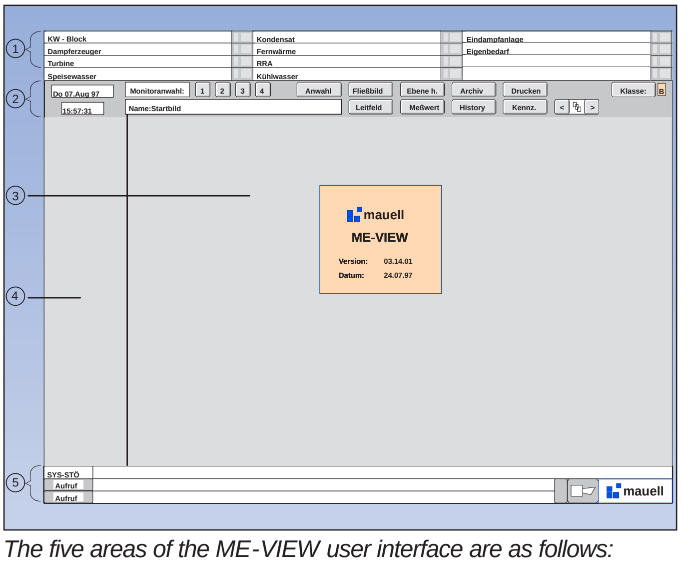
- Only a minimum of wiring necessary
  As the hardcopy server is directly connected to the PD-LAN network of the ME-VIEW system, extensive wiring equipment usually necessary for the connection of RGB devices (comprehensive cabling, multiplexers, etc.) is not required.
- Automatic polling of all workstations
  After the printer server has been connected it automatically scans all workstations listed in the configuration file for initiated hardcopies. A hardcopy can be initiated by activating a user interface command button. The hardcopy is automatically transmitted to the server printer (filter transfer) where it is prepared for printout.
- Images of high quality
  The direct, digital filter transfer of the hardcopy produces images of very high quality.
- Minimum-maintenance operation
  After the printer server has been installed all you have to do is provide the expendable material. No further adjustments or maintenance jobs have to be carried out as no analog equipment is used.
- Representation of flashing messages/symbols
  Flashing messages/symbols inform the operator about important process events. The printer server uses different colours to represent this information on the hardcopy.
- Printout
  The hardcopy is printed on standard colour printers (laser, ink-jet, thermal transfer printer). A Windows 95/NT printer driver must be available.

### Structure of the User Interface

The relevant information from the process must be presented to the operator in a clear and informative way. In order to achieve this all dialogs of the ME-VIEW user interface are divided into the same five areas.

This standardized structure ensures that specific information and standard command buttons can always be found at the same position in any of the dialogs.

The five areas of an ME-VIEW dialog are illustrated in the screenshot below.




*The five areas of the ME-VIEW user interface are as follows:*

1. *Plant overview with area group messages*
2. *Selection area*
3. *Flow diagram area*
4. *Process control area*
5. *Signalling area*
   - *System status bar*
   - *Alarm message bars*

## Plant Overview

The part reserved for the plant overview gives the operator quick access to the various plant section diagrams and the associated pending group messages.

This area consists of 12 fields displaying the names of the existing plant sections. The fields can be used to call up the first diagram or the signalling functions of the corresponding plant section. The area group messages are displayed to the right of each text field.

Indicators for the message types exist for each section:

- process fault alarm (red)
- device fault alarm (yellow)

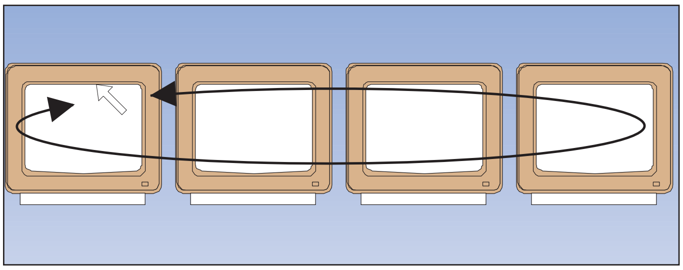
Pending, already acknowledged messages are indicated by a steady light. Messages not yet acknowledged are indicated by a flashing light.

The plant overview always presents itself in the same way, irrespective of the currently displayed diagram and its classification.

The red indicators for process fault group messages are activated by the ME-REG function. Selecting this indicator brings you to the message page of the corresponding plant section.

The yellow indicators for device fault group messages are activated when device faults have occurred in the corresponding plant section. Selecting this indicator opens the flow diagram with the most recent unacknowledged device fault message.

Up to four monitors can be connected to an ME-VIEW operator station. The mouse pointer can be directly moved across all four monitors without interruption so that the operator is provided with a large working area. The units for large-screen projection can be arranged both horizontally and vertically - the mouse control is automatically adapted. If, for example, the four monitors of an operator station are arranged 2 by 2, then in this arrangement, too, the mouse pointer can be directly moved across all four units.



*Multiscreening with four monitors*

## Flow Diagram Area

The flow diagrams of the individual plant sections are displayed in the center of the working area below the dialog's selectable functions. They supply the operator with the necessary information about the current process state. The operator can call up user-specific as well as standardized process graphics, such as control panel, measuring value, criteria, loop diagrams or graph windows. It is possible to activate various functions (depending on the type of flow diagram) from within a flow diagram (e.g., call up process control elements) or branch into more detailed flow diagrams.

## Process Control Panel

The process control panel at the left-hand side of the dialog displays standardized elements (also called measurement or pushbutton control panels) for the control and monitoring of measuring points, automated functions, closed-loop controllers, drives, etc.. To activate a function, select the corresponding command button with the mouse/track ball and then press the associated key on the keyboard (if required, also press the enable key). It is also possible to call up more detailed diagrams, for example, the diagram showing the unfulfilled switching criteria.

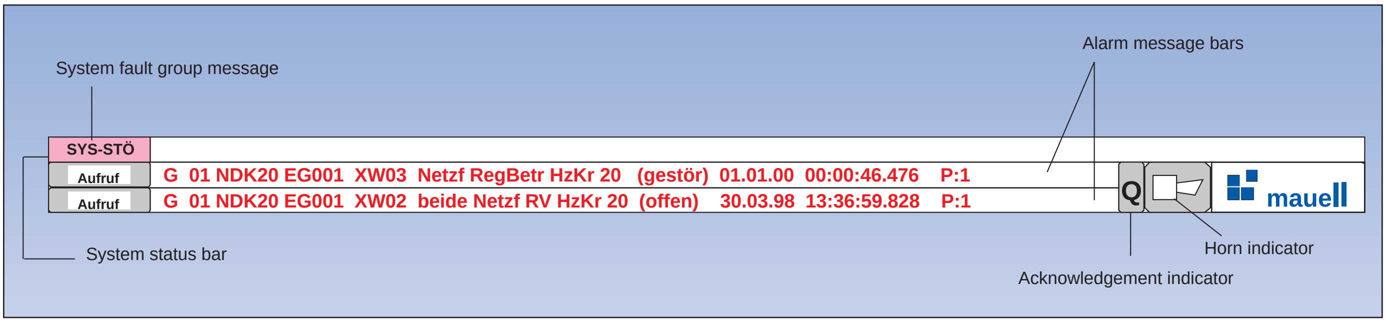
To call up a control panel, select the corresponding symbol in the active flow diagram.

## Signalling Area

The signalling area in the lower part of the dialog (see illustration below) comprises the system status bar, the two alarm message bars, and the acknowledgement and horn indicators.

## System Status Bar

The system status bar informs you about faults in the process control system and also about faults in the ME-VIEW system itself. The group message of all system faults is displayed in the far left box (violet colour) of the status bar. Select this box to call up the system fault diagram which indicates all faults detected in the process control system. The violet group message box flashes as long as unacknowledged fault messages are pending. When all fault messages in the system fault diagram have been acknowledged, but messages are still pending, the box emits a steady light. The light goes out when no messages are pending.




*Signalling area*

### Alarm Message Bars

The upper alarm message bar displays the oldest unacknowledged process fault message and the lower one the most recent unacknowledged process fault message. Activate the **Call** buttons to open the corresponding flow diagrams.

### Acknowledgement Indicator

The acknowledgement indicator is activated through the ME-REG function. If the acknowledgement of messages takes longer than usual - due to a large number of messages or if other ME-VIEW systems are acknowledged at the same time - the ‘Q’ symbol is displayed. During this time it is possible that message indication is different on the individual systems or that the relation between single message and the corresponding group message indication appears illogical. However, this situation will only prevail for a few seconds (assuming that system-wide message acknowledgement is not otherwise disabled, e.g., due to a system fault).

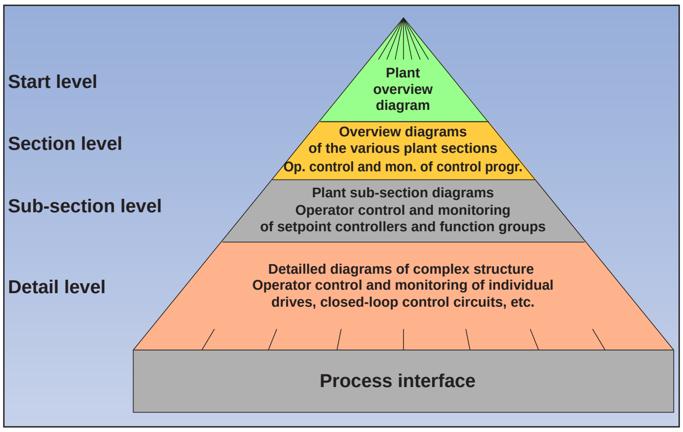
### Horn Indicator

The horn symbol visually indicates a pending acoustic message in the control room activated through the ME-REG function. The horn, usually displayed with a black frame, is then displayed with a red frame. Select the symbol in order to acknowledge the signal.

### Flow Diagram Hierarchy

Process control systems used for the automation of power stations or large industrial plants organize the individual tasks in a hierarchical structure of functionally separated control levels.

The individual areas of the control room, plant control level, group control level, switching level and single control level and their associated functions can be clearly identified. Design and structure of the ME-VIEW process graphics closely follow this pattern. The flow diagrams are produced on hierarchically structured image levels (vertical structure). As you can see from the illustration, the




*Hierarchical image level of the ME-VIEW operator control and process monitoring system*

flow diagrams are organized in four levels (starting level, section level, sub-section level and detail level) which directly reflect the hierarchic levels of the process control system.

### Flow Diagram Allocation

In the section level, the processes of the individual plant sections are clearly represented in one flow diagram for each plant section. The need for more detailled images of individual sub-sections or function groups leads to a structure of additional sub-levels. You can enter the next sub-level from within the currently displayed flow diagram by activating the approriate function, or by means of the hierarchical diagram selection. For every flow diagram up to 12 additional diagrams can be selected on every sub-level.

The clearly-structured flow diagram hierarchy not only allows the direct activation of a flow diagram but also lets you find a specific diagram out of the 1885 possible diagrams with only three mouse clicks in the corresponding selection window.

Maximum number of flow diagrams for the individual levels:

| | | |
|---|---|---|
| • Start level | **1 flow diagram** | 1 diagr. |
| • Section level | **12 flow diagrams** | 12 diagr. |
| • Sub-section level | **12 x 12 flow diagrams** | 144 diagr. |
| • Detail level | **12 x 12 x 12 flow diagrams** | 1.728 diagr. |
| | | ∑ 1.885 diagr. |

### Types of Process Graphics

In addition to the flow diagrams required for a clear overview of the plant processes, standardized diagrams for the control of the process are available:

- Flow diagram (process images, R+I)
- Control panel
- Measuring value diagram
- Criteria diagram
- Loop diagram
- Graphs
- System fault diagram
- Message page

### Flow Diagrams

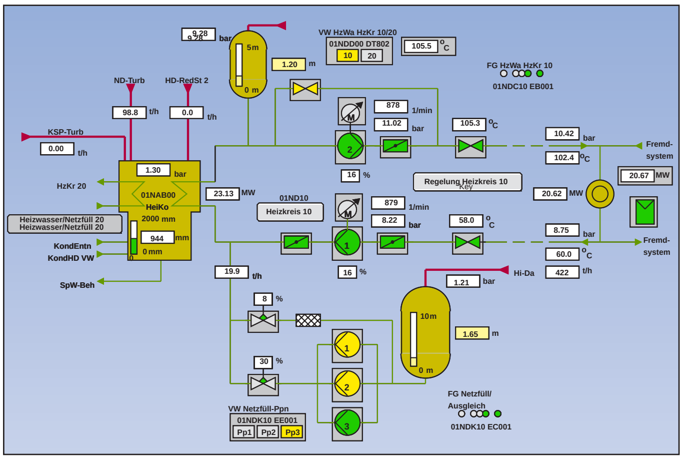
Flow diagrams give you an overview of the technological functions of a plant or plant section.

The image design is based on **DIN 28004**, a German standard for flow diagrams in industrial plants, taking the specifications for process diagrams and the simplified R+I schemes with process engineering pictorial markings acc. to **DIN 30600** into account. Two standard sizes with a ratio of approx. 1 to 1.5 are used for the graphic elements - also called flow diagram symbols, or just symbols. The symbols are available from comprehensive symbol libraries. Symbols for containers and similar objects can be scaled to size to adapt them to the specific task. The design possibilities are virtually unlimited.

A symbol occupies approximately 0.5% of the available flow diagram area. In order to maintain a clear and open structure we recommend that you do not place more than 50 process-related symbols in a flow diagram. Different forms of measured-value displays (decimal display, semaphore, phasor or curve display) can be incorporated to increase the information quantity.

Operating states and faults are usually indicated through changes in colour or flashing of the symbols acc. to DIN 19235 (adapted to the boundary conditions of the screen display system), in rare situations also through symbol replacement (e.g., switch open / closed). The colour specifications for the technological lines are according to DIN 2403 taking the type of medium into account. This ensures that the use of double lines or other types of lines can generally be avoided which facilitates the subsequent maintenance of the diagrams. Different line sizes, adapted to the size of the symbol and the technological requirements, can be used.

The employed signal indications methods of the main operator control function are desribed in section 2 ”Single control level”. It is possible to branch into other diagrams from within the currently active flow diagram. For process-related symbols, especially for symbols representing operator-controllable units, controllers, function groups, etc., or for measured-value displays, additional control elements can be called up in the process control area to the left of the flow diagram.




*Example of a flow diagram*

## Control Panel Diagram

The control panel diagram allows you to operate and monitor all relevant process elements. Its design is similar to that of the control panels and indicators used in Mauell’s mosaic and compact control room systems so that the operator is provided with well-known and well-proven indication and control facilities. The operator has thus the advantage of using a method of operator control he or she is already used to.

## Criteria diagram

The complex processes in large industrial plants follow specific rules and conditions which affect the functions of the individual drives and function groups. These conditions are called criteria which, depending on the required task, can initiate protective circuits, enable the activation of drives or execute a function group sequence. The possibility to view the currently active criteria for the relevant drives or function groups on the screen is therefore very helpful for an efficient operator control of the plant processes (operator prompting).

The diagram displays all criteria for the relevant drive. An unfulfilled criterion is indicated by a yellow background. Pending fault messages and the drive switching state are indicated by symbols and in plain text in the lower right part of the diagram.

Inactive states and faults are constantly displayed in light grey.

The following example of a sump pump shows how the criteria diagram facilitates the operator control of a drive: the pump is switched off by a criterion if the level of the medium to be pumped falls below a critical value. This level limit value thus represents a Protection Off function for the pump. The associated criteria text informs the operator about the reason for the shutdown. Accordingly, the unfulfilled On/Off criterion for every drive can be integrated into the diagram. For function groups, too, usually one or two criteria diagrams displaying the unfulfilled switching criteria can be called up.

While the On/Off criteria (for function groups: operation and standstill criteria) can be displayed by operating the relevant key, the criteria in the step programs are activated by the propgram itself. Only the current criteria of each step are indicated. A maximum of 64 characters can be displayed in one line. The texts are created during function planning and are made available by the database.

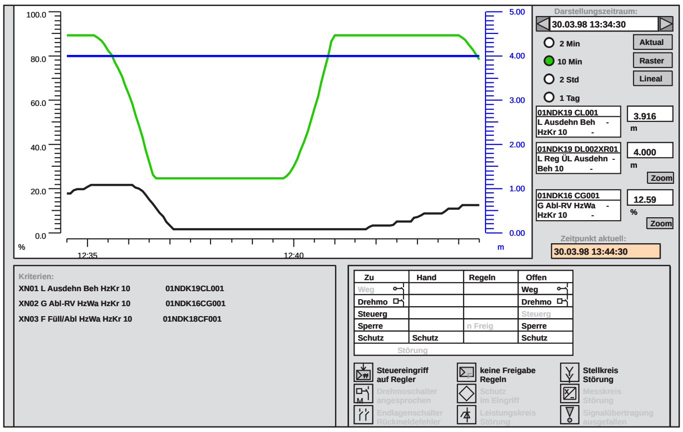
## Loop Diagram

The loop diagram shows the time characteristics of the actual value, setpoint and actuating variable in the form of curves. The scale of the actuating variable is shown in the diagram’s left-hand part, the common scale for setpoint and actual value is displayed in the right-hand part. The dimensions are shown below the scales. Each value is given an identificaton, a plain text and a decimal notation. The colours are assigned in the following way: green for the actual value, blue for the setpoint value, and black for the actuating variable. The common scale for setpoint and actual value is also blue.

The loop diagram can be adapted to the current viewing angle. However, the necessary changes are not saved so that the loop diagram always appears in its original format every time it is called up. The operator can

- select the representation period, 4 options
- change the representation time by searching in the measured-value archive up to the maximum archive depth. This can either be done in constant steps (step length = half window width) or by selecting a specific point of time (point of time of the left window edge)
- spread the display area of the value axes (zooming) to any size within the measuring range limits, separately for the actuator variable and setpoint/actual value scale.
- activate a ruler which can be moved in both directions of the time axis to view the curve values related to a specific point of time. If a diagram is constantly updated, the ruler does not move with the time axis. If historical values are displayed, the curves are fixed anyway so that the ruler time specifications are used as reference when the representation period is changed.
- activate a grid to facilitate curve analysis.
- change the colour of the curve window background, ruler, grid and dimensions. Theses changes are saved and will then apply to all loop diagrams of the ME-VIEW system..

Similarly to the criteria diagram, the unfulfilled switching criteria which can be called up by the operator or which are activated by the controller itself (depending on the type of criteria), are displayed in the lower part of the loop diagram. Just like the criteria diagram, the loop diagram, too, supplies you with status and fault information.



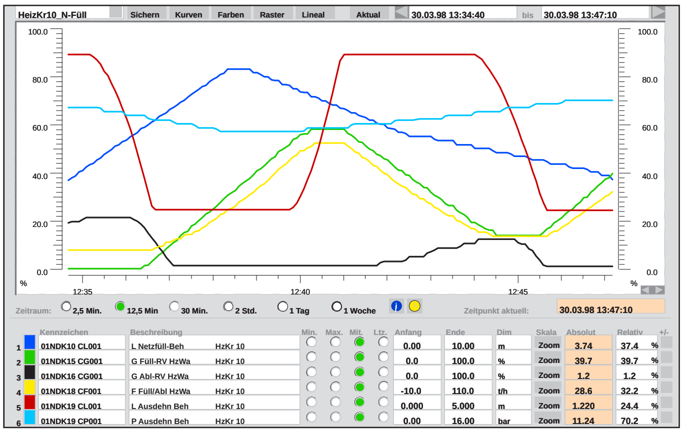
*Loop diagram*

## Graph Window

Up to 6 measuring values can be represented as a function of time. Two basic types of graph windows are available:

- Free graph window
- Fixed graph window

Both types of graph windows have similar functions. The characteristics of a free graph window - which can be activated by pressing the **Archive** button in the selection area - can be defined by the user. The fixed graph window is configured during the project design stage and cannot be used for other measuring points. It can be activated with the **Archive** button but also from within the measuring-point fields whose values are shown in the associated graph window (see below diagram).



*Example of a graph window*

The graph window offers comprehensive diagnostic tools (save and graph selection functions, line colours, grid, ruler, time period selection, zoom function, maximum/minimum value representation, etc.). Various time periods can be selected to allow an exact analysis of technological transitions: 2.5 min, 12.5 min, 30 min, 1 h, 2 h, 10 h, 1 day, 1week, 1 month and 1 year. The curve characteristic is based on 150 support points. At a resolution of 1 s, this results in time period of 2.5 min.

Pressing the (i) symbol opens an information window with status information for the measured-value archiving. The free and the total memory space is shown in kilobytes. The difference of these two values represents the used memory space which is clearly indicated by means of a semaphore indicator (in %). The window also shows you date and time of the ‘oldest’ storage procedure. Depending on the system configuration, additional information can be available. If redundant archiving is implemented, time and date of the oldest redundant archive is shown. If historical data shall be reinstalled, the oldest and the most recent date is shown for the historical data archive.

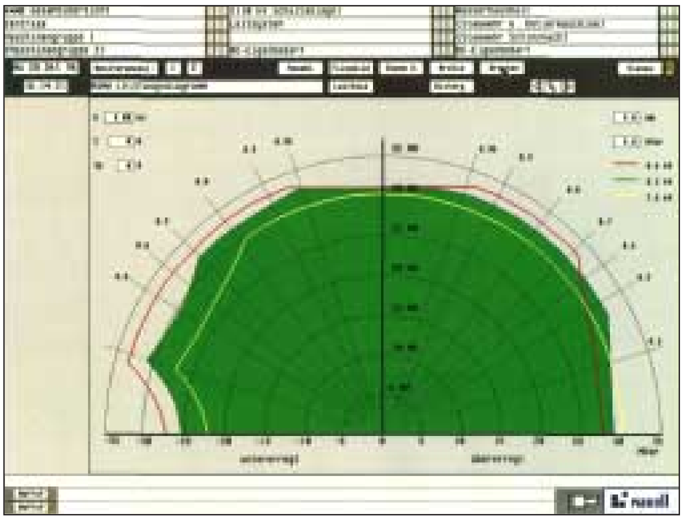
## Characteristic Data Diagram

It is often very helpful to know the current operating point of a large unit. It is therefore possible to call up a characteristic data diagram which shows the operating point in the form of crosshair over static characteristic data. The measured-values are displayed next to the crosshair in decimal notation.

For several similar units with similar characteristics, several crosshairs in different colours can be displayed simultaneously.

The characteristic data diagram can be created with the ME-VIEW image design editor. It is important that the individual characteristics of the diagram are sufficiently defined through equations or primary data. A good copy of a characteristic data diagram or a file in DXF format might also be adequate in some cases.

The crosshair - as a function of an X- and an Y-value - is moved within the area of definable limit curves .


*Characteristic data diagram (motion diagram)*

## Profile Diagram

Measured-values of the same type and measuring range are displayed in the form of vertical coloumns. Designation possibilities are limited, e.g., temperature profile.

## Measured-value Archiving and Representation

The ME-VIEW system allwos you to represent the time characteristics of measured-values in the form of graphs. In order to implement this function historical data archives have to be created. More about data archives and how data can be stored both permanently and consistently is described in the following sections.

## Acquisition and Storage of Curve Values

The measured values are transmitted to the ME-VIEW- system over the SUB-NET bus. Basic signal processing procedures, like signal filtering, are already performed in the measured-value acquisition module of the process control system. These signal processing procedures take into account the boundary conditions of the signal source and the intended application of the signals, e.g., for closed-loop control or limit value generation. The deviation at which a signal transfer is to be initiated is specified prior to the transmission to the SUB-NET bus (hysteresis). The value depends on the intended signal application in the other SUB-NET bus subscribers, e.g., the ME-VIEW system. The application with the highest demands determines the hysteresis value.

To ensure that the characteristics of the curve displayed in ME-VIEW reflect the actual process characteristics, the value for the scanning frequency must be at least twice as high as the value for the signal's rate of change (Shannon's sampling theorem). A scanning frequency (in our case for the scanning of the SUB-NET bus through the ME-VIEW system) of one second has proved to be sufficient for most applications. The ME-VIEW system fulfills this requirerment by implementing cyclic scanning at intervals of $\leq 1$ second.

The currently acquired signals are compared with the values acquired last. If the deviation is not within the specifed limits, the new value is saved. If the value is within the specified limits, it is not saved. This method is called delta value method, or hysteresis. The value is saved together with the time and date of its occurrence. The physical units of the curve values are saved too so that is not necessary to also save the measuring range. The measuring range to be displayed in the graph window (e.g., for the scale) can be derived from the configuration data.

### Delta Value Method (Hysteresis)

The hysteresis operates with fixed values for the deviation from the upper and the lower limit, i.e., the total deviation is twice the hysteresis value, or in other words, if the measured value departs from the upper or lower limit by the hysteresis value - compared to the measured value saved last - the currently measured value is saved (time t1). In the ME-VIEW system, this value is defined in tenths of a percent of the measuring range.

This results in a new position of the hysteresis value. If the value measured next deviates from the specified hysteresis value, the measured value is saved and the position of the hysteresis value changes again (time t2 and t3).

The hysteresis method allows very effective utilization of the storage space as the measured values are only saved if they deviate from the specified hysteresis value. The total number of saved values is thus determined by the dynamic performance of the plant's processes. Empirical values allow an estimation of the required storage space. As signal changes which are within the limits of the hysteresis band are not saved, long periods can occur during which no values are saved. ME-VIEW therefore saves at least one value per interval even if there is no change.

## Data Compression

The method of measured-value archiving described in the preceding section can be called 'spontaneous archiving' resulting in measured-value graphs of the highest possible time resolution. The hysteresis method does not produce any equidistant pivoting points. This means that there are different time intervals from one value to the next. To make this into a continuous curve, ME-VIEW computes uniform pivoting points by means of linear interpolation taking the corresponding times of occurrence into account so that the gap between two values can be represented by a straight line.

A measured-value characteristic can thus be represented over a minimum time period of 150 seconds. As this time period is inadequate for the analysis of most processes, compressed data can be used to generate graphs of longer representation periods (up to one year).
The ME-VIEW data compression tool offers four compression intervals. For short representation periods of up to 2 hours, data compression can also be initiated when the graph window is activated without reducing system performance.

The data are compressed by computing the arithmetic mean values, i.e., the measured values are averaged. This changes the appearance of the graph which becomes more flat the higher the factor of compression. To compensate this, the maximum and minimum values are also saved for each compression interval. These values can be activated in the graph window allowing an accurate interpretation of the process response. In addition, the spontaneous value is saved as the 'last' value for every compression interval, which provides a precise representation of the process behaviour.

The following five compression intervals have proven to be useful. Up to four of these intervals can be used.

| Representation period | Compression interval |
|---|---|
| 10 hours | 4 minutes |
| 1 day | 10 minutes |
| 1 week | 3 hours |
| 1 month | 12 hours |
| 1 year | 6.5 days |

You can specify other compression intervals if required. If possible, the higher compression intervals should be a multiple of the lower compression intervals. You can also define compression intervals below a 4 minute period but these are normally not required for normal graph representation.

The ME-VIEW systems offers comprehensive signalling and recording functions (ME-REG) which inform the operator about deviations from the plant's normal operating states, unit failures, and about faults in the process control system itself. Operating states and faults can also be recorded, stored and printed.

The ME-REG function scope comprises functions for the recording of events/alarms, the message display on monitors, the message output on printers and message saving on two different size drum storage facilities.

If required, a software (ME-ANALY) for an external message analysis is available. The ME-ANALY program reads out the ME-VIEW long-term message memory and links its content to a Microsoft Access database. Using the praxis-oriented predefined filter and sorting functions and message statistics, all signalling events can be easily analyzed. The entire function scope of Microsoft Access is also available.

The signalling and recording functions of the ME-VIEW system provides the operating personnel with the necessary information that enables them to

- detect faults in time,
- quickly find the cause of the fault,
- and take the approproate measures to correct the fault.

The decentralized message acquisition takes place in the programmable controllers of the ME 4012 system. The messages can be transmitted to each one of the ME-VIEW monitors (or ME-REG monitors) and one of the four possible printers.

Basic characteristics of the message processing system:

- All messages are provided with a time stamp at the source
- The system transfers the messages to the message buffer using 5 second intervals; messages that arrive afterwards are indicated by an '!'.
- The message processing functions can be configured for each message individually. The following functions can be specified:
  - Coming message only (single message) or coming and going message (double message)
  - Rising or falling signal edge indication of the coming message
  - Message colour assignment with respect to the message priority
  - Messages can be combined to form message areas
  - A message can be connected to a specific flow diagram which can be activated from within the message line (ME-VIEW)
  - The message output device (monitor, printer) can be specified
  - Individual message texts and additional information
  - Up to 3 acoustic indicators (horns) can be assigned

**Message Types**

The signalling system presents you with an overview of all coming messages. The supplied information can be divided into five groups:

- Recording of operating data
- Recording of trigger causes
- Indication of process faults
- Display of device fault messages (ME-VIEW)
- Dispaly of system fault messages (ME-VIEW)

The subprocessor modules provide each process message with a time stamp before it is transmitted to the monitoring and event recording system over the SUB-NET process bus. The time signal for the synchronization of the individual subprocessors is generated by radio clock receiver and transmitted over the SUB-NET process bus. The message are printed out in reports with a time resolution of 1 ms.

**Operational Data**

The recording of operational data of drives, closed-loop controllers and function groups are important for the analysis of the plant operation. Processes can be reconstructed and conclusions about automatically and manually initiated sequences can be drawn.

**Trigger Cause Messages**

These messages inform the control room personnel about the automatic switching of units for the protection of the operating personnel or plant components. By means of logic circuits in the programmable controllers of the ME 4012 system, the messages are generated individually for each unit and each trigger signal, finished with a time stamp and transmitted to the ME-VIEW system over the SUB-NET.

**Process Fault Messages**

Process fault messages inform the control room personnel about those plant states which require attention and whose cause can be remedied by corrective measures. The transmission with time stamp ensures message acquisition If additional fault information is required for individual units, these messages should be configured as process fault or trigger messages, i.e. as single messages furnished with a time stamp at the source. This feature is not part of the system's function scope and should therefore be configured individually for the specific tasks.

**Device Fault Messages (ME-VIEW)**

The group of the device fault messages comprises all trigger events that require an acknowledgement of the control component (drives, closed-loop controllers, etc.) and also measurement faults (not acknowledgement-dependent). The information is made available to the system by means of signal words transmitted from the individual units (controllers, drives, measuring points). The signal words contain the detailed acknowledgement of operating states and failure causes in coded form. In the associated flow diagram the information can be analyzed and the message can be acknowledged using the diagram's displays and operating elements.

If additional fault information is required for individual units, these messages should be configured as process fault or trigger messages, i.e. as single messages furnished with a time stamp at the source. This feature is not part of the system's function scope and should therefore be configured individually for the specific tasks.

### System Fault Messages (ME-VIEW)

This group of messages informs you about all faults in the process control system (hardware and software faults).

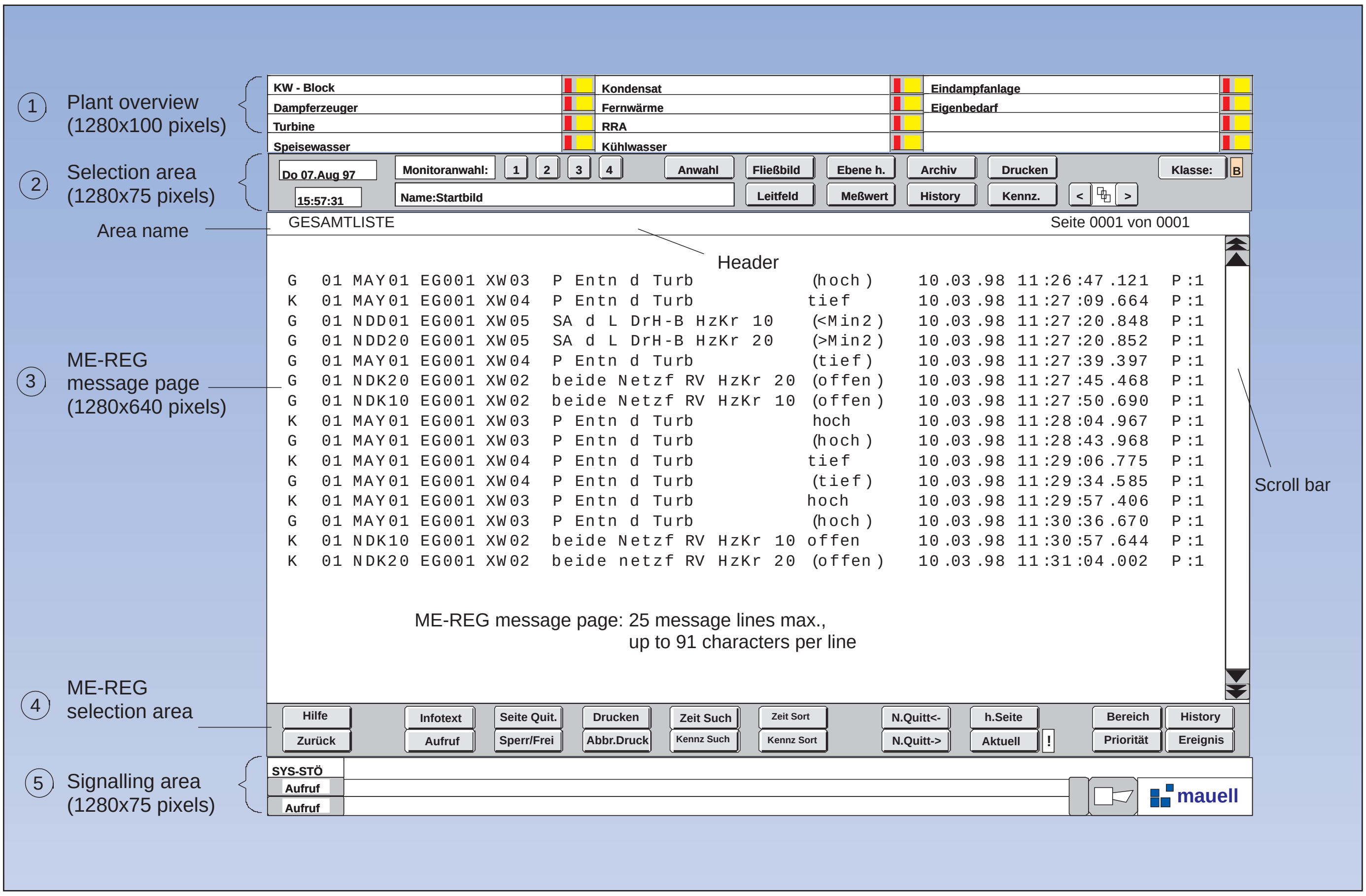
Software faults are all messages which are recognised and transmitted by the software of the ME 4012 subscribers. The messages are triggered by evaluating the error words which are transmitted by the active SUB-NET subscribers - either at specified intervals or if a change occurs. Due to the chronological recording of software faults in the error memories of the individual ME 4012 programmale controllers, the recording of software faults is not implemented in the ME-VIEW system (execpt for the subsriber failure messages).

Hardware faults are faults which are detected by means of hardware or whose causes can be traced to the peripheral devices (example: automatic circuit-breaker tripped). They are decentrally acquired by the cubicle monitoring modules and passed on over the SUB-NET. Before the messages are transmitted to the ME-VIEW system they are preprocessed (preceding logic operations) in separate system diagnosis components. Messages that are to be recorded are furnished with a time stamp.

### Strucure and Functionality of the User Interface

A well-structured representation of the signalling functions is essential for an efficient operator control of the system. The signalling functions therefore use some of the permanently displayed elements of the ME-VIEW user interface. When activated the message window (ME-REG window) is displayed in the control panel and flow diagram area of the user interface which results in the following screen structure:

① Plant overview with area group messages
② Selection area
③ ME-REG message page
④ ME-REG selection area
⑤ Signalling area
- System status bar
- Alarm message bars




*Message page in the ME-REG window*

The user interface is divided into 5 areas: areas 3 and 4 make up the ME-REG-specific signalling window, areas 1, 2 and 5 are fixed areas which are part of all dialogs.

The ME-REG message page can be displayed on one of the monitors of the ME-VIEW workstations.

### Plant Overview

The area group messages (12 messages max.) in the plant overview area are intended for the visual indication of pending fault messages. Indicators for the message types

- process fault alarm (red)
- device fault alarm (yellow)

exist for each section. The indicator flashes as long as at least one unacknowledged fault messages is pending. When all messages have been acknowledged, but messages are still pending, the box emits a steady light. The light goes out when no messages are pending.

- **Indication of process fault messages**
  Pending process fault messages are announced by the red group message indicator provided for each plant section. Selecting this indicator opens the corresponding message page. Here you can view and acknowledge the single messages for the selected plant section. Aknowledgement of all messages also acknowledges the associated group message which subsequently stops flashing. If no message is pending, the red indicator is reset (goes out).
  The process fault group messages in conjunction with the message pages represent a classical visual indication system and are thus intended for those fault messages which allow operator intervention in order to prevent the activation of tripping-on-fault circuits in the overall system or individual plant sections.

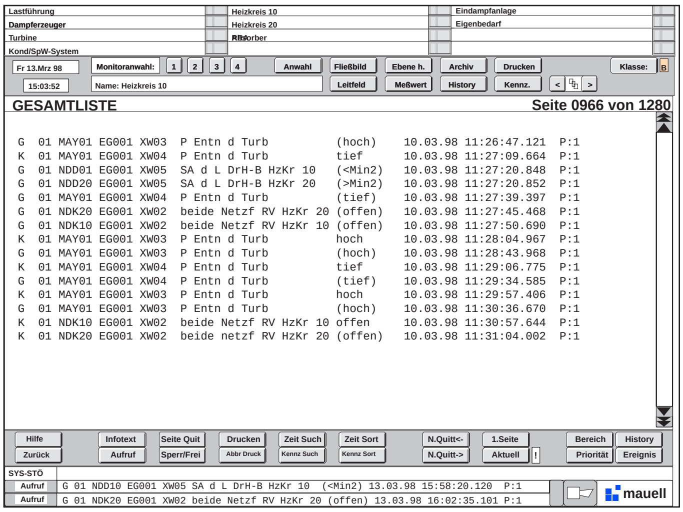
- **Indication of Device Fault Group Messages (ME-VIEW)**
  Pending device fault messages are announced by the yellow group message indicator provided for each plant section. Selecting this indicator opens the flow diagram with the faulty device where you can perform the necessary actions to remedy the fault.

  Selecting a flashing indicator opens the flow diagram with the most recent unacknowledged device message. Selecting an indicator showing a steady light allows you to open the flow diagrams containing - in consecutive order- the fault messages already viewed, but still pending. If new fault messages arrive, the group message box will again respond by showing a flashing light.

  The fault message indication box also displays the number of device faults detected.

### Message History

All comimg and going process fault messages are stored in chronological order in the so-called history buffer (in the form of message lines). Up to 32 000 messages can be stored in this message buffer. If this number is exceeded, the oldest message will be overwritten. It is also possible to cyclically store the messages on storage media for long-term archiving. This can be the computer's hard disk or storage medium which is connected to the ME-VIEW system via the PD-LAN network (the ME-VIEW archive server, for example). In this case, ME-VIEW has no longer acces to these messages. The optional program ME-ANALY can then be used for the external message analysis.
Select the output format "History" to view the messages page by page. As a message can be triggered several times (coming as well as going messages) it can also appear several times on the history page. All messages are displayed in the same colour, irrespective of their priority or whether they are coming or going messages. The history buffer is constantly updated with the newly arriving messages. The maximum number of 32 000 messages results in a maximum of 1280 history message pages. Use the scroll bar to view a page line by line, page up or down, or to move to any position in the message buffer.



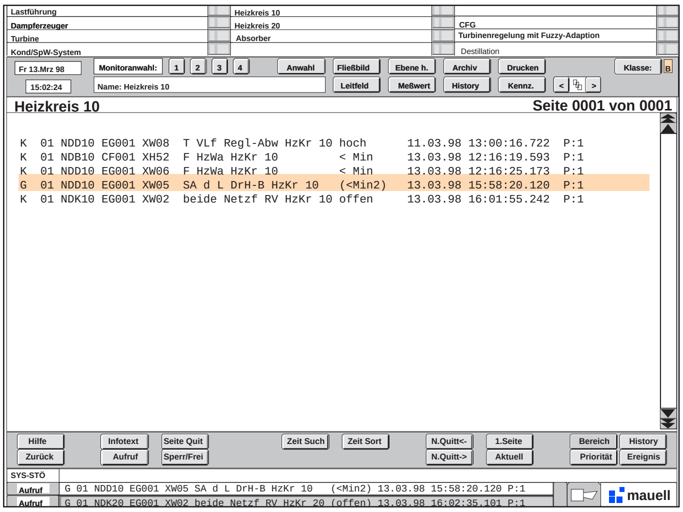
*Message output format "History"*

### Area Messages

The area message output format corresponds to the conventional form of visual/acoustic message indication. Select this format to call up all currently pending and all unacknowledged messages of a specific group message area (exception: messages of the area 0 or with the priority 0 do not appear in group messages).

To specify a group message area select the corresponding red group message box in the plant overview. The name of the area is displayed in the window header. The pressed "Area" button also indicates that this message output format is currently selected.

Acknowledged going messages are deleted from the group messages (double message). The following applies to single messages: if the going message is not acknowledgement-dependent, it is deleted after the coming message has been acknowledged. Use the scroll bar as described above. For the 12 plant sections, a maximum of 16 000 group messages can be organized on 640 pages.

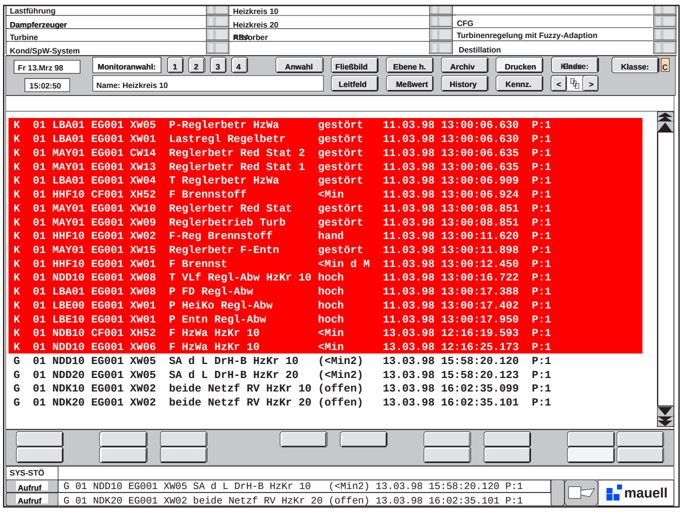



*Message output format "Area"*

It is an essential characteristic of area messages that every area message only occupies one line on the message page (provided that it is pending or not yet acknowledged). Even if one and the same message is triggered again and subsequently its time of occurrence and state are updated, it will still occupy the same position on the message page. This ensures that messages can be easily found and recognized on the message page and that the information about pending and unacknowledged messages can be quickly extracted. All message lines are displayed in the same colour. Only the coming and the going message differ in colour, irrespective of the message's priority. The messages on the area message page are always acknowledgement-dependent. You can specify for every message (during project design) whether only the coming message (single message) or the coming and the going message (double message) shall be acknowledgement-dependent.

## Priority

The functionality of this message output format is similar to that of the message output format "Area" except that the priority format also allows pending messages of priority 0 to be displayed. The message priorities are sorted in ascending order (priority 0 to 9).




*Message output format "Priority"*

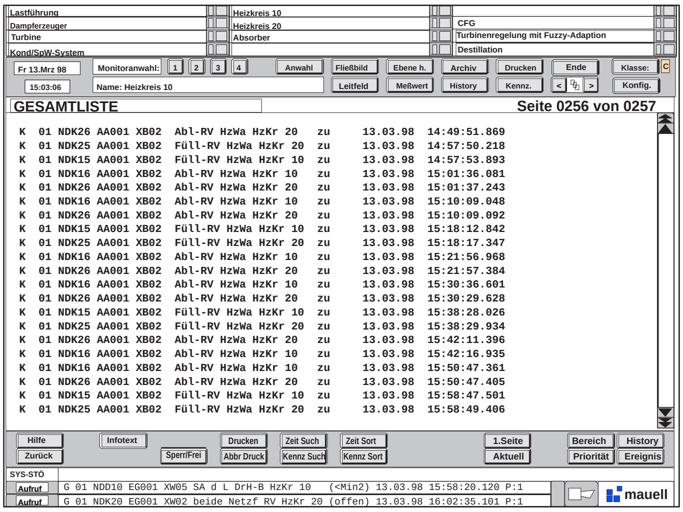
The messages are arranged in chronological order (the most recent message is displayed in the bottom line) within the different priority levels . Different colours are used for messages of different priority, and also for coming and going messages. The colours for priority, coming and going message, and also for the representation in the alarm display, can be assigned during the project design stage.

All messages in the output format "Priority" are acknowledgement-dependent.

## Event Messages (Operational Messages)

The messages about the switching states of drives, closed-loop controllers, function groups, etc., are handled by a separate message buffer - the event buffer. Up to 20 000 entries (800 pages) can be organized in this message buffer. The messages are not assigned to a group area. Just like all other process messages, the operational messages, too, are provided with an identification code which relates them to a specific plant section.

The event buffer is organized in a similar way as the history buffer. Long-term archiving on hard disk or external storage medium is possible; the ME-ANALY program can be used for the external



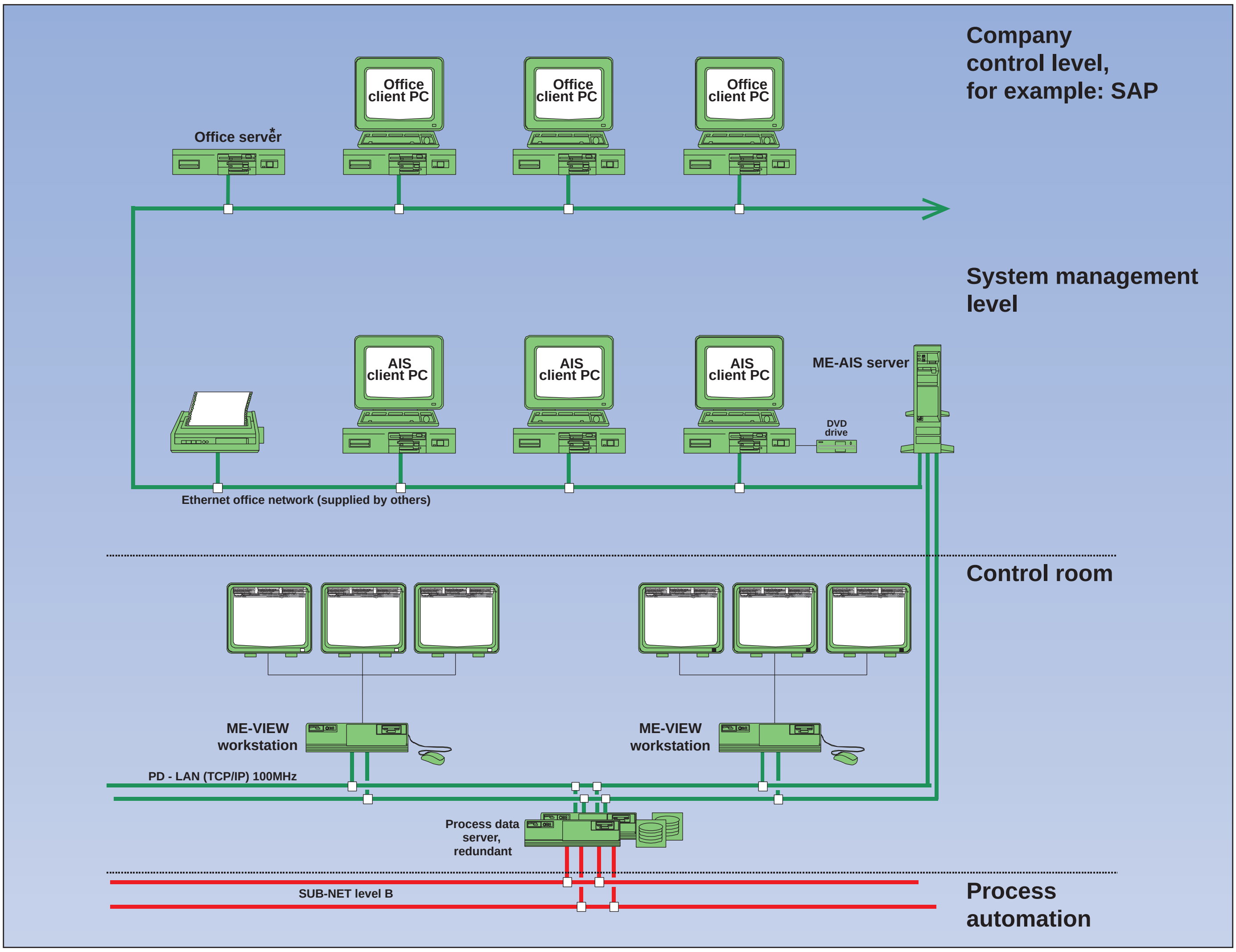

*Message output format "Event"*

analysis. Due to their diversity operational messages cannot be displayd in the output formats described above. Operational messages are not acknowledgement-dependent and are all displayed in the same colour. Priorities cannot be assigned.

## Plant Information System ME-AIS

The Mauell ME-AIS plant information system allows access to all operational data in the ME-VIEW process server, and to further process and evaluate this information. ME-AIS is an autonomous system for reading and evaluating process data, and for process monitoring and fault diagnosis in power stations. It is designed for the medium-term and long-term analysis of process data with the aim to:

- optimize the process,
- obtain characteristic values and use these to increase resource availability,
- document the individual operational process sequences.




*ME-AIS server and ME-AIS workstations (clients) and their integration in the network of the company's management control system*

The ME-AIS system can also be used for long-term data archiving and performance analysis in the areas of resource utilization and power generation efficiency. It is also a suitable tool for monitoring and evaluating slow variations over long periods. The principal tasks of the ME-AIS process information management system are as follows:

- Long-term archiving of the process data provided by the ME-VIEW system. The values to be archived can be instantaneous process values or values that are reduced according to defined algorithms.
- Data reduction to calculate sum, mean and extreme values and cyclical data backup on safe storage media over long periods
- Computing of important characteristics and performance data
- Generation of balance sheets and statistics
- Output of reports, at regular intervals and on request
- Plant monitoring to obtain data about runtimes, consumption, production and maintenance intervals
- Modification of the resulting data by the operator (manual data input)
- Process visualization in configurable graphics and tables
- Preparation of process data for access by external applications
- Visual representation of power generation data provided by higher-level systems
- Calculation of maintenance data

## ME-AIS System Hardware

The ME-AIS system receives its data from the ME-VIEW process data server (PD server: main server or standby server). The information required for operations planning and management in the PC office environment of the power station is also provided in this way. Transmission of this information to the visualization systems is under development.

Due to our integrated systems approach the ME-AIS system does not require any special configuration to receive the process data. All changes that occur in the ME 4012 process control system are automatically adopted by the ME-AIS system as soon as the operator initiates the request.

The ME-AIS architecture is based on the client/server principle using Windows NT. This makes it possible to install ME-AIS workstations anywhere in the plant. The ME-AIS client/server architecture also offers the advantage of facilitating further integration in customer data processing systems.

## Hardware Environment

The ME-AIS server executes all cyclical calculations and functions that are required by the clients, whereas the clients are responsible for all standardized and user-specific evaluations. The resulting files can be made available in the company management network as required, always taking into account the defined user rights.

Smaller applications may run the client and the server on the same hardware.

Overloading can be avoided by running no third-party programs. To ensure that all calculations can be safely carried out in the defined intervals, say every 5 minutes, powerful industrial PCs with an MS-Windows operating system should be used for the server and the clients. In an ME-VIEW application with server redundancy the ME-AIS server is connected to both process data servers (PD servers) and is therefore also used for mass data storage. The size of the memory is determined by the volume of the process data to be recorded, by the dynamics of the process and the required period for data backup.

At present all process data is stored on up to 6 hard disks of 18 GByte each on highly available storage media of RAID 5 security. Should a fault occur in the RAID bank or on a local PD server disk, all PD servers connected to the network and the ME-AIS system are automatically matched after power recovery. This distributed memory organization ensures consistent and gap-free long-term archiving even in the event of a hard disk failure.

## Protected Data Communication

Access to the data of the process control system is protected by restricting the basic mechanisms of the IP forwarding procedure.

## ME-AIS Standard Applications

The ME-AIS server acts as the application computer and executes all calculations required for measurement value transmission, plausibility checks, summations and balancing. These calculations are based either on the instantaneous values or the reduced values (min., max. or average over a defined period), as required.

The integration of widely accepted standard software and the introduction of standards for table calculations (MS-Excel) pave the way for almost unlimited possibilities of further processing and representation of process data to optimize plant management. The user can thus evaluate the process data using functions such as

- Table calculations
- Presentation graphics
- Data analysis
- Individual application programming
- Standard applications for
  - Counting operational hours
  - Conting switching cycles
  - Generating shift reports containing daily, monthly or yearly reports
  - Additional programs as required

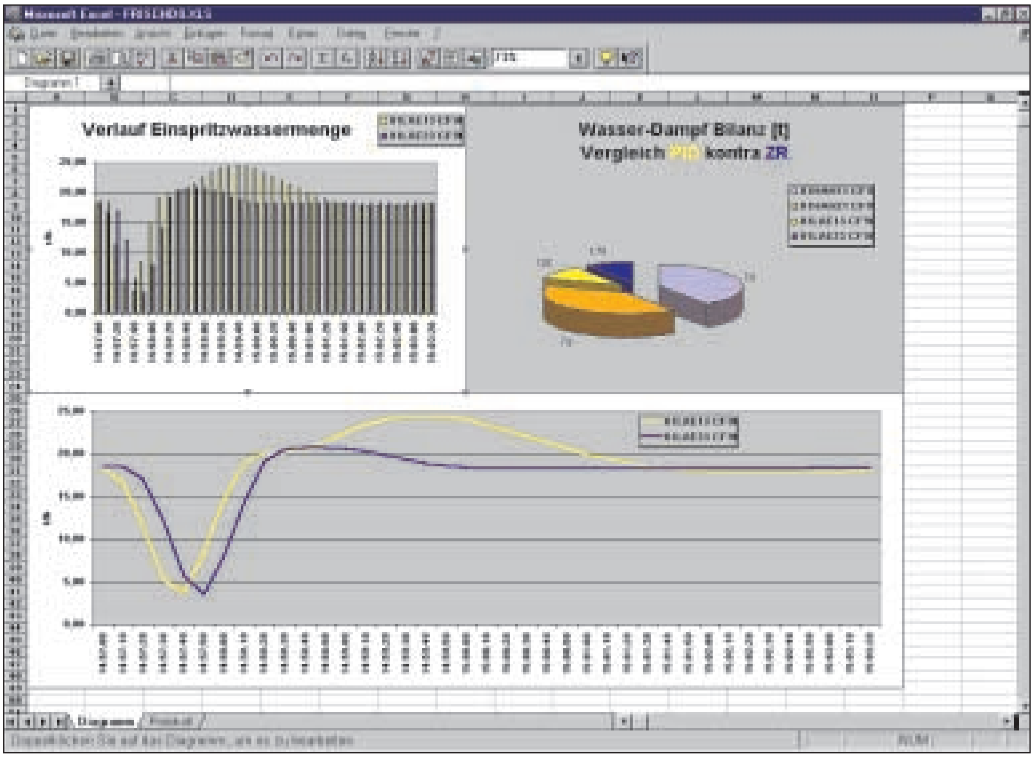



*Diagram view in a process data analysis tool*

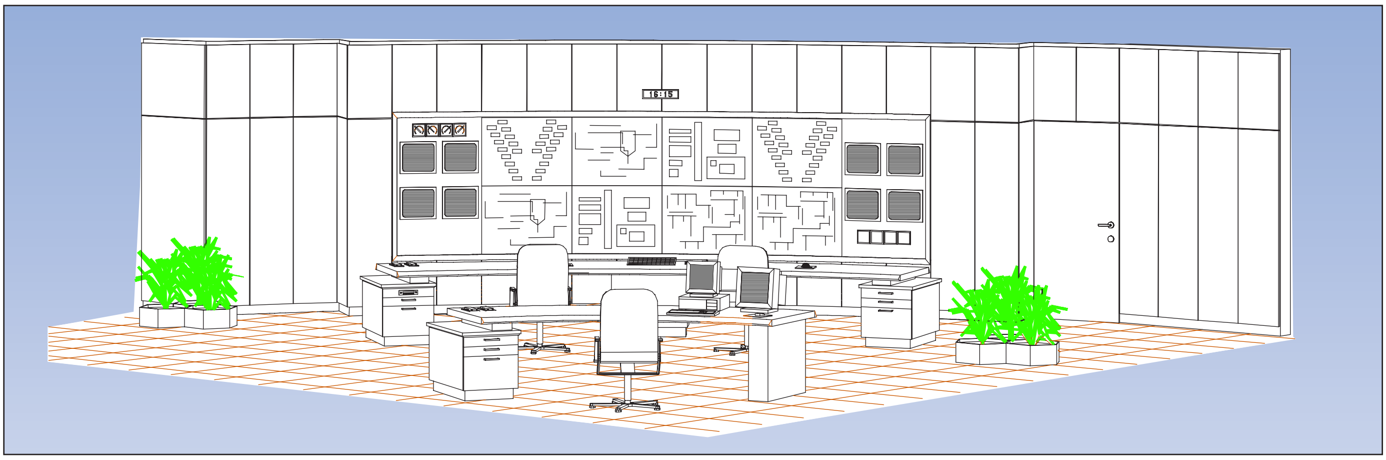
The figure on the left shows some of the applications that can be used to analyze and illustrate process values and process behaviour.

## Control Room Design

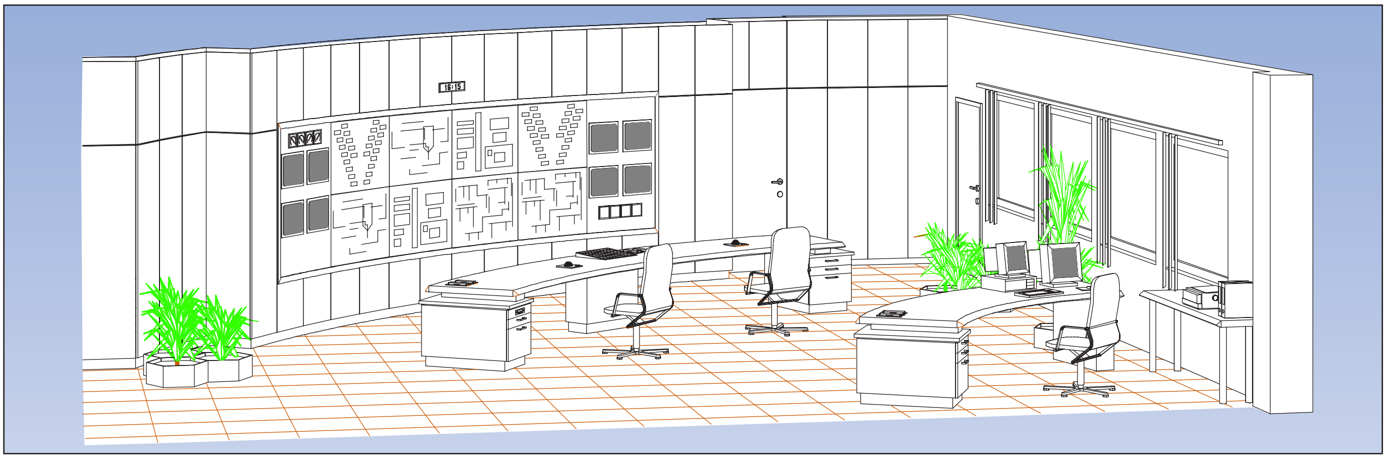
The control room is the interface between the plant operators and the process. Easy and safe plant operation depends to a large degree on the layout of the control room.

A clearly structured layout and the optimal use of mosaic-type displays, visual display units and large-screen projection ensure that the plant operators can easily read and interpret the information displayed.

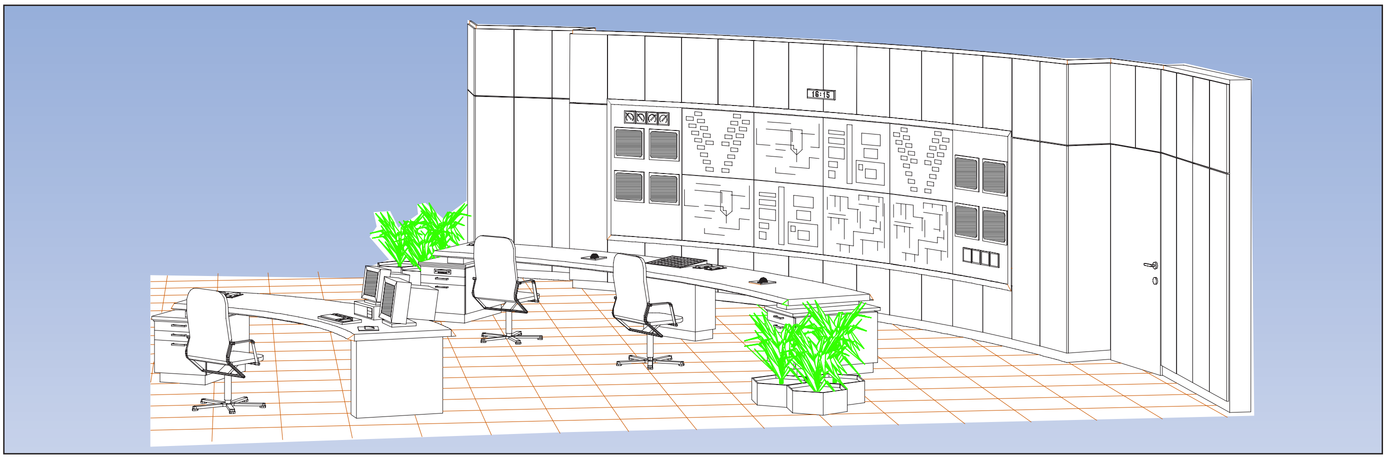
Helmut Mauell GmbH have many years of experience in the design of control rooms. Layout and architecture of the control room are usually planned in close cooperation with the client. In addition to the technical and economic requirements, aspects such as ergonomic design and human engineering play an imoprtant part in our design concepts.




*Control room concept: Monitor room*




*Control room concept: View 1*




*Control room concept: View 2*

### Objective of the ME-DRP Concept

Due to the ever increasing complexity of modern automated plants and installations, one of the difficulties in today's installation planning is the fact that many different technical entities must be able to communicate with each other.

The example of a pump illustrates the task:

- The process engineer defines in the basic engineering plan that a pump with defined technical characteristics is required.
- The pump supplier delivers a pump according to this specification.
- The electrical engineer defines the characteristics of the drive.
- The process control engineer enters the drive in the automation concept.

Each of these different engineering fields has developed its own methods and tools to optimize project planning and design. Although all engineers have the same object in mind - in our example, the pump -, they evaluate their specific part of the problem without any consideration for the other engineering aspects.

In precisely this situation, an object server which is the basis for the ME-DRP computer-aided engineering solution has a huge optimization effect.

Another reason for the development of the ME-DRP concept was the awareness that today a considerable part (10 to 15%) of the overall project costs lies in the knowledge-based information. The fact that the information content in the installation planning phase is closely linked to the costs of a project is more and more recognized by enterprise management. The introduction of maintenance and management systems is at present the immediate result of this development. Plant information which should be made available by the project planning team is usually not yet taken into account.

This means that in practice there is a break of information between installation planning and installation maintenance. A second effort is necessary to obtain this information (process and plant data) a second time, and to manually feed it into the relevant systems.

### Control Concept Planning, Commissioning, Diagnosis and the Concept of Coherent Computer-Aided Design and Configuration (ME-DRP)

The ME-DRP concept provides the user with security and data presence in various ways.

- It allows the planner and the plant owner to work with only one tool in all lifecycle phases of the project so that all plant information is consistent and available at all stages of the project: during planning, during installation and erection, during commissioning and maintenance. ME-DRP also allows the integration of already existing third-party systems.
- The system is database-independent, which means that today relational databases (RDBMS) can be linked to it. In addition, the structure of the ME-DRP concept will in the future allow the use of object-oriented databases. This results in a considerable protection of your previous investments in relational databases such as ms SQL Server or ORACLE.
- The international open standard OLE Automation made it possible to remove all database-specific enquiries (relations) from the ME-DRP modules and transfer them to the Object Manager. Other than existing database concepts, this principle has the effect of separating the application/user interface levels from the database level.
- The consequent use of OLE objects has resulted in a system structure which at present counts among the most open. Any third-party application with OLE capabilities has therefore access to common and consistent data by making use of the OLE objects of the ME-DRP server.
- Easy use of the server functions of the object manager by means of ME-DRP modules, and also by means of already existing standard software or modules of third-party providers on the basis of standard software, such as MS-Office (Word, Excel), and of open standard programming tools, such as Visual Basic, Visual C++, etc.
- Access to the databases exclusively by means of the ME-DRP Object Manager. This means:
  - Consistency for all ME-DRP modules
  - Identical and therefore easy handling and maintenance procedures for administors, users and supporters of the overall database.
  - Easy adjustment of customer applications and creation of new applications due to standardized OLE interface.

### Object Manager

All object operations are processed by the ME-DRP Object Manager. Objects, once used, are kept in the Object Manager's memory administration. This means that repeated access to the object does not require a repeated search in the database. Time-consuming database access procedures are thus kept at a minimum.

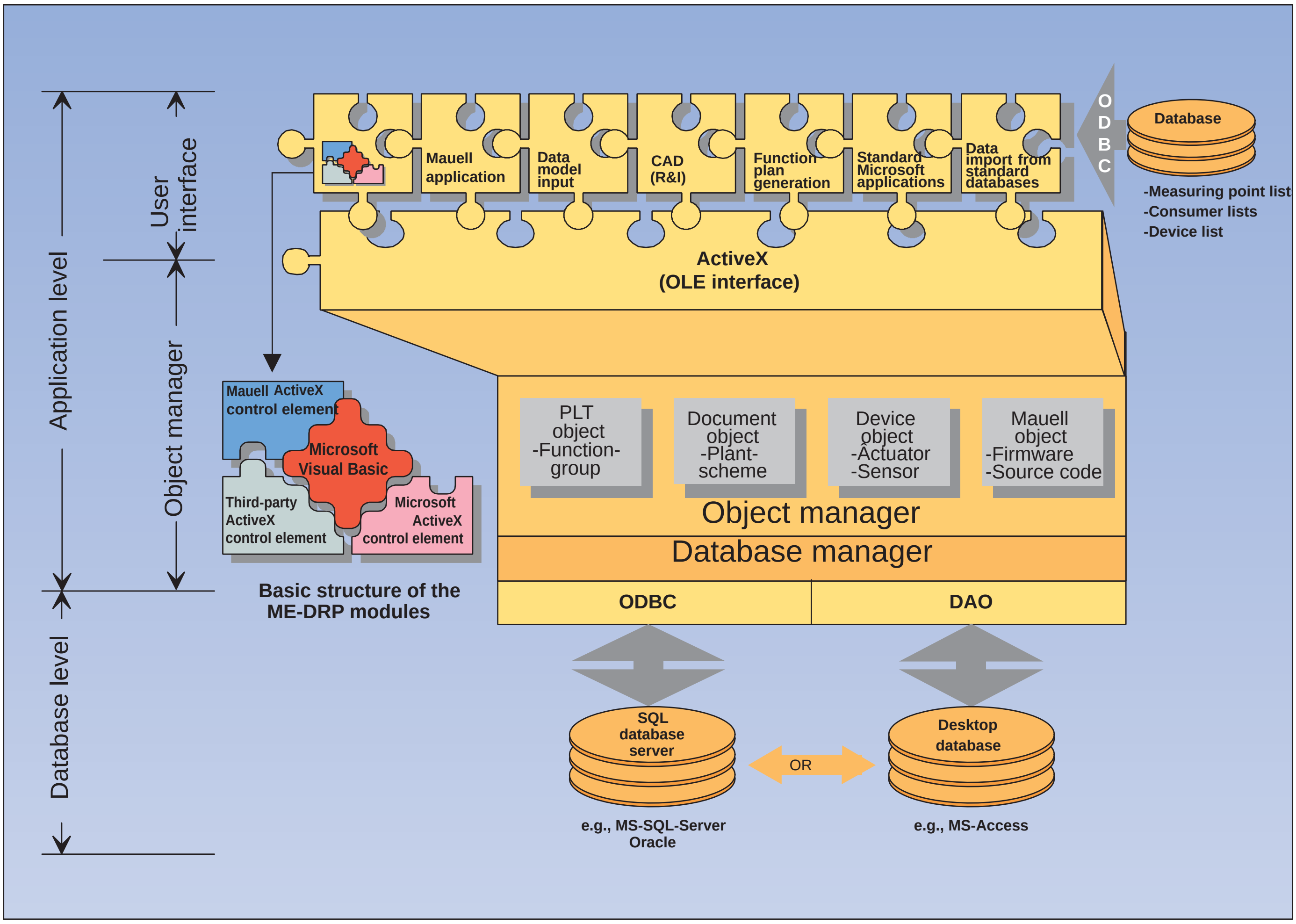
The ME-DRP Object Manager ensures that the requested object data is always the most current data, even if several people connected to the DRP-LAN network work on the same project. If an object is stored in the working memory of several stations, and it is modified or deleted on one station, there is no risk that the other stations work with “old” versions of the object. ME-DRP continuously informs the workstations registered with ME-DRP of any objects which have been modified or deleted. The Object Management of the addressed ME-DRP workstation automatically updates the object properties accordingly.

**.Database Manager**
The database manager of the ME-DRP system is a standard MICROSOFT product: the Jet database module. The Jet module is a component for data management which is also the basis for other applications with data acsess capabilities (MS-ACCESS and Visual Basic). The requested information is called and stored with the aid of data access objects (DAO) and ODBC (Open Database Connectivity).

**Desktop Database**
The database manager also handles the connections to the database system. A Desktop Database (MS-ACCESS compatible data format) is an integral part of the ME-DRP system and does not require any special administration.

**SQL Database Server**
The data access objects (DAO) of the Jet module can establish a connection to any database that has an ODBC driver. The administrator uses ME-DRP tools to create the required tables in the requested relational database (SQL Server) and to link these to the database manager.

**ME-DRP Software Structure**
The development of the ME-DRP system driven by the aim to create a comprehensive and open program packet on the basis of standard interfaces, such as COM and ActiveX. It provides a uniform windows-oriented graphical user interface for the planning, commissioning, operation and maintenance sections. The requirement for this was the compliance with a number of regulations and standards and quality control specifications (Windows NT, VGB 170-C, DIN/ISO 9001).

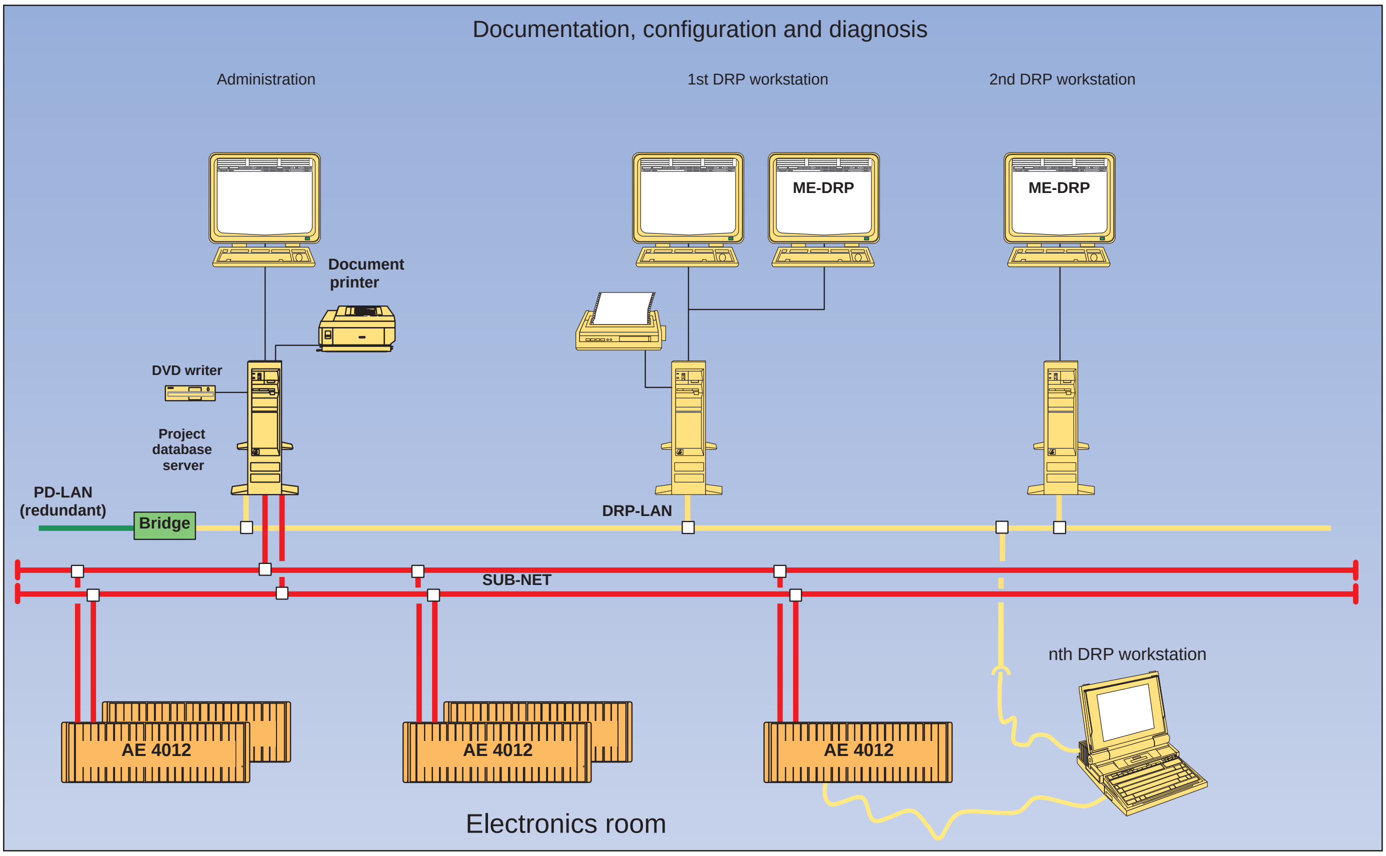



*ME-DRP software structure*

**ME-DRP Hardware Structure and Functional Scope**

The ME-DRP concept allows the central planning, documenting and processing of the functions and configuration of the ME-VIEW operator control and process monitoring system, and of the AE 4012 and ME 400 automation units. This requires a configuration network (DRP-LAN), comprising a central project data server with printer and at least one CAE workstation. The number of workstations is not restricted. Each workstation has full and equal access to all ME-DRP functions. The workstations can be individually equipped with additional devices, such as up to four screens or local printers.

If the ME-DRP workstation is a portable computer connected to the DRP-LAN network, it is possible to connect this workstation through the serial interface directly with individual suprocessors of the AE 4012 automation units. This accelerates the data exchange with this particular subprocessor which may prove necessary for the transmission of large programs.




*ME-DRP hardware structure*

The ME-DRP workstations allow the following functions:

- Management of the site-specific control equipment and the project database
- Generation of all lists and cross-references with regard to the central project database
- Installation planning and generation of all function and execution descriptions
- Hardware planning
- System structure planning
- Generation of the source code of all subprocessors of the AE 4012 automation units across the entire SUB-NET process bus
- Generation of plant schemes for the function plan. These plant schemes also serve as the basis for the screen diagrams and graphics for the ME-VIEW operator control and process monitoring system
- Connection of a remote diagnosis interface for online fault diagnosis and service support by the Helmut Mauell Service Team in the Mauell headquarters
- Central data backup by means of DVD disk drive (Writer) in an DVD RAM

Although the configuration and design work can be carried out simultaneously on several workstations, data integrity and consistency are ensured by the central project database and the online connection between the various workstations and the server over the DRP-LAN network.

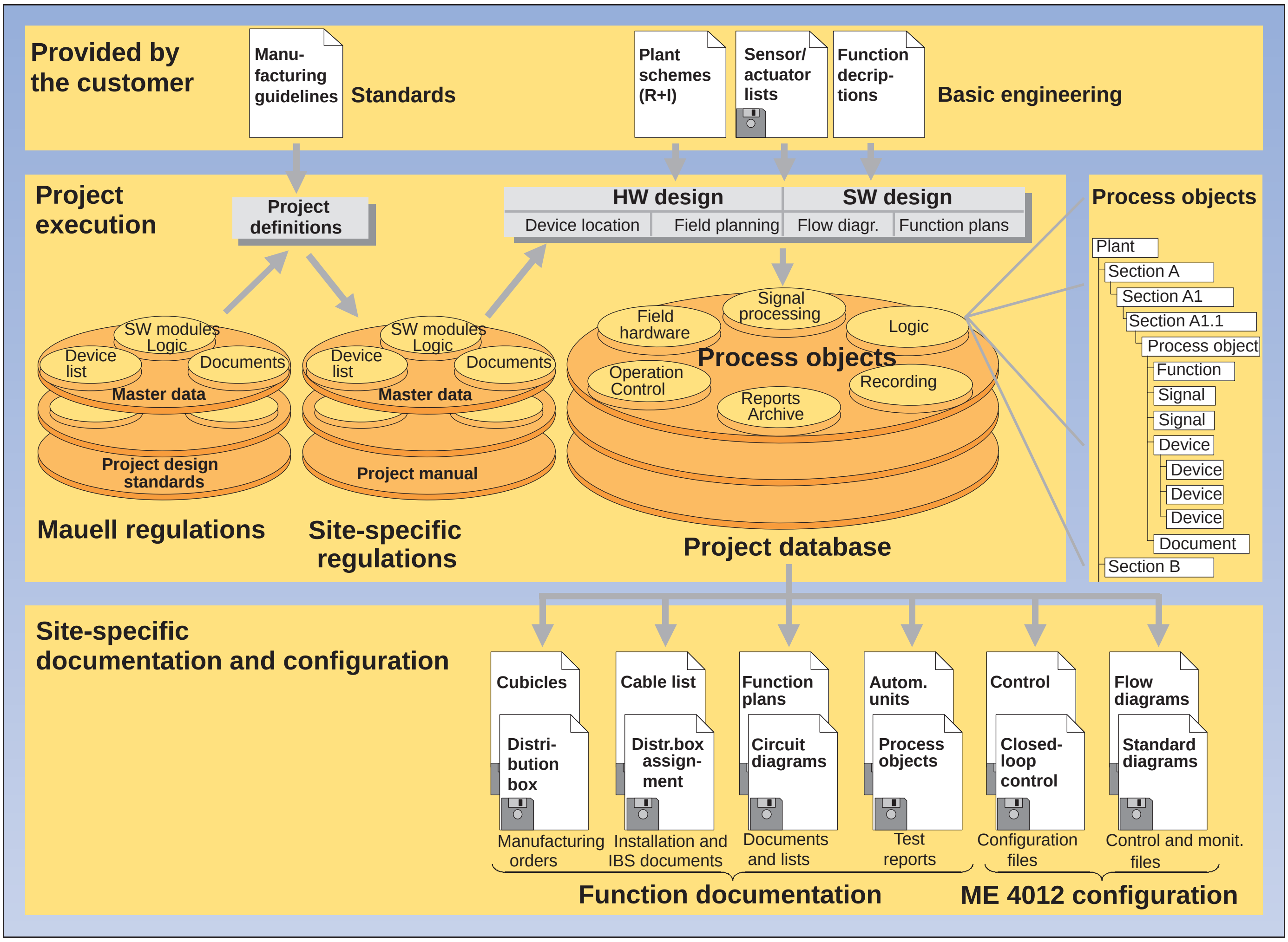
The configuration files of the distributed subprocessors connected to the SUB-NET process bus are read and written through a direct SUB-NET interface of the ME-DRP project database server.

New ME-VIEW screen graphics and preconfigured diagrams and graphical data representations are loaded through the bridge to the PD-LAN (process data LAN). This LAN directly connects the design workstations to the running ME-VIEW operator control and process monitoring systems.

The central server also acts as the printer server when it comes to printing out the project data documentation, including the configuration data and the entire ME-VIEW graphical user interface. For this purpose it is connected to a colour video printer or laser printer. This interface processes the ME-VIEW process diagrams digitally taking into account the current plant status. Thus, a flashing light on the screen is printed out in a special colour.

### Function Planning

Already at the earliest stage - in the tendering phase - of a process control project are the customer execution regulations and Mauell's design and configuration standards matched and clearly defined and taken into account in the quotation. This includes details such as delivery times and limits, the range of devices to be employed, and the principal structure of the control scheme.




*Overview of the ME-DRP structures*

This detailed tender forms the basis for our project team, our client and their planners, if applicable, in the joint preparation of a precise and site-specific project manual and a more detailed architecture of the control scheme.

The information required for the computer-aided design is taken from the master data and adjusted to the specific site conditions. This includes for instance details on the device spectrum (control system components and sensors and acutuators), project documentation for all project stages, the software functions to be applied, the labelling methods used for the equipment, the process objects, and the site locations.

The term "process objects" covers all actuators, sensors and autonomous software functions (e.g., step control, preselections, closed-loop controls, etc.). To each of these process objects is allocated a basic function which may comprise elements such as field hardware (e.g., transducers), I/O signal conditioning (e.g., measurement value filtering), basic logics, operator control and process monitoring, data logging/archiving and message recording. Every function and consequently every process object can of course be assembled of individual elements. Yet it is recommended to ensure a high degree of standardization so that engineering work for planning, testing and commissioning can be kept to a minimum.

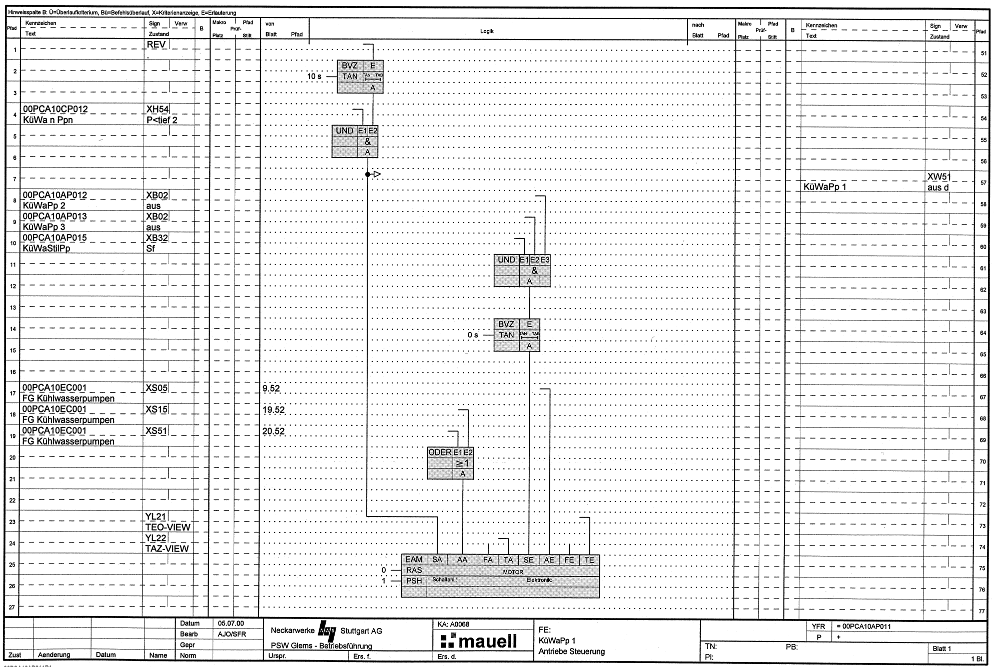
### Execution Planning

Planning the execution of the project and implementing the automation task requires a basic engineering concept from the customer, comprising R+I schemes, lists of the measurement points and drives as well as function descriptions. The R+I schemes describe the relationship between all drives (actuators), measurement points (sensors), tanks (containers) and their connections (e.g. pipelines). The project team then uses these basic engineering plans to elaborate a detailed engineering concept in the form of a function document that is based on an object-oriented product database. The principal parts of the function document are:

- Lists of measurement points
- Lists of drives
- Plant schemes as part of the function plans and as the basis for the ME-VIEW screen diagrams
- Function description in accordance with VGB 170R, incl. function units (see following examples)

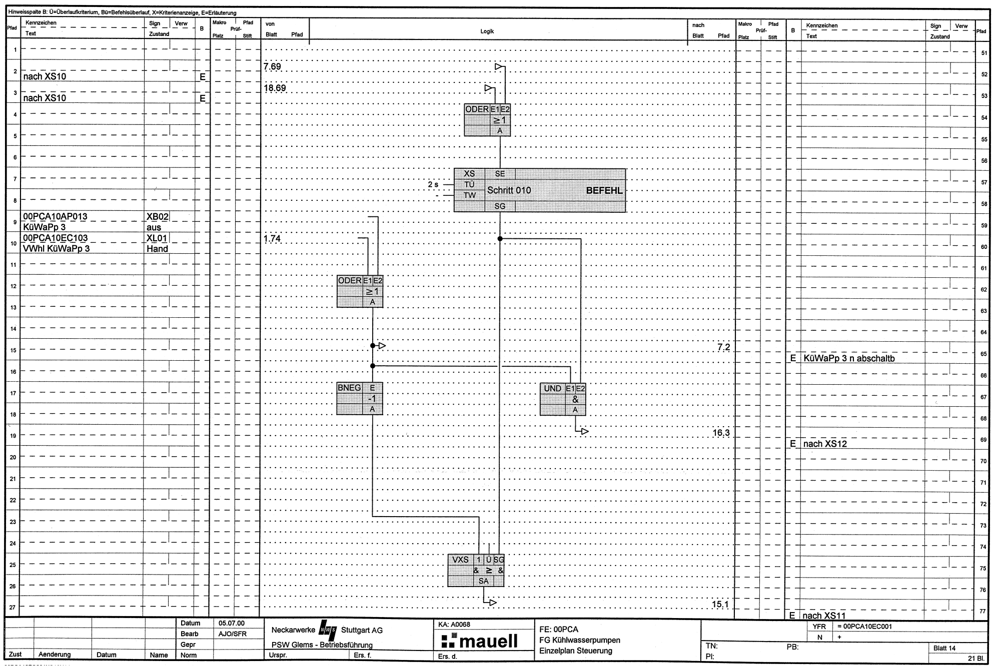
Other important project documents describe the following installations:

- LAN network
- SUB-NET process bus
- Architecture of the automation units, incl circuit diagrams
- Layout of the devices in the control and configuration room (complete connection manuals)
- Layout and circuits of the auxiliary control cubicles for power supply, distribution, power actuators, coupling units, etc.
- Cabling descriptions
- Installation description, incl. installation diagrams
- Field device descriptions (device catalog)
- Erection plans




*Function plan "Drive control"*

In the next project phase -which at present is still a separate design step- the documentation described above is converted into a set of configuration data using a graphical function plan editor (similar to IEC 1131-3), which is 100 percent compliant with the philosophy of the ME-DRP program packet. This easy-to-use design tool allows the user to establish the connections between the inputs and the outputs of the function macros by simple mouse click. It also allows to move macros from one position to another in a very easy way, whereby all connections associated with the macro are automatically rerouted.




*Function plan "Step program" (excerpt)*

In this way, existing functions can be easily combined to build user-specific function blocks which can also be stored in the block library for future use.

This configuration tool, too, allows the user to monitor the designed function representation in the online mode.

The designed function plans can of course be printed out on (laser) printers so that they can be used to complete the project documentation.

All design steps described above are accompanied by a continuous automatic plausibility and syntax verification of the defined process object data. The tool also checks automatically that the defined logic connections match the control equipment on site as specified. These built-in check facilities ensure a consistent database and help to avoid double entries.

The electronic control cubicles are totally enclosed, have double-wing doors at the front and the back, and are mounted on a swivel frame. The bottom is open. Cable entry can be from the bottom or the top.

The connection terminals are located behind the swivel frame and are accessed by opening the swivel frame and the rear double-wing door.

The closed double-wing doors can be replaced by mosaic-type inserts or doors with windows. In these cases it is to be considered whether the control cubicle is still a standard design or whether its depth needs to be modified.

Due to the extremely low power loss of the ME 4012 electronic modules the power dissipation in a fully equipped control cubicle is kept at 300 watts approximately. There is therefore no danger of heat concentration and consequently no need for special regulations with regard to the layout inside the cubicle.

### Swivel Frame

A frame for standard cubicle height (2200 mm) accepts 4 subracks of 8 HU (height units) each, with wide designation label, cable entry and standard dc supply and voltage monitoring.

### Peripheral Connections

Different types of terminals are offered for the connection of external signals. It is generally the number of signals to be connected that determines the most suitable type.

The highest connection density of 3800 wires can be achieved with the standard design. It provides two rows of ten 8 x 25 terminal blocks each, for the connection of 2000 wires from and to process I/O devices in one row and their shunting to the other row. A third row containing nine terminal blocks is available for directly connected I/O signals. The connection on the I/O wiring side is made by maxi-termipoint or soldering (0.5 $mm^2$ max.).

Cabling of cross-sectional areas larger than 0.5 $mm^2$ requires terminal connectors and therefore reduces the I/O connection density and consequently the number of I/O modules in the cubicle.

### System Cabling and Terminal Blocks

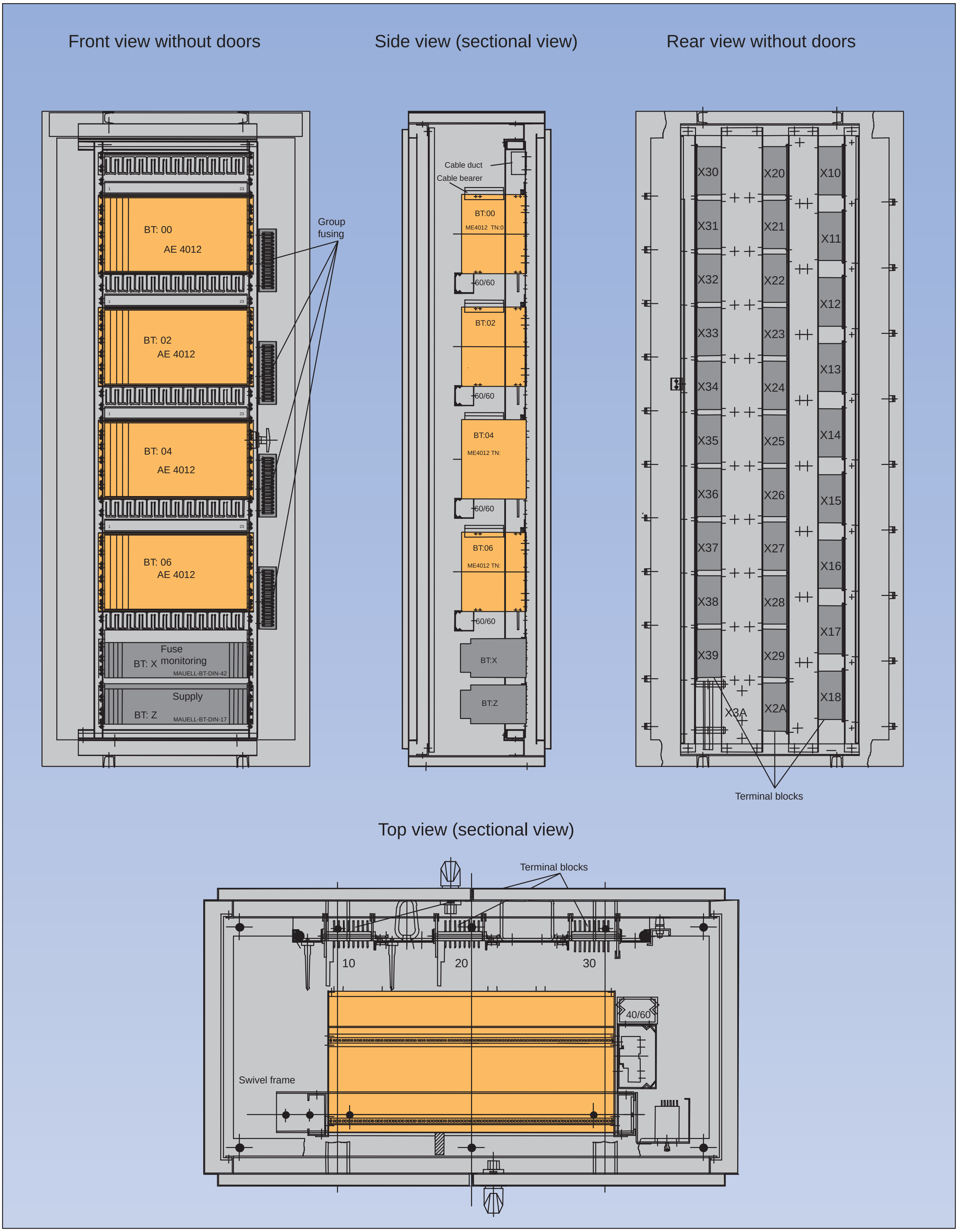
Standard system cables with connectors that are welded at both ends are available for the connection of the ME 4012 electronic modules with the process I/O equipment.

### ME 4012 System Cubicle - Technical Characteristics

| | |
|---|---|
| Dimensions | W x H x D = 900mm x 2200mm x 500 mm |
| Material | Zinc ore steel sheet, 2 mm |
| Body | Fully welded |
| Doors | Zinc ore steel sheet, 1.25 mm, fully welded and fitted, easy to remove, 180° opening angle |
| Door lock | Rod lock, can be operated with<br>- Two-way key (standard 3 mm gudgeon)<br>- Turning handle<br>- Turning handle, lockable |
| Colour | Textured varnish (inside and outside)<br>RAL 7032 (pebble gray).<br>Special varnish on request.<br>Inserted parts, such as swivel frame and subracks, are chromalized. |
| Header bar | At front and rear<br>RAL 7035<br>Light gray, black labelling. |
| Cubicle lamp | One lamp in the centre of the front header bar. |
| Cubicle weight (standard values) | With mounting frame, empty: 140 kg approx.<br>With modules and cabling: 300 kg approx.<br>Complete, with cabling: 400 kg approx. |
| Additional features | Thermostat, adjustable to 45 °C<br>Door contacts, indicating open doors |
| Protection class | With vent slots: IP 20<br>Totally enclosed: IP 42 |

Special designs for other protection classes are available on request.

## Mechanical Design




*ME 4012 system cubicle*

### Cubicle Supply

The system cubicles of the ME 4012 process control system are designed for a redundant supply from two independent 24V sources. The coupled voltages (L+), the reference potential (LM) and the ground potential are fed to busbars. All further voltage distribution and protection inside the cubicle spreads from this busbar connection.

Each subrack receives its own direct supply and protection from the busbar across the subrack's backplane board. An individual subrack protection can be selected at this point.

The external (peripheral) circuits are supplied through the circuit breakers of the group protection which is allocated to the subrack. The supply voltage for the individual modules is connected to front connectors or to current-carrying terminals on the subrack backplane, depending on the type of the module.

The voltage supply to the SUB-NET network and all repeaters, fiber optic converters and bus interfaces associated with it is ensured by separate supply modules. Each network channel has its own supply module. Transient overvoltages in the feeder cables are suppressed by network filters connected into the supply section.

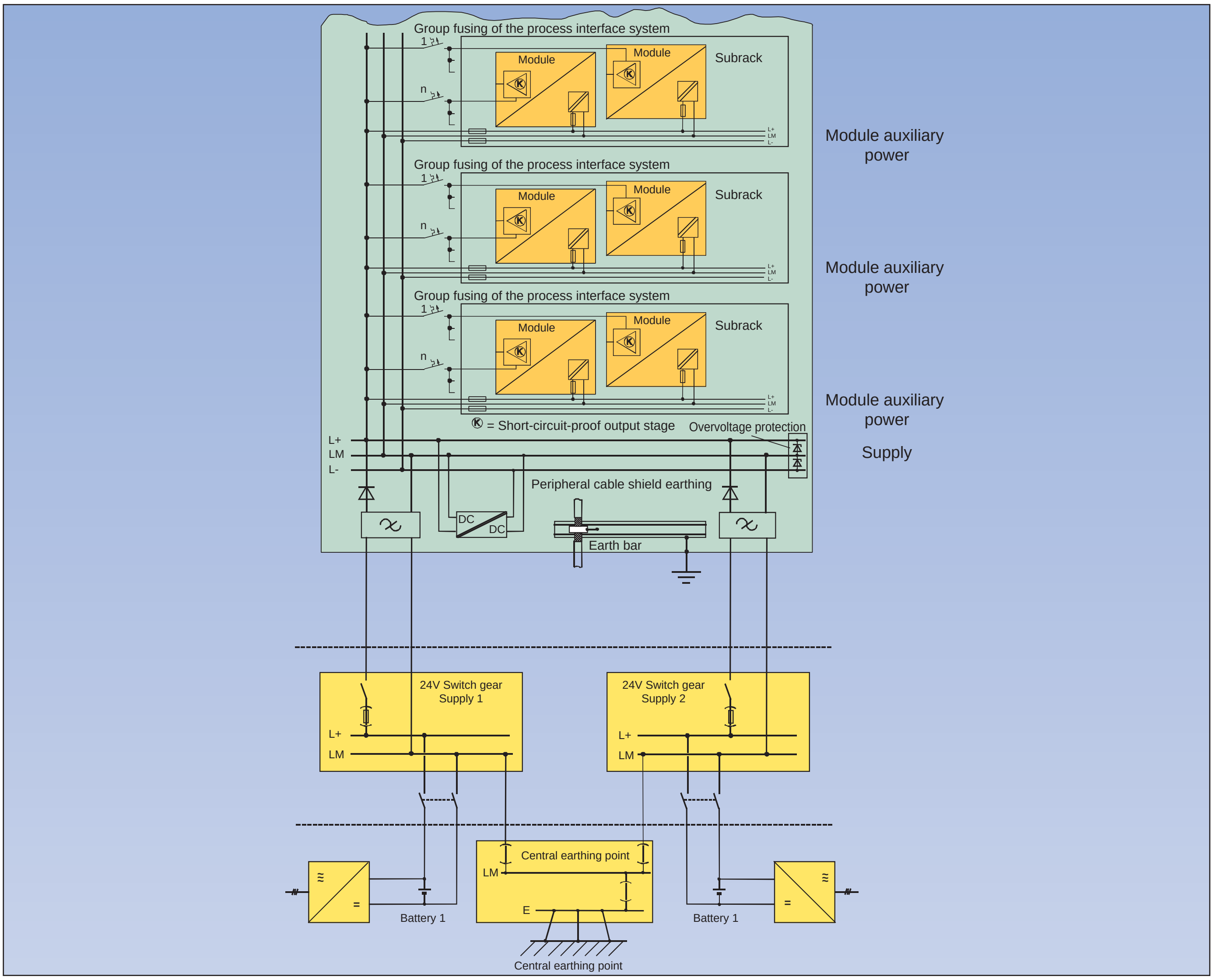
Each cubicle supply section contains a central overvoltage protection in the form of fast suppression diodes. Their reaction is indicated by an annunciator relay.

These decoupling diodes can be replaced or supplemented by power supply units of any type, for instance for the supply of -24V in order to increase the contact scanning voltage, or for other supply voltages.

The devices and systems for data and information processing that require a 230V AC supply can be classified into three groups (please note that industrial PCs manufactured by Helmut Mauell GmbH can be ordered for 24V DC supply):

- Network
- Process control and plant control
- Configuration and diagnosis

These devices receive their power supply from the safe rail of the AC distribution. Each device or component is equipped with its own protection.




*Example of the voltage supply and internal distribution/fusing arrangement in an ME 4012 system cubicle*

## System Diagnosis

System diagnosis has the purpose of automatically recognising and indicating any fault or disturbance in the controlled installation with the aim to allow quick and pointed corrective measures. System diagnosis monitors all peripherals units and all devices and assemblies that are part of the control system.

Fault messages generated by system diagnosis procedures are processed according to defined standards. Number and type of the control cubicles to be monitored can of course be varied. The same applies to the way the messages are distributed and relayed to various destinations within the system (ME-VIEW-systems / control room) and to the method of message output (monitor, printer, coning and going messages , etc.).

Control system components are:

- ME 4012 system cubicles
- ME-VIEW system cubicles
- ME 4002S system cubicles
- Power controller cubicles
- Coupling cubicles
- All other auxiliary and special control cubicles, provided they contain active control components.

Peripheral devices are:

- Control and actuator drives
- Continuous drives (pumps, fans, etc.)
- Solenoid valves
- Analog measurement points
- Binary transmitters,

inclusive of all the associated switchgear, power controllers, coupling devices, transducers, etc.

The faults and disturbances that may occur in the system can be classified into three groups:

### Hardware, Software und Device Faults.

**Hardware faults** are detected by means of hardware or caused by faulty hardware. Example: circuit breaker tripped.

**Software faults** are recognised and indicated by the software of the ME 4012 stations and nodes.

**Device faults** are caused by a specific device in the system and can affect the result of the process control performance. Example: a faulty transducer.

## Technical Characteristics of the AE 4012 Programmable Controller

### Auxiliary Supply L+

| | |
|---|---|
| Rated voltage | 24 V DC |
| Permissible range | 19.2 V to 28.8 V |
| Permissible ripple | < 5 % |
| Overvoltage | < 40 V, < 1 ms |
| Permissible interruption without malfunctioning | < 1 ms typical |
| Working voltage limit | 30 V |
| Current feed per cubicle | 15 A max, 10 A typical |
| Permissible limit voltage before cubicle supply | 30.5 V |

### Auxiliary Supply L-

only required for 48V contact scanning voltage.

| | |
|---|---|
| Rated voltage | -24 V DC |
| Permissible range | -19.2 V to -28.8 V |
| Current feed per cubicle | 3 A |
| Overvoltage | < 40 V, < 1 ms |

### Power Dissipation

Inside the system cubicle, a power dissipation of 75 watts must be anticipated for each subrack. A fully equipped system cubicle will therefore generate an internal power loss of 300 watts. Additional power losses caused by peripheral equipment such as switchgear and transducers and by the cables depend on the equipment installed.

### Ambient Conditions

for control cubicles without internal ventilation and

| | |
|---|---|
| Forced ventilation | 0 to 40 °C<br>up to 1000 m above sea level |
| Upper limit temperature for subrack | 70 °C |
| Permissible relative humidity | < 75 % without dew |
| Storage temperature range | -40 °C to +85 °C |
| Relative humidity during storage | < 85 % |

### EMC Test Plan for the ME 4012 System

### Electromagnetic Compatibility Test

Test standards: DIN EN 50082-2:96-02 / VDE 0839 Part 82-2.

The following tests are carried out:

| Test: | in accordance with: |
|---|---|
| ESD | DIN EN 61000-4-2:96-03 |
| EM-HF field | DIN EN 61000-4-3:97-08/ IEC 1000-4-3:1995/ VDE 0847-4-3 |
| EM-HF field generated by digital mobile phones | DIN EN 61000-4-3:97-08/ IEC 1000-4-3:1995/ VDE 0847-4-3 |
| Burst | DIN EN 61000-4-4:96-03 |
| Surge | DIN EN 61000-4-5:96-09 |
| HF interference | DIN EN 61000-4-6:97-04 |
| 50 Hz magnetic field | DIN EN 61000-4-8:94-05 |
| AC voltage fluctuations | DIN EN 61000-4-11:95-04 |
| DC voltage fluctutions | Factory specifications |

### Noise Emission Test

Test standards: DIN EN 50081-2:94-03 / VDE 0839 Part 81-2.

The following measurements are carried out:

| Test: | in accordance with: |
|---|---|
| Radio interference voltage | DIN EN 55011:97-10, VDE 0875-11, Class A, Gr. 1 |
| Noise emission | DIN EN 55011:97-10, VDE 0875-11, Class A, Gr. 1 |

### EC Conformity Declaration with CE Label

The conformity of our devices and systems guaranteed by the CE label complies with the legal specification no.89/336/EWG..

# Representatives

## INTERNATIONAL

**Mauell AG**
Furtbachstraße 17
**CH-8107 Buchs / Switzerland**
Tel. +41 (0)1/844 48 11
Fax +41 (0)1/844 44 56

**Mauell GmbH**
Brown-Boveri-Straße 8/12
**A-2351 Wiener Neudorf / Austria**
Tel. +43 (0)22 36/2 11 01-0
Fax +43 (0)22 36/2 11 01-30

**Helmut Mauell B.V.**
Postbus 89
**NL-3840 AB Harderwijk / Netherlands**
Tel. +31 (0)3 41/41 15 80
Fax +31 (0)3 41/41 15 81

**Mauell Ltd.**
P.O. Box No. 183
**GB-Calne, SN11 9BZ, Wiltshire / Great Britain**
Tel. +44 (0)12 49/81 20 46
Fax +44 (0)12 49/81 70 96

**Mauell Corporation**
31 Old Cabin Hollow Road
**Dillsburg PA 17019 / USA**
Tel. +1717 4 32 86 86
Fax +1717 4 32 86 88

**Helmut Mauell do Brasil Ltda.**
Caixa Postal 54
**06850-000 Itapecerica da Serra São Paulo / Brazil**
Tel. +55 (0)11 79 47-17 77
Fax +55 (0)11 79 47-17 74

**J. Lorente**
Apartado de Correos 5
**E-Las Rozas (Madrid) / Spain**
Tel. +34 (0)9/16 30 07 50
Fax +34 (0)9/16 30 33 09

**N.V. Rogelec S.P.R.L.**
Nieuwevaart 101
**B-9000 Gent / Belgium**
Tel. +32 (0)9/2 25 54 06
Fax +32 (0)9/2 23 44 10

**Ingeniørfirmaet K. Fritzbøger A/S**
Kongevejen 79
**DK-2840 Holte / Denmark**
Tel. +45 45 41 45 31
Fax +45 45 41 45 32

**Berggård Amundsen & Co. A/S**
Postboks 25, Manglerud
**N-0612 Oslo 6 / Norway**
Tel. +47 (0)22/68 10 00
Fax +47 (0)22/68 98 43
Telex 76 031

**Fortum Engineering Ltd**
Rajatorpantie 8, Vantaa
**FIN-01019 Vantaa / Finland**
Tel. +358 (0)9/8561 4436
Fax +358 (0)9/8561 4418

**SERVICIOS Y SUMINISTROS S.A.**
Casilla Correo 5239
**RA-1000 Buenos Aires / Argentina**
Tel. +54 (0)11/4796-12 80
Fax +54 (0)11/4791-86 65

**Helmut Mauell GmbH**
Nová 967
**CZ 285 22 Zruč nad Sázavou**
**Czech Republic**
Tel. / Fax +420 (0)3 27/93 42 80
Mobiltel. 0602/38 97 70

**MaxiCont**
Resch Pál
**H 1088 Budapest / Ungarn**
Krúdy Gyula u. 14./II
Tel. +36 (0)1 485-7011
Fax +36 (0)1 485-7019
Mobil 0036 20 9391-847

**SULTAN INTERNATIONAL**
P.O. Box 3486
**Abu Dhabi U.A.E.**
Tel. +9712/6 22 44 11
Fax +9712/6 22 44 55

**KANA CONTROLS**
**GEN. TRADING & CONTRACTING CO. w.l.l.**
Plot 28-30 Street No.31
Al Rai Industrial Area Kuwait
P. O. Box 25 59 3 Safat
**13116 Kuwait**
Tel. +9 65/47 41 3 7 3-76
Fax +9 65 /47 41 537

## GERMANY

**Helmut Mauell GmbH**
Am Rosenhügel 1-7
**D-42553 Velbert**
Tel. +49 (0)20 53/1 30
Fax +49 (0)20 53/1 34 03
www.mauell.com
info@mauell.com

**Helmut Mauell GmbH**
Werk Weida
Papiermühlenweg 10
**D-07570 Weida**
Tel. +49 (0)3 66 03/4 80
Fax +49 (0)3 66 03/4 83 10