Digital Turbine Control Systems

System Overview Reference List

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As all fields of engineering, power station technology 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 shedding
- 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

- operational safety
- availability
- extended life expectancy
- convenient operator guidance and
- easy maintenance.

Throughout its long operational life the turbine set is to run and be maintained at maximum efficiency.

Digital turbine control systems - Perspectives

With the development of the digital turbine controller, the Helmut Mauell company was able to implement the experience and know-how obtained over many years in the

- development
- design
- manufacturing
- installation and
- commissioning

of control and instrumentation systems. The ME 4012 was developed into a process control system that is completely open for all areas of block and turbine control. This also applies to processes which impose particularly strict requirements on the controller cycle time, such as turbine speed control.

Main functions of the turbine control system:

- Turbine controller (speed and power control)
- Turbine temperature controller (life expectancy and transient calculation)
- Turbine auxiliary plant (measurement, drives, closed-loop controls, function groups)
- Turbine load current protection (oscillation, expansion, temperatures)
- Automatic test of load current protection
- Turbine no-load current protection (overspeed, generator and tank protection)
- Automatic test of no-load protection
- Turbine control room (operator control and monitoring, alarm logging)
- Central control system diagnostics, configuration and documentation
- Easy interfacing for connection to block control system based on the SUB-NET process bus

Based on these functions, the utility industry is provided with a process control system which, using standard

- system hardware
- firmware
- documentation
- operator interface

economically and conveniently automates, monitors and controls the entire power station process which includes the

- steam generator
- turbine set
- auxiliary plant for operation and pollution monitoring.

The resulting advantages for the power supply companies is our contribution to new perspectives in digital turbine control.

Digital Turbine Control Concepts

Conditions for future operation

DVG guide lines for plant safety

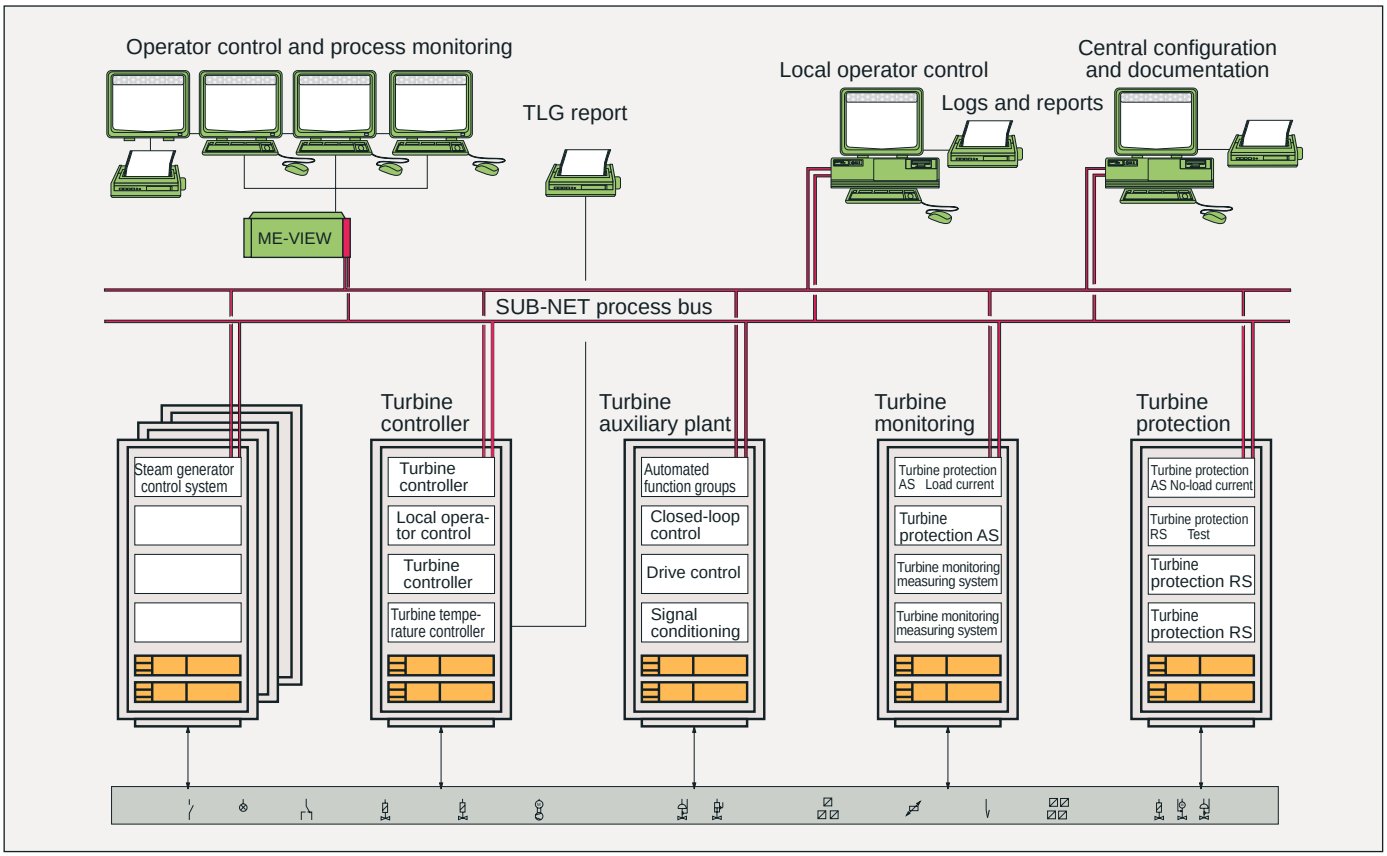
Primary control
(frequency back-up control)
Secondary control
(system characteristic control)
Block control reserve
Overspeed protection
Fundamental protection
Extended protection

Recommendations for future operation

Life expectancy
Availability / Reliability
Extended safety
Operation monitoring

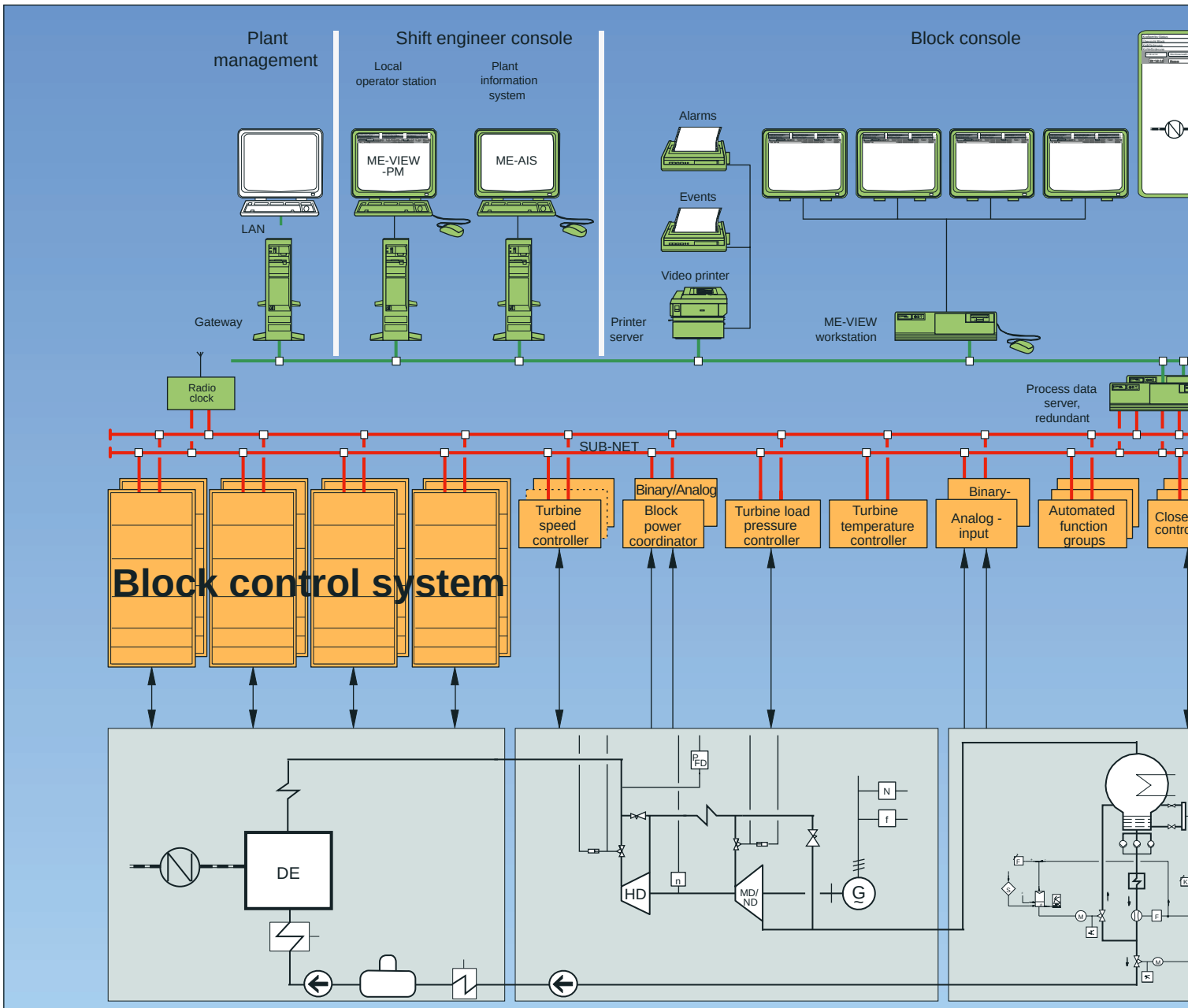
Temperature controller (TLG)
Load limit facility
MP inlet control
Protection monitoring
Turbine monitoring
Turbine auxiliary plant

Control System Overall Concept



ME 4012 digital turbine control: hardware system overview

Digital Turbine Control Systems - Layout Diagram



Steam generator
- Coaling, pulverization
- Air / flue gas
- Coaling (fail-safe)
- Feed-water
- Superheater
- Condensed steam
- Long-range energy branch
- Station auxiliaries service

Auxiliary plant
- Flue gas desulfurization
- DeNOx, NH3 tankage
- Water treatment
- Condensed steam treatment
- Coal, lime supply
- Ashes, gypsum disposal

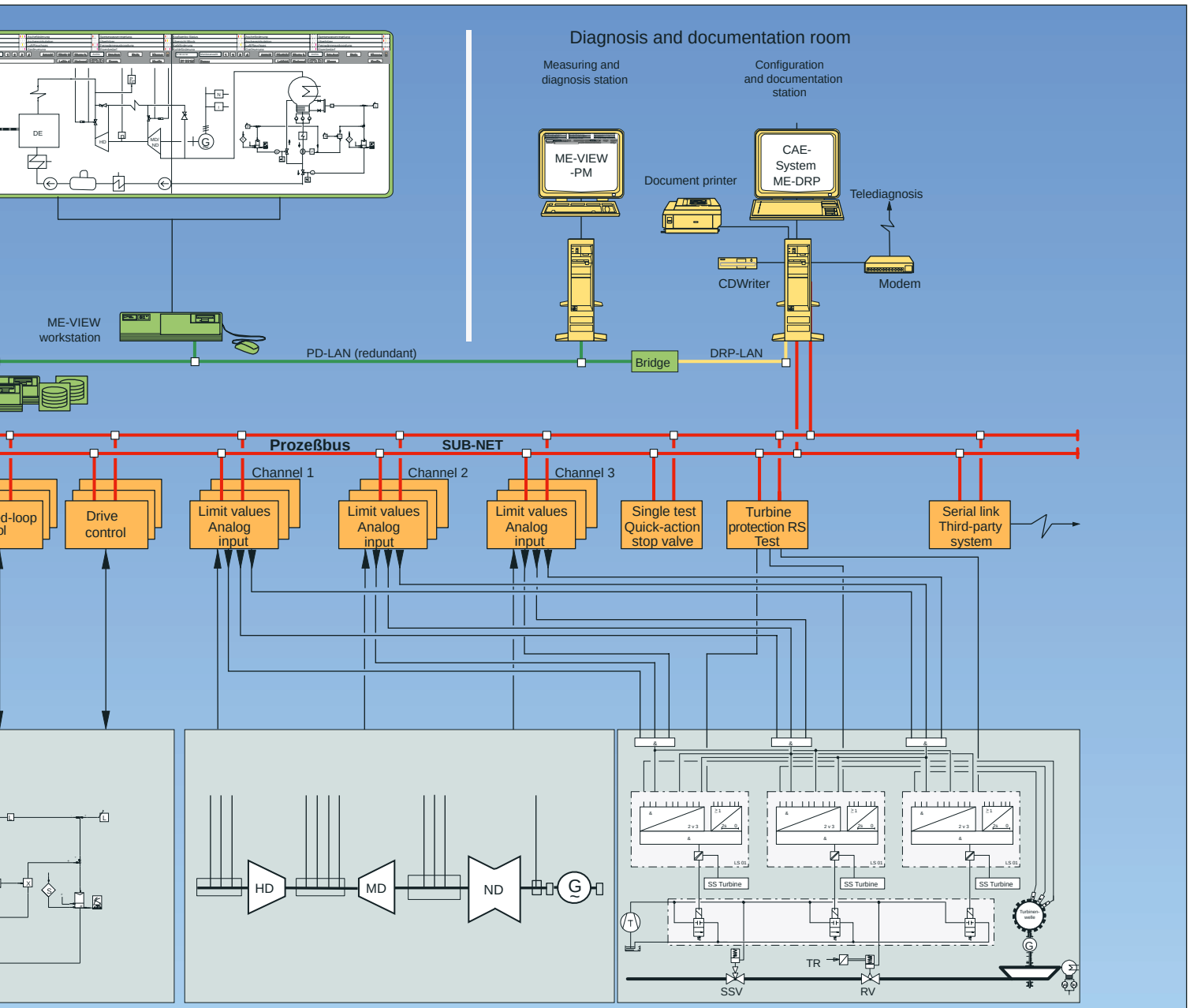
Turbine controller
- Speed controller and speed master controller 2v3
- Power controller and power master controller
- MP inlet control
- Live steam limit pressure control
- Hot reheater accumulation control
- Heat extraction control
- Temperature control LP lines
- Valve positioner HP, MP/LP

Turbine temperature controller
- Life expectancy calculation
- Transient limitation
- Logging and reporting
- Temperature control backup

Block power coordinator

Turbine auxiliary pla
Closed-loop control
- Gland steam pressur
- Gland steam tempera
- Bearing oil temperatu
- Condenser level con
- Condenser min. qty.
- MP bypass control w pressure and injectio

Function groups
- Function group Cooli
- FG Condensed stear
- FG Bearing oil, actuatir
- FG Evacuation
- FG Blocking steam
- FG Bleeding
- FG Water extraction
- FG Turbine control



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ng fluid and rotary mechanism

Turbine monitoring
- Turbine speed
- Shaft oscillation
- Bearing housing oscillation
- Relative expansion
- Shaft position
- Absolute expansion
- Axial thrust

Turbine load current protection
- Sensor 2v3
- Processing 2v3
- Trip 2v3

Single test Quick-action stop valve

Turbine no-load current protection
- Overspeed
- Condenser pressure
- Bearing oil pressure
- Tank protection
- Generator protection
- Tail blade protection
- Shaft position

} Sensor and processing 2v3, trip RS 1v2

Protection monitoring No-load current
- Electronic protection system
- Hydraulic trip

Turbine controller (TR)

As the turbine controller's modular design is based on the ME 4012 standard modules, the system for industrial turbines can be of single-channel structure, whereas a two-channel structure with bumpless transfer can be implemented for the highest power ranges.

The functions of the turbine controller:

- Measuring data preparation
- Speed control
- Pressure control
- Power control
- Valve position control
- Control logics
- Alarm generation
- Operator guidance

Turbine controller special features:

- Controller cycle time of approx. 10 ms
- Speed signal resolution: 0.5 mHz
- Speed measuring accuracy: 2 mHz abs. at 50 Hz

Control and instrumentation of the turbine auxiliary plant (THR)

Besides the turbine speed and power control systems, the turbine auxiliary plant too is of great importance for the safe operation and control of the turbine. Some of its main tasks are:

- Gland steam pressure control
- Gland steam temperature control

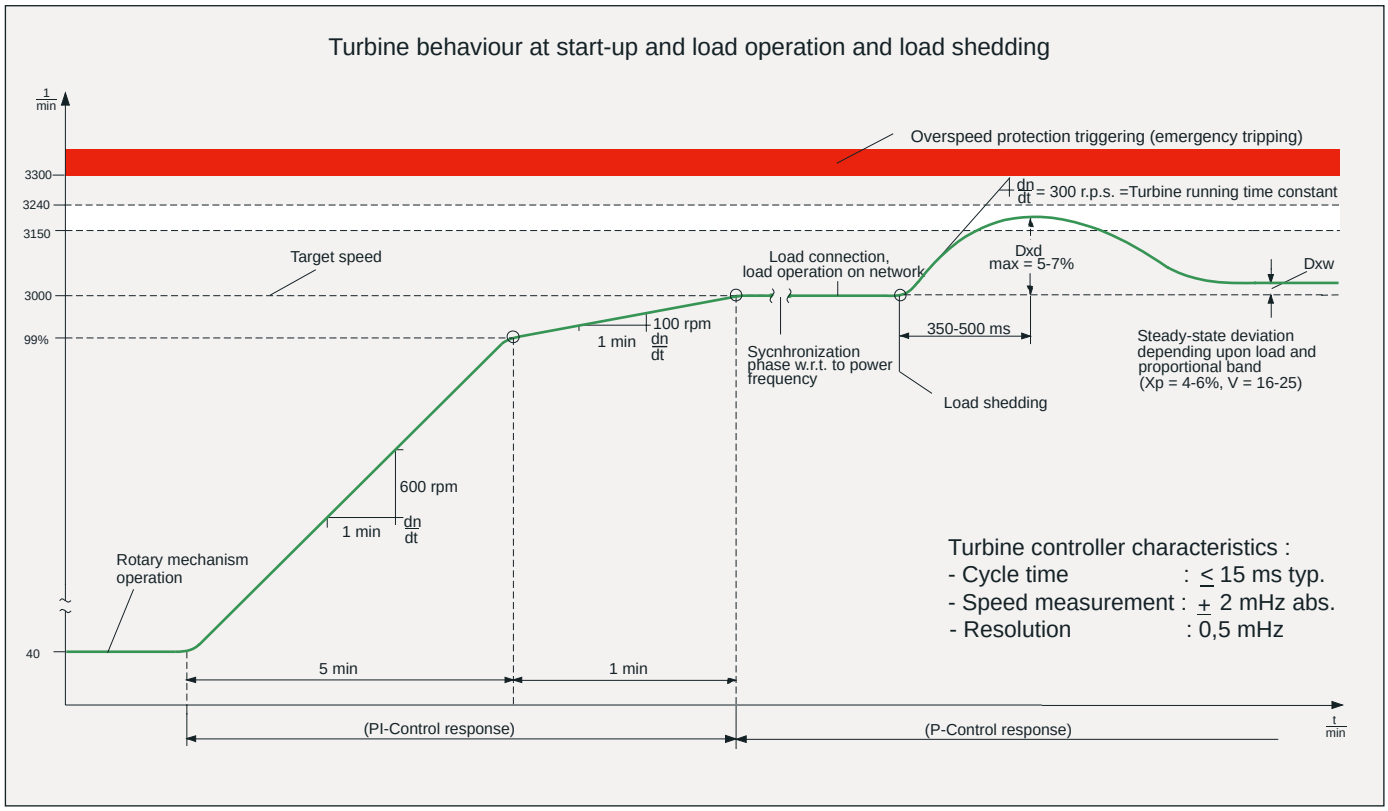
Using the ME 4012 standard modules, the system can be configured to implement clear and well-structured control solutions for the defined tasks.

The system comprises:

- Field units for measuring and instrumentation
- Field installation and cabling
- Measuring data preparation
- Binary signal conditioning
- Drive control
- Closed-loop control and power controller
- Alarm generation
- Automated function groups
- Operator control level

The main functions are:

- Control of the turbine auxiliary control loops
- Control of the servo drives
- Automated function groups for controlled operation
- Operator guidance at manual operating mode
- Operator control and monitoring from a central control room



Turbine behaviour: start-up and load operation

Turbine monitoring

Derived from the investigations into plant safety and availability, the concept of dynamic simulated tests of all sensors and modules for measuring data preparation and limit value generation ensures maximum availability with only a minimum of expenditure. Also, thanks to the two-channel measuring data preparation and limit value generation, any due repairs can be attended to without having to interrupt turbine operation. Based on elaborate test reports, preventive actions (or measures) can be taken to monitor and slow down material ageing.

Turbine monitoring comprises:

- Measuring data preparation with interface to the online dynamic simulated test
- Signal evaluation and limit value generation
- Measuring data indication and alarm generation

Principal measurements:

- Turbine speed (accuracy: ± 0.04 ‰ absolute)
- Shaft oscillation
- Bearing housing oscillation
- Relative and absolute expansion
- Shaft position
- Axial thrust

Turbine protection (TS)

The turbine protection covers all criteria that can cause damage to the plant. If one of the criteria exceeds a permissible limit, the turbine protection interrupts the operation of the plant.

In compliance with the classification of protection criteria (VGB brochure VGB-R 103-M "Monitoring, safety and protection equipment in steam turbine plants"), the turbine protection is structured in such a way that it fulfills the requirements for reliability and availability of the overall system.

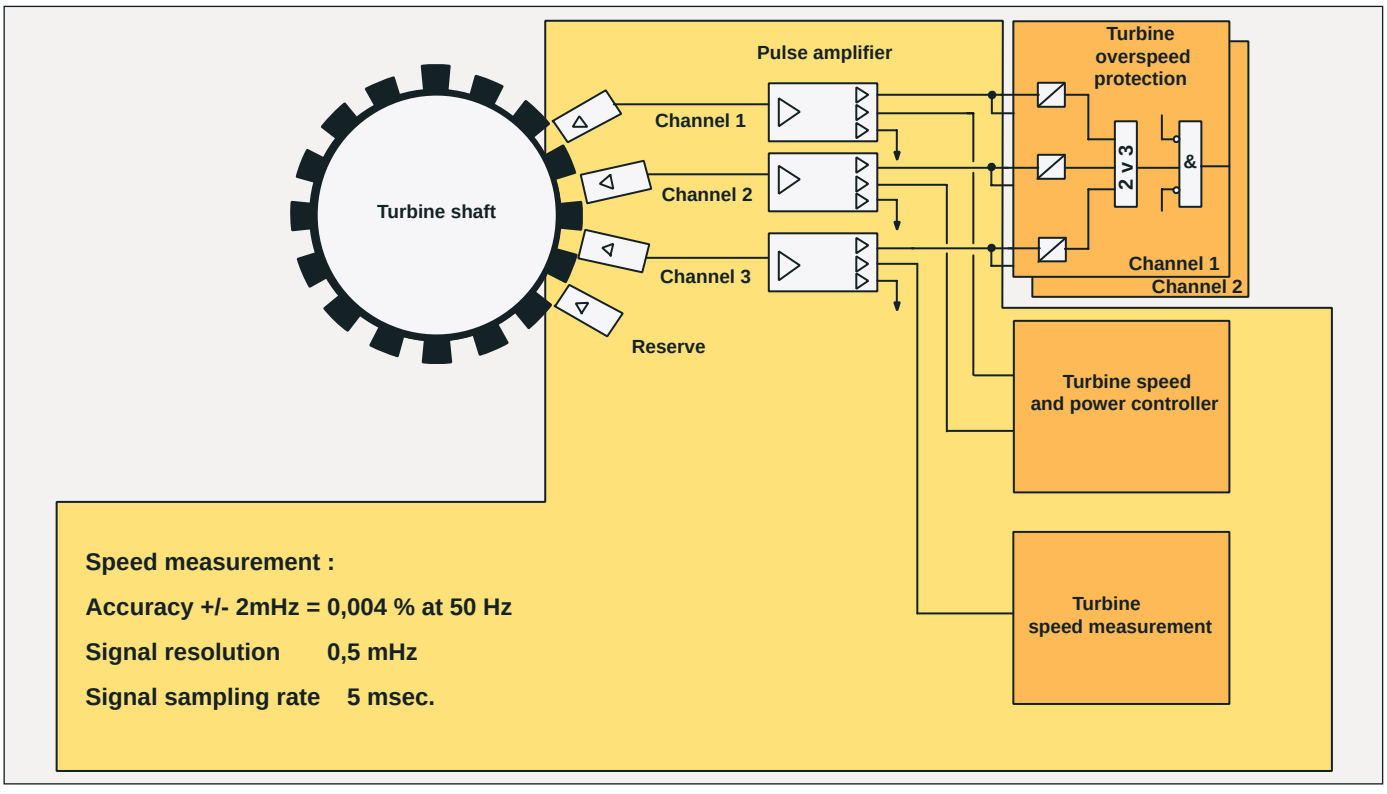
Turbine protection comprises:

- 3-channel overspeed protection (double redundancy)
- Limit value generation and signal linking
- No-load current tripping signal generation
- Online test facilities for all protection components

Main functions:

- Overspeed protection
- Fundamental protection
  (bearing oil and condensator pressure, shaft position, tank protection, generator protection, emergency stop)
- Extended protection
  (shaft oscillation, relative expansion, bearing temperatures, waste steam temperatures, temperature difference HP, MP

The protection system is completely backed up by a redundant protection system in all areas of signal processing. Wired OR logic is used to link the signals from the turbine monitoring with general machine protection. The redundant electromagnetic seat valves in order to relieve the spring-loaded quick-action stop and servo valves are directly activated via a hard-wired N/C current NAND module. Moreover, the automatic test procedure on independent subprocessors allows the turbine protection facilities - including the quick-action stop valve activation - to be online tested at any time, without significant impairment of the turbine operation.



Turbine speed signal derivation and conditioning

Turbine temperature controller (TLG)

Taking into account various measuring values, the turbine temperature controller computes the permissible transient values of the turbine's steam temperatures, performance and valve position. In addition, it constantly determines the degree of fatigue of those turbine parts which are subjected to heavy strains.

The integration of the TLG hardware in the turbine controller cabinet and the direct connection to the process ensure that the TLG is optimally linked to the plant's control and instrumentation system.This allows, for example, to conveniently print out the collected data on the allocated TLG report printer or monitor of a local operator station.

The TLG's technical features:

- Process computer with 32-bit central unit
- Redundant SUB-NET process interface for all process data and control commands
- Hard disk drive
- TLG report printer
- Monitor interface
- Key board interface

Main tasks of the TLG:

- Life expectancy calculation
- Transient limitation to prolong material life

Operator control and process monitoring

Operator control and process monitoring of the digital turbine control systems (TLT) can be implemented in two ways:

1. Mauell - TLT works as a stand-alone process control system which is linked to a higher-level third-party process control system.

The TLT is linked to a higher-level block control system via a serial interface.

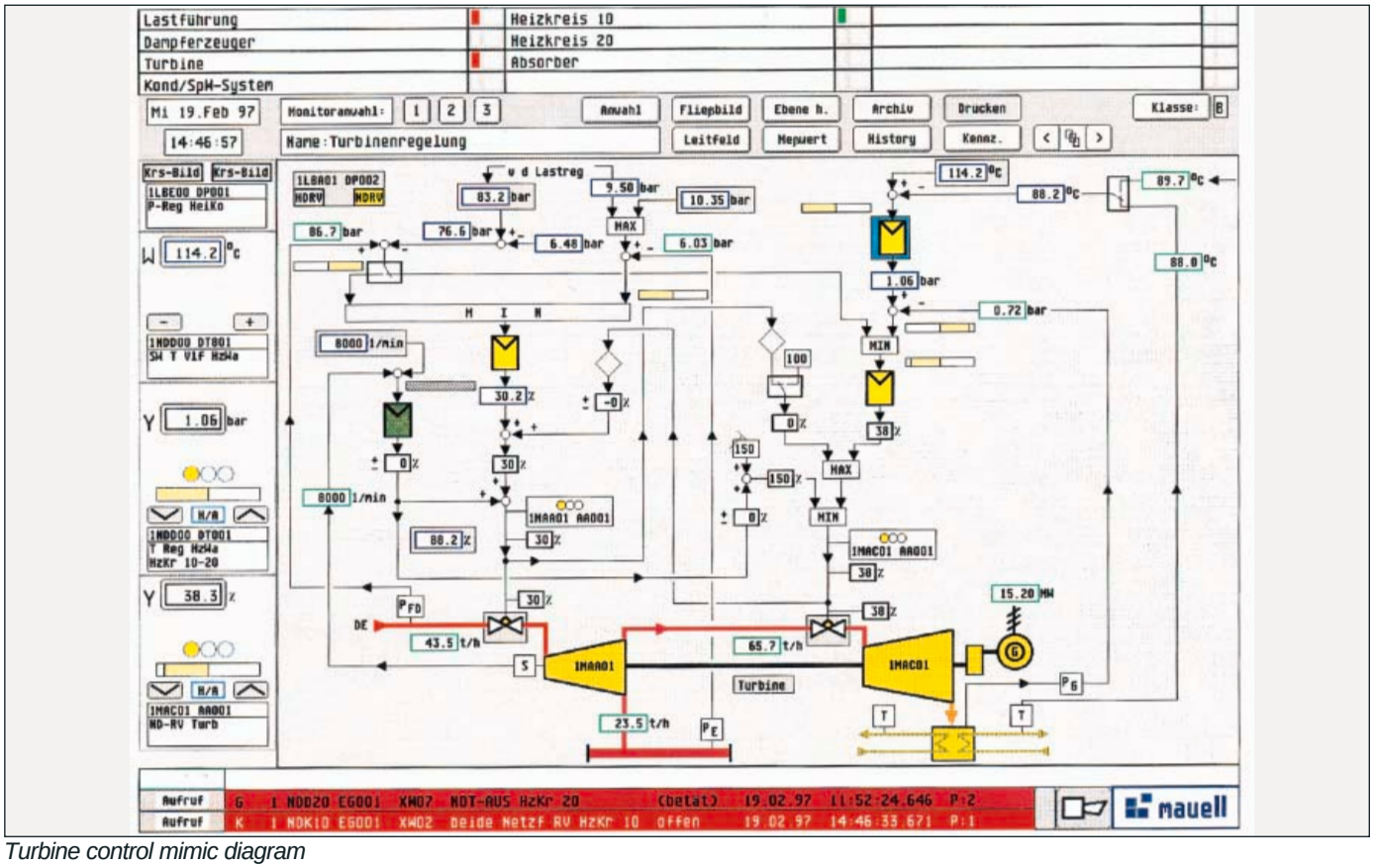
2. Mauell - TLT is an integrated part of the higher-level ME 4012 process control system.

In comparison to the stand-alone system, this solution offers a number of advantages:

- uniform design
- uniform documentation
- uniform alarm processing
- uniform operator control and process monitoring philosophy
- central configuration and diagnostics

An ME-VIEW-PM system is used for local operator control and process monitoring.

Furthermore, the simulation and test equipment can be started by means of an operator's panel provided for each turbine controller inside the cabinet.



Turbine control mimic diagram

Customer	Location	Block	Turbine *	Output (MW)	Function	TCS	OEM
ESKOM Engineering Group, Südafrika	Matimba	1 - 6	ME	6 x 665	TS, TLG	ME 4012RL (Teilanl.)	AE
ESKOM Engineering Group, Südafrika	Lethabo	1 - 6	ME	6 x 620	TS, TLG	ME 4012RL (Teilanl.)	AE
ENSO Gutzeit OY, Finnland	Imatra	1	ME	92	TS, TR	ME 4012RL	AE
RWE Energie AG/VSE	Ensdorf C	1	ME	315	TR, TLG	ME 4012RL	AE
E.ON / Großkraftwerk Franken	Franken I	2	ME	400	TR	ME 4012RL	AE
E.ON / Ilse Bayernwerk Energieanl. GmbH	Pleinting	Q	ME	425	THR	ME 4012RL	
E.ON / Ilse Bayernwerk Energieanl. GmbH	Pleinting	A	AEG	300	TS, THR	ME 4002-Steuerung, Riva-alt	AE
MD Papier / Haindl Papier	Augsburg	IV	ME	20	TR	ME 4012RL	AE
Voest AG, Österreich	Linz	4	ME	85	TR, TS, TLG	ME 4012SN	AE
VSE	Ensdorf A	VII	AEG	110	TS, TR	ME 4012RL	AE
Halle-Trotha	Halle	GT+DT	SIE		INT	ME 4012RL	
Österreichische Draukraftwerke AG	Voitsberg	1	ME	330	TS, TLG	ME 4002 + Riva	AE
GEW Köln	Niehl	I	ME	323	TR, TS	ME 4012SN	AE
PCK Schwedt	Schwedt		GAE	90	TR, TS	ME 4012SN	AE
PCK Schwedt	Schwedt		GAE	90	TR, TS	ME 4012SN	AE
Peißenberger Kraftwerksges.	Peißenberg III		ME	40	TR, TS	ME 4012SN	AE
IEC Israel Electric Corporation Limited	Rutenberg	5 - 6	ME	2 x 550	TS, TLG	ME 4012RL + Riva	AE
MVA Kiel	Kiel	1	B&V	9	TR, THR	ME 400	
Rheinbraun AG	Wachtberg	2	ME	90	TS	ME 4012SN + HD-Stell.-Regler	AE
STEAG	Lünen	7	AEG	350	TR, TS	ME 4012SN	AE
VKR	Knepper	C	AEG	350	TR, TS	ME 4012SN	AE
IEC Israel Electric Corporation Limited	MD-B, Hadera	1, 3	ME	2 x 550	THR, TS, TG	ME 4012RL + Riva	AE
NOK Theiß, Österreich / EVN	Theiß	B	GAE	250	TR, TS	ME 4012SN	AE
RWE Energie AG	Frimmersdorf Q	Q	ME	300	TR	ME 4012SN	AE
Conel	Braila	1	LMZ	2 x 210	TR	ME 4012SN	AE
Tha Toom	Thailand	1 - 2	GAE	2 x 160	TR, TS	ME 4012SN	AE
SwB Erzeugung, Bremen	Hafen	6	ME	300	TR, TS	ME 4012SN	AE
Energie-Versorgung Niederösterreich AG	Dürrnrohr	A	ME	320	TS, TLG	TS: ME 4012SN, TR: Riva	AE
Braunschweigische Kohlenbergwerke AG	Buschhaus	2	ME	350	TLG, TS	ME 4012SN	
KEK	Kosovo	1	ME	350	THC	ME 4012SN	AE
VALA	Finnland	-	GAE	230	TR, TS	ME 4012SN	AE
KEK	Kosovo	2	ME	350	TR	ME 4012SN Stellungsregler	AE
AWG Wuppertal	Wuppertal	Turb. A		25	TS	ME 4012SN	
ESKOM Engineering Group, Südafrika	Matla	1 - 6	ME	6 x 600	TR	ME 4012SN	AE
ICPET S. A. Bukarest	Rumänien				TR	ME 400, ME 4012SN	

Turbine Control Systems - Reference List
(Excerpt)

Customer	Location	Block	Turbine * (MW)	Output	Function	TCS	OEM
Stadtwerke München, HKW Süd - GUD 1	München	DT1	ME	83	TR, TS	ME 4012SN	
Stadtwerke München, HKW Süd - GUD 1	München	GT1	SIE V94	99	TR, TS	ME 4012SN	
Stadtwerke München, HKW Süd - GUD 1	München	GT2	SIE V94	99	TR, TS	ME 4012SN	
Stadtwerke München, HKW Süd - GUD 2	München	DT	Alstom	150	TR, TS	ME 4012SN	
Stadtwerke München, HKW Süd - GUD 2	München	GT1	GE Mark V	150	INT	ME 4012SN	
Stadtwerke München, HKW Süd - GUD 2	München	GT2	GE Mark V	150	INT	ME 4012SN	
Stadtwerke Saarbrücken, HKW Römerbrücke	Saarbrücken		ME	90	TR, TS	ME 4012SN	
E.ON Kraftwerke AG	Heyden		ME	920	TR	ME 4012SN	
HEW AG	Tiefstack-Ersatz	TU 7	ME	160	TR, TS, TLG	ME 4012SN	AE
MVA Stapelfeld	Stapelfeld		Siemens	14	TR	ME 4012SN	
RWE Energie AG	Huckingen	1 - 2	ME	2 x 315	TR, TLG	ME 4012RL	AE
EPON, Niederlande	Bergum	1, 3	ME	2x300	TLG, TR	Leitgerät: ME 4012SN, TR:Riva-alt	AE
VEAG, Berlin	Jänschwalde	A - F	LMZ	6 x 500	TR, TS, TLG	ME 4012RL	AE
ESKOM Engineering Group, Südafrika	Grootvlei	1 - 6		6 x 200	TS, TLG	ME 4012SN	AE
Gas turbines:							
EnBW Kraftwerke	Altbach	GT A	SIE V93		TR	ME 4012SN	
Freudenberg	Weinheim	GT 1		6,3	TS	ME 4012SN	
Stadtwerke München, HKW Süd - GUD 2	München	GT1	GE Mark V	150	INT	ME 4012SN	
Stadtwerke München, HKW Süd - GUD 2	München	GT2	GE Mark V	150	INT	ME 4012SN	
Stadtwerke München, HKW Süd - GUD 1	München	GT1	SIE V94	99	TR, TS	ME 4012SN	
Stadtwerke München, HKW Süd - GUD 1	München	GT2	SIE V94	99	TR, TS	ME 4012SN	

*** Abbreviations**

TR	Turbine speed and power controller
TS	Turbine protection with power part and test unit
TLG	Turbine temperature controller
THR	Automatic turbine with control loops and process controller interface
INT	Integration
ME	MAN-ENERGIE, Nuremberg
LMZ	Leningrader metal work St. Petersburg
GAE	GEC-Alstom Energie Nuremberg
SIE	Siemens V93... / V94...
B&V	Blohm & Voß, Hamburg
AEG	AEG-AG, Berlin

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