2005

Case Studies for
SIPROTEC Protection Relays and Power Quality

SIEMENS

Case Studies for Protective Relaying and Power Quality

Dear reader,

this brochure describes a selection of projects which apply SIPROTEC relays and SIMEAS power quality devices in the power system and machine protection field.

SIPROTEC and SIMEAS have firmly established themselves on the market as a standard for numerical protective relaying and power quality devices respectively. No matter if you need to protect transmission lines, transformers, motors, generators, substations or busbars, SIPROTEC relays will always provide an optimized and efficient solution, which in association with SIMEAS power quality devices will provide you reliability and control beyond your expectations.

The case studies are focused on the following topics:

- The variety of functions in the protection relays often allow “one bay one unit concept” for protection and bay control for each bay.
- The uncomplicated logic functions, with the CFC editor, greatly simplify system configuration
- Flexible and easy to retrofit communication modules mean that SIPROTEC relays can be easily linked to your existing control and protection equipment.
- Power system disturbances (or fluctuations in the quality of supply) are of course highly undesirable. SIMEAS digital power quality products can quickly and accurately record, indicate and analyze faults and measurements.

I invite you to read through the case studies, and learn about the versatility and flexibility of SIPROTEC relays and SIMEAS Power Quality solutions. Not only savings in operation and maintenance, but also simplified engineering, less complexity, and long-term reliability and expandability can make you one of the winners in tomorrow’s marketplace.

Paulo Ricardo Stark
Vice President
Power Transmission and Distribution – Energy Automation
Protection Systems division

“We ensure reliability in energy supply!”

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Case Studies for SIPROTEC Protection Relays and Power Quality

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With Maximum Flexibility, Ready for Anything

SIPROTEC 4 line differential protection for five line ends and distance protection

■ The company

Providing area-wide power – and thus a basis for economic growth - is the job of the power supply company. This is why Vietnam's national power company Electricity of Vietnam (EVN) is constantly expanding its power supply system. A power plant complex is currently being built in the Phu My industrial park. Upon its completion, it will supply up to 3600 MW of power to the 500 kV and 220 kV transmission systems.

Siemens Power Generation (PG) is part of the project. "Phu My 3", currently Vietnam's largest private GUD power plant and located about 70 km southeast of Ho Chi Minh City, was commissioned by PG. Three power station units supply 720 MW to the extra-high voltage system.


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Fig. 1 Industrial area Phu My

■ The starting situation

The customer wanted a fully redundant protection system, plus a cost-effective solution for the long-distance transmission of trip commands to circuit-breakers at remote line ends. This requires that trip commands from the busbar and breaker failure protection relays be transmitted from the 500 kV station to the circuit- breakers upstream from the power station units via binary inputs on the protection relays. In the opposite direction, TRIP commands must be transmitted from the protection relay of the power station unit transformers and from the breaker failure protection to the circuit-breakers in the 500 kV station. For reasons of cost, no circuit-breakers were installed on the 500 kV side of the generator transformers. For protection purposes, optical fibers were integrated into the overhead earth (ground) wire of the 500 kV line.

■ The concept

Following an analysis phase, Siemens Power Automation Vienna presented a comprehensive protection system with the following components (see Fig. 4):

- One 7SD523 line differential protection relay and one 7SA522 distance protection relay for each of the two ends of overhead line 11. Both relay types are equipped with a fiber-optic connection.
- For the three ends of the protected zone, comprising overhead line 12 and the outgoing circuits of generator transformers T2 and T3, Siemens recommended three 7SD523 line differential protection relays and three 7SA522 distance protection relays. One optical ring is provided per protection relay for a dual redundant communication link.

SIPROTEC 4 line protection relays protect the power station's two major 500 kV outgoing cables. With a total of ten 7SD523 and 7SA522 line differential and distance protection relays, Siemens Power Automation (PTD PA) has designed a state-of-the-art, flexible protection system. Moreover, SIPROTEC 4 line protection relays can be interconnected via optical rings, meaning they can immediately detect a communication link failure. In a matter of milliseconds, the protection relays switch from the failed ring connection to a chain connection. Neither the protection functions nor long-distance signal transmission is affected by this fault, which is extremely important – especially when transmitting long-distance trip commands.

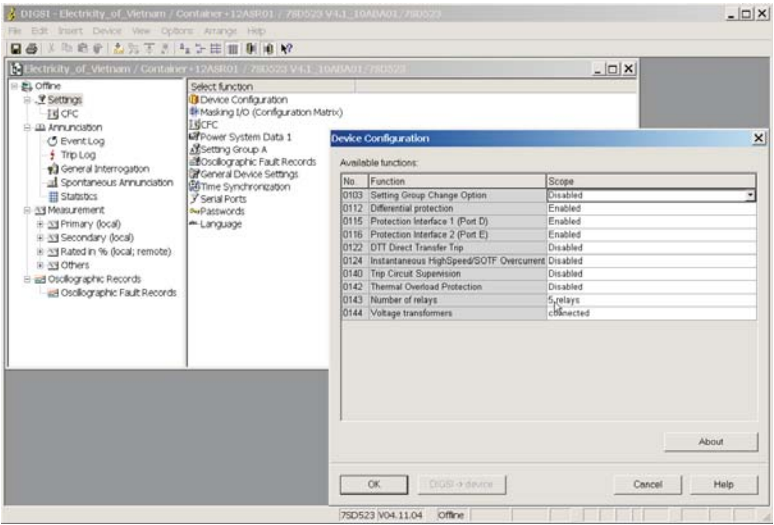

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Fig. 2 Easy setting with DIGSI program

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Fig. 3 Main and backup protection 7SD52 and 7SA522

Another innovative, detailed solution involves independent communication links for the long-distance signal paths used for transmitting trip commands. Transmission is via both the 7SD523 main protection relay and the 7SA522 backup protection relay.

■ *The special advantages*

Flexible, secure and fast thanks to pre-parameterization with DIGSI

The SIPROTEC 4 protection relays can be quickly and reliably adapted, based on the primary system's degree of completion. The parameter sets can already be prepared during the project planning phase. All the Siemens protection relays will be configured, parameterized, tested and safely commissioned with the aid of the DIGSI universal operating program.

■ *From practical experience*

Power transmission without a station

The flexibility of the SIPROTEC product range was of particular advantage in this project, making many things possible that would otherwise have been impossible. When the day appointed for the power station's commissioning finally arrived, for example, construction of the 500 kV station and new 500 kV transmission lines for transporting power to the metropolitan areas had not yet been completed. Consequently, our engineers decided to build a provisional structure next to the site of the new 500 kV station. Two transformers, each with 450 MVA transmission power, were temporarily installed to feed power from the Phu My 3 plant to the 220 kV power system via a nearby substation.

Power station test run under extreme conditions

But how can you hand over a power station to the customer unless you first test it at nominal load? The challenge: Transmit 570 MVA power from power station units 2 and 3 via 500 kV line 12 and the underdimensioned 450 MVA transformer. The solution: Connect the two 500 kV lines in parallel during the Phu My 3 test phase. This made it possible to use the standby capacity of the second 450 MVA transformer connected to line 11. However, if a short-circuit occurred while testing the overall system – comprising three generator transformers, two 500 kV lines, the two provisional transformers and connecting cables on the 220 kV side – the power could be shut down only by an emergency trip. It was therefore decided that the parallel connection of the two 500 kV lines would be dismantled once the test phase was over. Until the new 500 kV station is completed, the power station will be operated so as to prevent the provisional 450 MVA transformer connected to line 12 from being overloaded.

SIPROTEC 7SD523 and 7SA522 temporarily protect the transmission system with 5 line ends

Siemens Power Automation gladly accepted the challenge of protecting this 5-end system. The planning, setup and testing of the protection cubicles had already been completed when the owner issued a new request. In this case, the flexibility of the SIPROTEC relays permitted a fast and simple conversion to a protection system for five line ends.

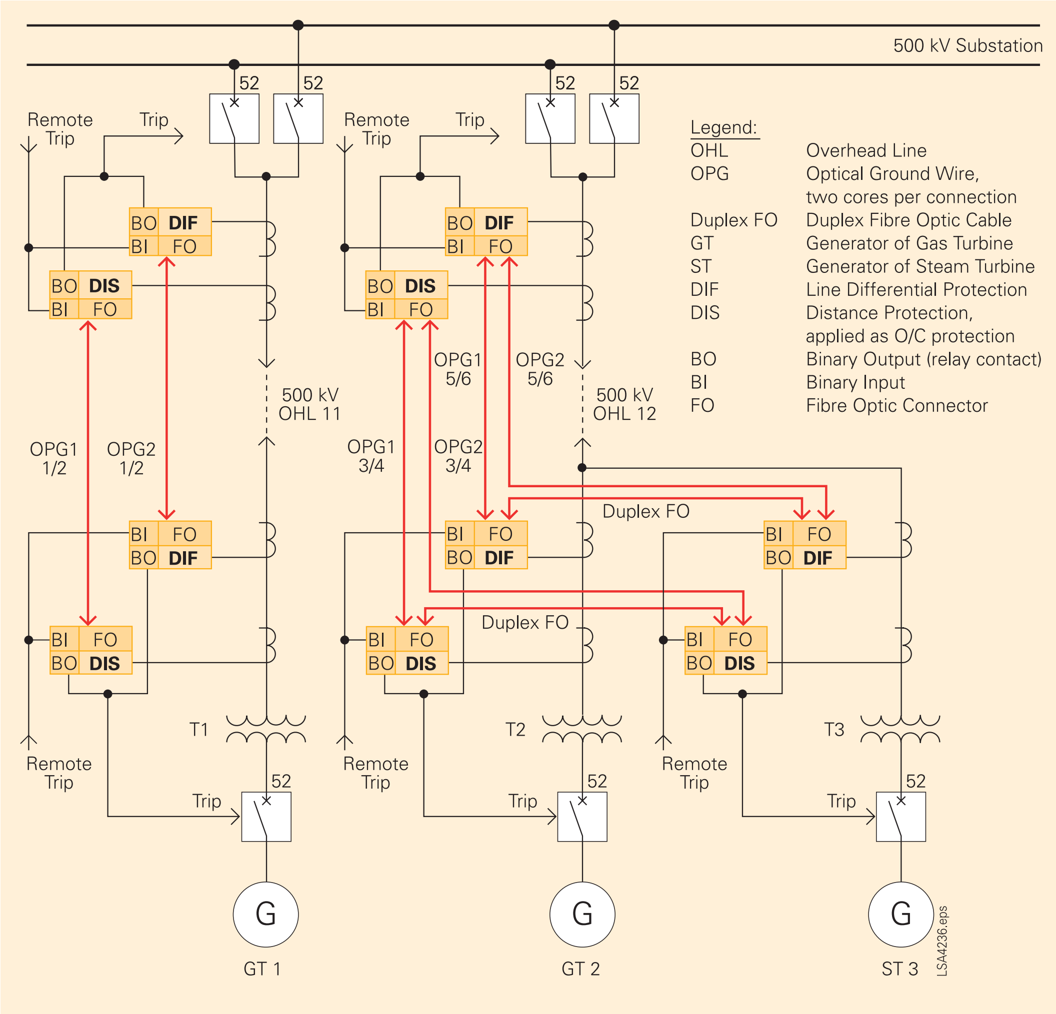

Fig. 4 Concept for the final scheme

The 7SD523 differential protection relays for multiple line ends can be connected to the 2- to 6-end protection system and parameterized at any time at no additional cost. The 7SA522 distance protection relays, in combinations of one two-end and one three-end optical link, can also be connected to the 5-end protection system via copper-wire connections and conventional contacts.

Within a very short time, the protection solution was ready for presentation to the customer and the protection system could be adapted to the primary system's modified topology in three phases at no substantial additional cost:

- Phase 1: Protection of the 5-end transmission system during the power station test phase.
- Phase 2: Protection of the 2-end and 3-end transmission systems with long-distance signal transmission of commands from the protection system of the provisionally installed 500 kV/ 220 kV transformers and provisional 220 kV circuit.
- Phase 3: Protection of the final 2-end and 3-end transmission systems.

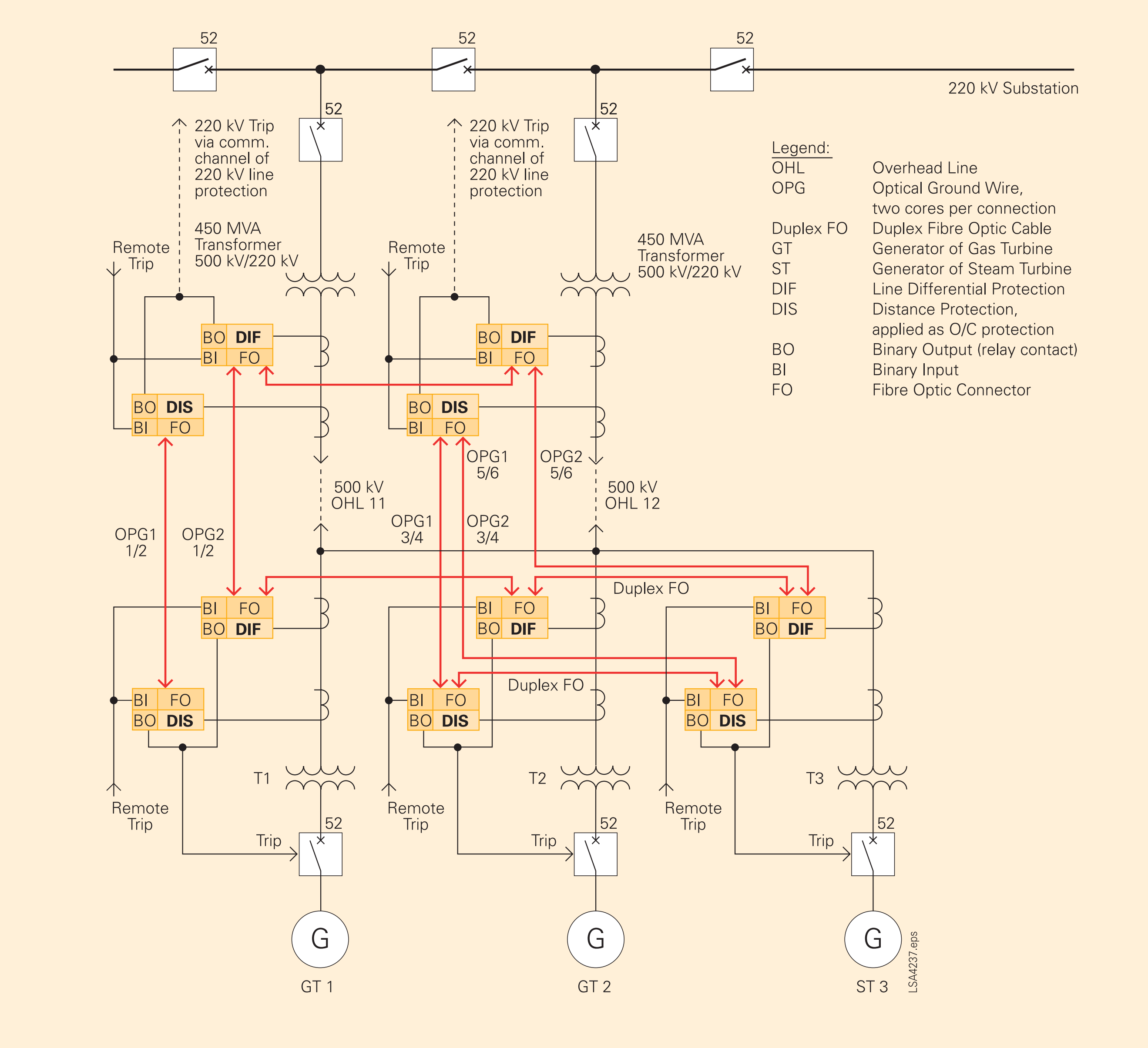

Fig. 5 Protection concept for the power station test phase

Conclusion

Thanks to the diversity of SIPROTEC relays and our engineers' expertise, we were able to significantly reduce the commissioning time for the finished power station, despite the fact that the infrastructure was not yet fully expanded. Vietnam's energy network was reinforced, providing a stronger basis for their booming economy.

Plus

The SIPROTEC relays have meanwhile been converted to the parameter set for operating phase 2. The power station was successfully tested and the parallel connection of the two transmission lines was dismantled. The protection commands from the SIPROTEC relays will now be transmitted to the 220 kV station until the 500 kV system has been completed.

Simplest Possible Handling for Greater Security

SIPROTEC 4 enables maximum supply security in the petrochemical industry

The company

BP Cologne, headquartered in Worringen, a suburb of Cologne, is a wholly-owned subsidiary of Deutsche BP AG in Hamburg. As the fifth largest petrochemical location in western Europe, BP Cologne is an important supplier of raw material to the chemical industry, with about 1,900 employees. Each year BP Cologne derives millions of tons of chemical raw materials from the light gasoline produced by refineries during the refining of petroleum. The chemical industry uses these materials as basic components for the production of plastics and fibers. The BP Cologne plant relies on the northwest European ethylene pipeline to supply chemical companies. Economic and reliable operation of the facility depends on a secure supply of electrical power. BP Cologne has a power requirement of approx. 160 MW.

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The starting situation

The supply of raw materials and the shipment of refined chemical products are inseparably linked to the actual chemical process. In the past, an enclosed single-busbar switchgear supplied power to the light gasoline tank farm and the compressor stations. Expanded production, higher supply security, and reduced personnel resources for operation and maintenance all combined to increase the demands placed on the switchgear and its primary and secondary systems. Failures in these areas have a direct impact on production, causing considerable damage and high costs. For this reason, a switchgear was built at a central point to guarantee a reliable supply of light petroleum for the cracker production and also the output of ethylene (over 1 million metric tons/year) into the 500-km long ethylene pipeline network.

Modern, low-cost standard solutions from a system provider offer maximum security for the power supply. A double-busbar switchgear with four busbar sections supplied by four incoming feeders was installed. The busbars feed the high-voltage motors of the compressor plants and the low-voltage network for supplying the tank farm pumps. A switchgear that relied on compact, low-maintenance technology was essential.

Beside the new solution concept for the primary systems, the secondary systems also required highly efficient, state-of-the-art technology. Because the compressor station motors are installed in an explosion-protected environment, the secondary systems employ motor protection relays that comply with the requirements of ATEX 100 and are certified by the PTB.

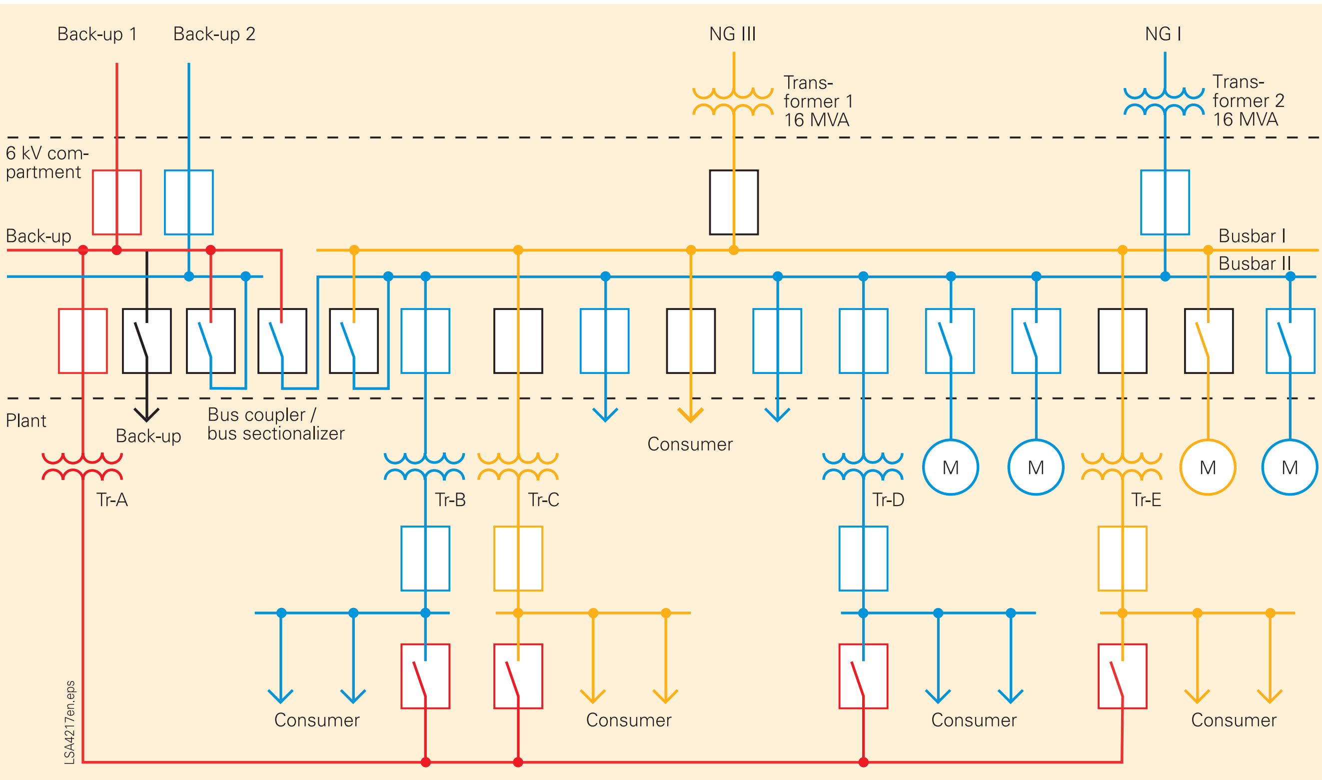
The concept

In collaboration with BP Cologne, Siemens PTD developed a solution with the highest reliability at the lowest cost, offering the following functions and advantages:

- Combined units implement protection and control functions to keep costs low.
- The station control system communicates with the power system control center via the existing noise-immune fiber-optic cables between the buildings.
- The power system control center controls the switchgear under normal operation. For this reason, two control center terminals using a standardized IEC 60870-5-101 protocol connect the station control system to the power system management and to the signaling system. The bay control units feature convenient and reliable local control options at the emergency level.
- The combined protection and control units link to the station control system (station level) in the control and signaling direction via the standardized protocol IEC 60870-5-103.
- Simple, standardized, intuitive operation of the protection and control units saves scarce personnel resources. The equipment's comprehensive self-monitoring mechanisms reduce costs for precautionary maintenance.
- Using the same software for establishing parameters for all protection and control units cuts the time and costs of training.
- Overcurrent protection functions and suitable motor protection functions securely and reliably protect the outgoing circuits.
- The new phase-selective differential protection of the four incoming feeders uses the existing fiber-optic cables connecting the buildings. This provides maximum supply security using the existing infrastructure, thereby reducing investment costs.
- Overcurrent protection in the bay control units protects the incoming feeder units. To protect the investment against operator error, the integrated synchrocheck functionality allows users to check the synchronous conditions before connecting to the supply.
- Panel-internal interlocking can be installed for safe operation of the switchgear. These are implemented in the devices by means of software.

The maintenance-free compact double-busbar switchgear of type NXPLUS, in conjunction with the matching numerical protection relays of the SIPROTEC 4 product range, provides the required high level of reliability.

Fig. 1
System operations under normal operation



The housing design with large detached operator display was selected from the SIPROTEC 4 product range. This design allows installation in the cubicle door in an ergonomic position. It also provides advantages with regard to operation, relay installation position, and mechanical stressing of the switchgear door.

Fig. 2
NXPLUS switchgear with SIPROTEC 4 relay

The control and monitoring functions can be performed easily and reliably on the relay display. All required operator control elements, such as the local key-operated switch, are integrated to avoid the need for external add-on elements. The user-friendly design allows intuitive operation of the devices even under emergency conditions, thus helping to ensure a reliable supply of electrical power for the production process.

The integrated graphical logic level (CFC) and a copper ring bus wires across the panels provide the required switching interlocks. The interlock check prevents busbar sections from being accidentally coupled via the two outgoing feeder disconnectors of a feeder, and keeps the circuit-breaker of the bus sectionalizer from being opened during this operating state.

Because of the modularity of the protection functions in the SIPROTEC 4 combined relays used, 7SJ6 overcurrent-time protection relays can be used as standard and adapted to the object to be protected. Relying on standard operations cuts the required training time significantly, saving scarce personnel resources and reducing the risks of operator error.

Another positive point to be mentioned is the fact that fewer assets are tied up, because a lower stock of spares needs to be maintained.

In order to protect the high-voltage motors in the explosion-protected areas of the compressor station, the 7SJ6 relays have suitable and proven motor protection functions that are also ATEX100-certified.

Fig. 3
SIPROTEC 4 relay with detached panel

For this application, the 7SJ63 relays feature starting time supervision and restart inhibit for motors. The former protects the motor against excessively long start-up processes, thereby providing extra overload protection. The restart inhibit prevents the motor from restarting if the rotor is expected to heat up above the permissible temperature during start-up.

The overload protection prevents thermal overstressing of the objects to be protected. The protection relay (with memory function) displays a thermal replica of the object, taking into account the overload history as well as the heat dissipated to the environment. This is of crucial importance, particularly in explosion-protected areas, since it is necessary to ensure that equipment temperatures do not reach levels that could trigger an explosion.

The four incoming feeder panels have SIPROTEC 7SJ64 numerical overcurrent time protection relays and 7SD610 line differential protection relays. Thanks to standard SIPROTEC 4 technologies, users can operate these relays simply and intuitively according to the same philosophy, and parameterize and read them out easily using the DIGSI software, which is standard for all numerical Siemens relays.

The 7SD610 line differential protection relay communicates via the existing fiber-optic cables across buildings.

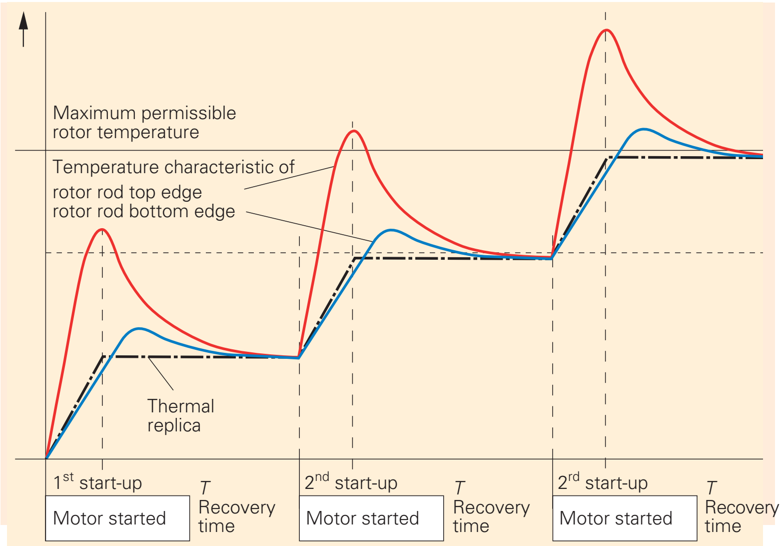


Fig. 4 Temperature characteristic of rotor

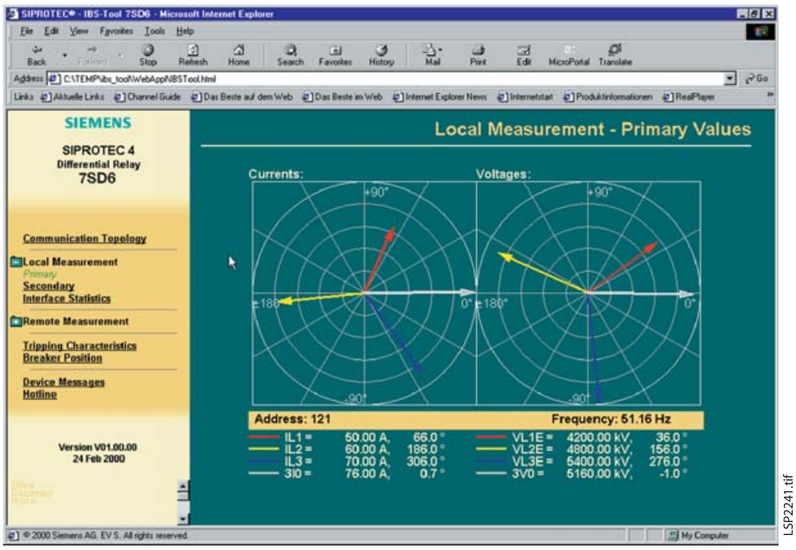


Fig. 5 Web browser in 7SD610

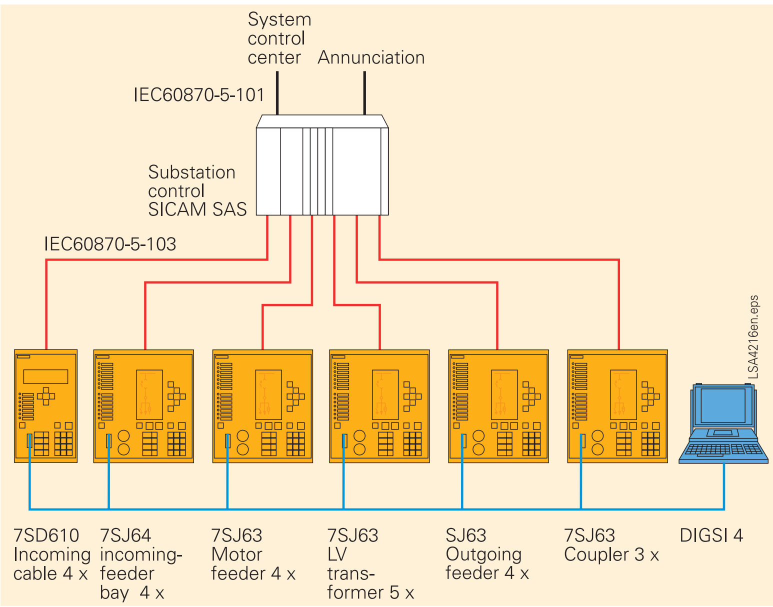


Fig. 6 Protection scheme

The integrated commissioning and monitoring help functions, based on Web technology, support efficient commissioning of the line sections. The Web technology cuts commissioning times and opens up the following new options for the service and maintenance personnel:

- Graphic display of local and remote measured values as vector diagrams
- Simple checking of the polarity of the transformer terminals
- Stability tests with display of the operating points in the tripping characteristic

Fiber-optic point-to-point connections link all SIPROTEC 4 relays to the station control system SICAM SAS. Communications in the control and signaling direction use the standardized protocol IEC 60870-5-103 between the bay unit and central unit. The station control system SICAM SAS connects to the power system control center and the signaling system via IEC 60870-5-101 protocol.

Conclusion

Because of standard equipment technology, users can operate the system safely even in emergency situations with little training, either from the control room or locally. The SIPROTEC 4 relays support operations through self-monitoring and comprehensive logging of events and messages.

Proven modular protection functions, adapted to the application, protect the electrical equipment important to production, such as switchgear, outgoing feeders, and motors. The control system logs and signals any faults immediately. As a result, users can analyze faults swiftly and take appropriate measures to prevent production losses. The all-in system solution, comprising primary and secondary systems, guarantees a high level of reliability for the entire plant, and ensures a reliable and efficient power supply for the compressor stations and the tank farm.

Intelligent Technology for Exceptional Requirements

Unipolar disconnector control in the Kazakhstan project

■ The company

The Kazakhstan Electricity Grid Operation Company (KEGOC) is responsible for operating that country's entire electric power supply system. To ensure its continuing economic development, this still-developing country must not only expand its power system but also ensure the reliability of its electric power supply.

■ The starting situation

A vital objective was to improve the reliability of power transmission as well as the availability of the electrical equipment in the power system. KEGOC therefore awarded Siemens Power Transmission and Distribution (PTD) the order to modernize the station control and protection systems for all transformer substations of Kazakhstan's electric power transmission system. But the existing switchgear had to remain in use without changes, which posed a special challenge to the bay controllers, since the switchgear was only suitable for unipolar control.

■ The concept

To maximize system reliability and stability, all 68 transformer substations of the high-voltage and extra-high-voltage level (110 kV to 1150 kV) were equipped with numerical protection and control units and with latest-generation substation control systems. Analog electronic protection relays were replaced by numerical SIPROTEC systems.

These devices were mounted in the switchgear cubicles and then installed directly at the construction sites and commissioned. In addition, in the control rooms of the transformer substations, conventional control panels were replaced by state-of-the-art display workstations for the maintenance personnel. The SICAM SAS substation automation system was used in this application. Based on SICAM and SIPROTEC components, this system povides a uniform solution for the control and monitoring of electrical transmission and distribution systems. Other critical reasons for the Kazakh utility's decision to opt for station control and protection systems from Siemens included the user friendliness of the system components, their reliability, long service life and the

Fig. 1 Substation in Kazakhstan

capability of making operational and diagnostic data available.

■ From practical experience

Our engineers have developed a solution for controlling the existing switchgear with state-of-the-art SIPROTEC 4 bay controllers. A unique approach was used for controlling the disconnectors in the KEGOC system. These disconnectors are operated with a single-pole control scheme in place of a double command for ON and OFF. The actuation direction depends on the momentary status, i.e. when the disconnector is closed, the command will open it. If it is open, the same command will cause it to close. But such a command doesn't exist yet in the DIGSI information catalog.

An additional function of the SIPROTEC relays and controllers will be to provide switching fault protection during manual local operation, using the same contacts that are used for remote control. Fig. 2 illustrates the configuration.

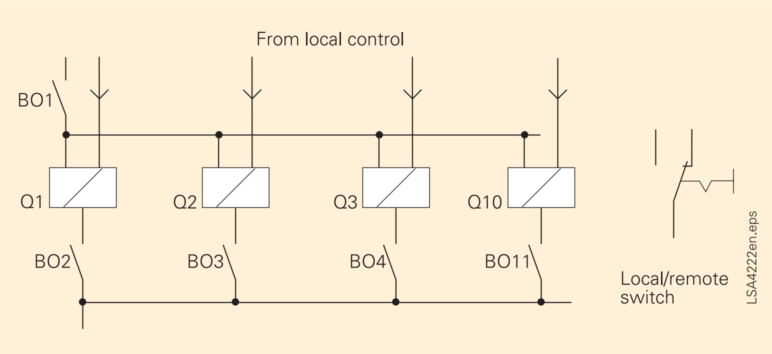


Fig. 2 Disconnector control at KEGOC

The rectangles – Disconnector Q 1 through Disconnector Q10 in the diagram – represent the disconnector connection boxes. These can be controlled either by the instrumentation and control system or by local control (pushbutton directly in the switchgear cubicle). Switching between local and remote control is accomplished by means of the Remote/Local selector (on the right in Fig. 2), which is read by the SIPROTEC relay.

In the "Remote" mode, the disconnectors are controlled by the SIPROTEC relay, i.e. the connections to local control that are represented by arrows are deactivated.

In this mode, every switching command triggers a change in the switchgear status. During these operations, feedback is detected as usual through two binary inputs (OFF, ON, Fault). Disconnector Q1 for instance is turned ON by the contacts BO1 and BO2 when it is OFF, and conversely, is turned OFF when it is ON. These switching operations are performed in accordance with the configured interlock conditions (switching fault protection).

In the "Local" mode, the disconnectors are controlled by pushbuttons directly at the switchgear cubicle. But during this operation too, the interlock conditions in the SIPROTEC must remain in effect. Consequently, when switching the Remote/Local selector to the Local setting, the meaning of the command outputs BO2 through BO11 must be changed: In this situation, SIPROTEC 4 relay closes all contacts that have allocated disconnectors whose interlock conditions are met. This logic allows those disconnectors to be controlled whose switching fault protection condition is being met at a given moment.

Solution

This complex requirement was swiftly and easily met by virtue of the flexibility of the DIGSI 4 operating program, the CFC editor contained in the program, and the latest device firmware. The approach eliminated the need for a project-specific software expansion (more contacts).

Connections

1. The unusual disconnector control scheme requires that ON and OFF be connected to one and the same contact. This hasn't been possible in the past. However, a detour via CFC logic can be used to model an incoming command in a specific message that is allocated to a single contact. Disadvantage: At present, the command must be allocated not only to the CFC destination but also to binary outputs in order to be activated for initiation. In new devices (V4.6 or newer) and DIGSI 4.6 this problem is eliminated. Allocation to the binary outputs is no longer necessary.
2. Use of the commands "Q1 ON/OFF" through "Q10 ON/OFF" produces the same log to the control and protection system as usual.
3. The corresponding outputs that are connected to the disconnector contacts "BO2" through "BO11" are actuated via the CFC logic, and so of course is the common contact "BO1".
4. All commands are interlocked; the conditions, which are stored in a separate group within the configuration matrix, are likewise generated in CFC logic.
5. The external Remote/Local selector is detected at a binary input via the "Remote->Local" specific message.
6. In the local control mode ("Local") single commands are also generated in the CFC under the group header Local Release. These single commands represent the interlocking release.

	Information			Source																										
	Display text	L	Type	BI																								F	S	C
				14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37			
User-def.CMD	BI34		SP																					H						
	BI35		SP																						H					
	BI36		SP																							H				
	BO22		OUT																											X
	BO15		OUT																											X
Cntrl Authority																													*	
Control Device	EntrMMSp		IntSP																										X	X
	Q0		CF_D2																										X	
	Q0		DP																											
	QS1		CF_D2																										X	
	QS1		DP																											
	QS2		CF_D2																										X	
	QS2		DP			X	X																							
	QS3		CF_D2																										X	
	QS3		DP												X	X														
	QS4		CF_D2																										X	
	QS4		DP																											
	QSG1		CF_D2																										X	
	QSG1		DP																											
	QSG2		CF_D2																										X	
	QSG2		DP					X	X																					
	QSG3.1		CF_D2																										X	
	QSG3.1		DP														X	X												
	QSG3.2		CF_D2																										X	
	QSG3.2		DM_S																X	X										
	QSG4		CF_D2																										X	
	QSG4		DP	X	X																									
CmdPulseOutput	P_QS1		OUT																											X
	P_QS2		OUT																											X
	P_QS3		OUT																											X
	P_QS4		OUT																											X
	P_QSG1		OUT																											X
	P_QSG2		OUT																											X
	P_QSG3.1		OUT																											X
	P_QSG3.2		OUT																											X
	P_QSG4		OUT																											X
	P_OFF_ON		OUT																											X
Local Release	LR_QS1		C_S																											X
	LR_QS2		C_S																											X
	LR_QS3		C_S																											X
	LR_QS4		C_S																											X
	LR_QSG1		C_S																											X
	LR_QSG2		C_S																											X
	LR_QSG3.1		C_S																											X
	LR_QSG3.2		C_S																											X
	LR_QSG4		C_S																											X

Display text	Type	Destination																									
		BO																						LE	B	S	C
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22				
BI34	SP																						U				X
BI35	SP																										X
BI36	SP																										X
BO22	OUT																						U				
BO15	OUT															U											
																										*	
EntrMMSp	IntSP																									X	
Q0	CF_D2					Tr	Cl																				X
Q0	DP																									X	X
QS1	CF_D2																										X
QS1	DP																									X	X
QS2	CF_D2																										X
QS2	DP																									X	X
QS3	CF_D2																										X
QS3	DP																									X	X
QS4	CF_D2																										X
QS4	DP																									X	X
QSG1	CF_D2																										X
QSG1	DP																									X	X
QSG2	CF_D2																										X
QSG2	DP																									X	X
QSG3.1	CF_D2																										X
QSG3.1	DP																									X	X
QSG3.2	CF_D2																										X
QSG3.2	DM_S																									X	X
QSG4	CF_D2																										X
QSG4	DP																									X	X
P_QS1	OUT	U																									
P_QS2	OUT								U																		
P_QS3	OUT			U																							
P_QS4	OUT												U														
P_QSG1	OUT		U																								
P_QSG2	OUT									U																	
P_QSG3.1	OUT										U																
P_QSG3.2	OUT											U															
P_QSG4	OUT													U													
P_OFF_ON	OUT																U	U									
LR_QS1	C_S	Cl																									
LR_QS2	C_S								Cl																		
LR_QS3	C_S			Cl																							
LR_QS4	C_S												Cl														
LR_QSG1	C_S		Cl																								
LR_QSG2	C_S									Cl																	
LR_QSG3.1	C_S										Cl																
LR_QSG3.2	C_S											Cl															
LR_QSG4	C_S													Cl													

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Fig. 3 Allocation of commands and interlock signals

Conclusion

Due to the extraordinary flexibility of the SIPROTEC products and the DIGSI software, the engineeres were able to meet the very special requirements of this project without costly development of additional software or hardware replacement. The installation of Siemens protection and control systems substantially reduced system outages in Kazakhstan and provided new incentives for investors.

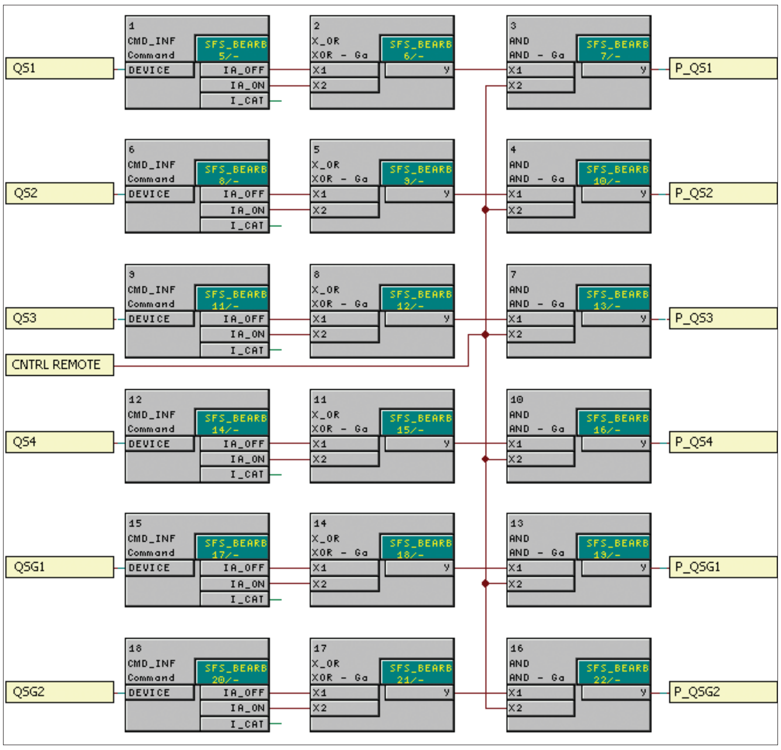

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Fig. 4 CFC logic for generating single commands out of double commands

Inter-Relay Communication (R2R) and Special Schemes for Emergency

SIPROTEC 7SA6 distance protection relay with inter-relay communication

■ The starting situation

As the power supply systems are getting more and more complex, special schemes for emergency situations have to be implemented.
In these special schemes, communication between substations is a necessary feature.
The 7SA6 distance protection relay provides a communication functionality that allows an easier implementation of special schemes.

In the case study described below, a customer started to construct a CIC substation to ensure power transmission from a thermal power station with GG-1/ 2 and GT1.
However, the substation did not get ready on time, and the CSN consumer was not connected to the bus. Therefore, the loads on the CCO –side of the system proved to be too small.

With this situation, load loss on the transmission line between the substations GRL and CCO would in fact mean an overloading of the transmission line between GRL and CSO (see Fig. 2). This is usually the case, when the power generated in the thermal power station is above 290 MVA at the fault occurrence time. Therefore, an additional load had to be connected to the system.

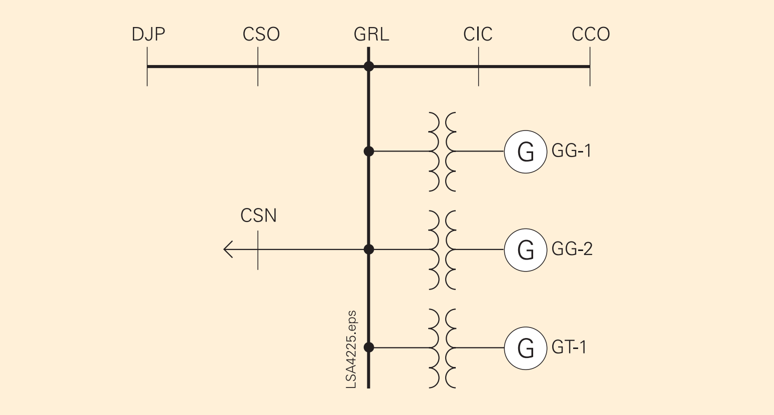

Fig. 1 System configuration

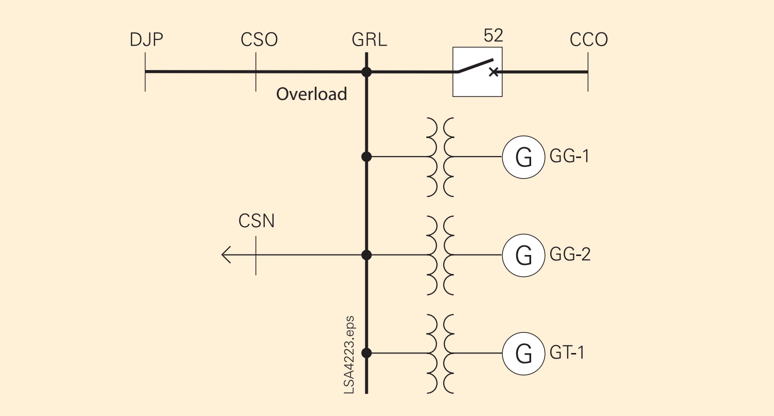

Fig. 2 System configuration under overload condition

■ The concept

The solution was to implement a connection between the GRL substation and the UMB substation.
In case of faults on the GRL-CCO transmission line, this line will be disconnected and the TL GRL-UMB transmission line will be connected .
Since the TL GRL-UMB has a higher thermal limit, this new configuration helps to solve the problem.

The 7SA6 communication function was used to exchange the information between the GRL and CCO substations.
When the main circuit-breaker or the load transfer breaker in the CCO substation opens due to a trip, the GRL relay receives the information by inter-relay communication. The "Special Emergency Scheme" is activated and then the relay output is reset.

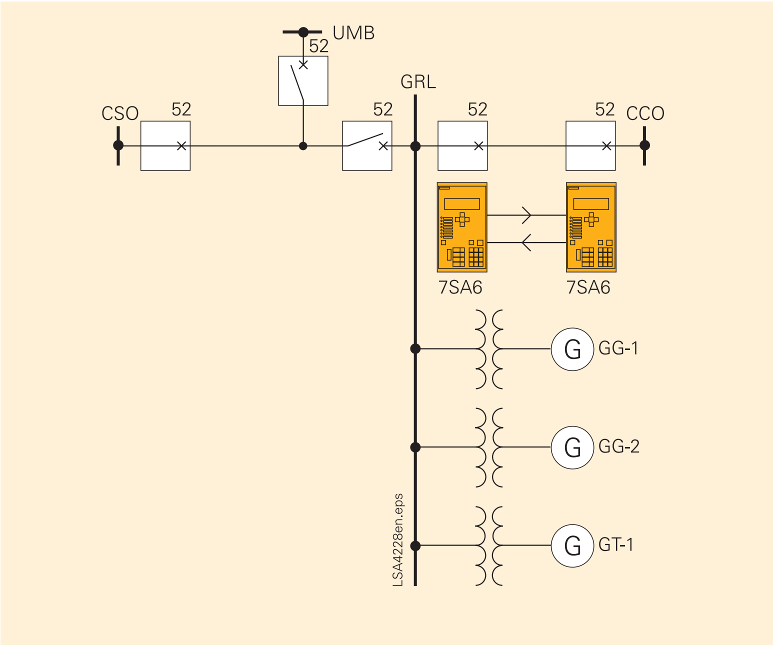

Fig. 3 Solution with inter-relay communication

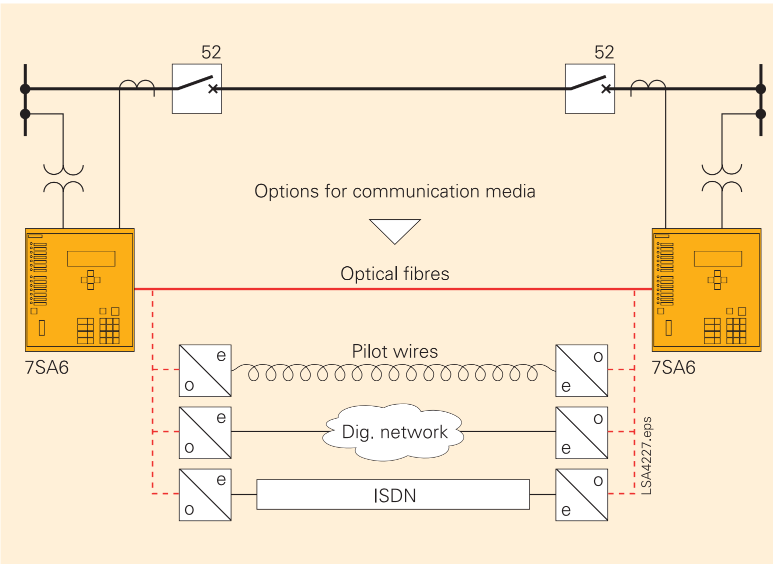

Fig. 4 Options for communication media

Special advantages

The inter-relay communication is used to simplify exchange of information between the substations and relay-internal carrying-out of the logic sequences.

This application uses only 2 remote signals, leaving another 26 signals for further applications. The 7SA6 work with a fast and very reliable protocol .
Due to the flexibility, upward and downward compatibility is provided at all times and communication via various communication media is also possible (see Fig. 4).

Conclusion

As shown in this case study, Siemens configured the "Special Emergency Scheme" for the customer by use of the SIPROTEC 7SA6 distance protection relay for all voltage levels. All requirements of the customer were met. This new scheme allows communication between the substations and therefore – if necessary - the automatic activation of special emergency schemes.

State-of- the-Art Protection for Cafayate Substation

SIPROTEC protection systems of the latest generation in Argentina

■ The company

EDESA is a power supply company in the province of Salta. The integration of the local substation in island operation into the Argentinean power supply system (SADI) was a challenge for EDESA, especially as all new substations have to comply with special standards and, like any private investment, must be profitable.

EDESA awarded Siemens the contract to implement the incorporation of the city of Cafayate into the SADI power system.

■ The starting situation

Power generation in the Northwest of Argentina is mainly thermal. The power system is characterized by transmission lines with average distances of 100 km, large loads located in the main cities and medium-sized customers scattered over a large area. EDESA's task was to build up a substation in Cafayate with the following features:

- Optimum protection
- Integration of many functions in one device to reduce space requirements
- Telecontrol function
- Cost-effectiveness

For the Pampa Grande substation that had to be connected to the Cafayate substation, EDESA demanded a solution for a reliable and efficient operation.

■ The concept

The Cafayate substation project comprised the construction of a T-line configuration in the middle part of a 132 kV transmission line connecting two substations: Trancas in the province of Tucuman and Cabra Corral in the province of Salta.

The new, 130 km long transmission line starts at the Pampa Grande substation.

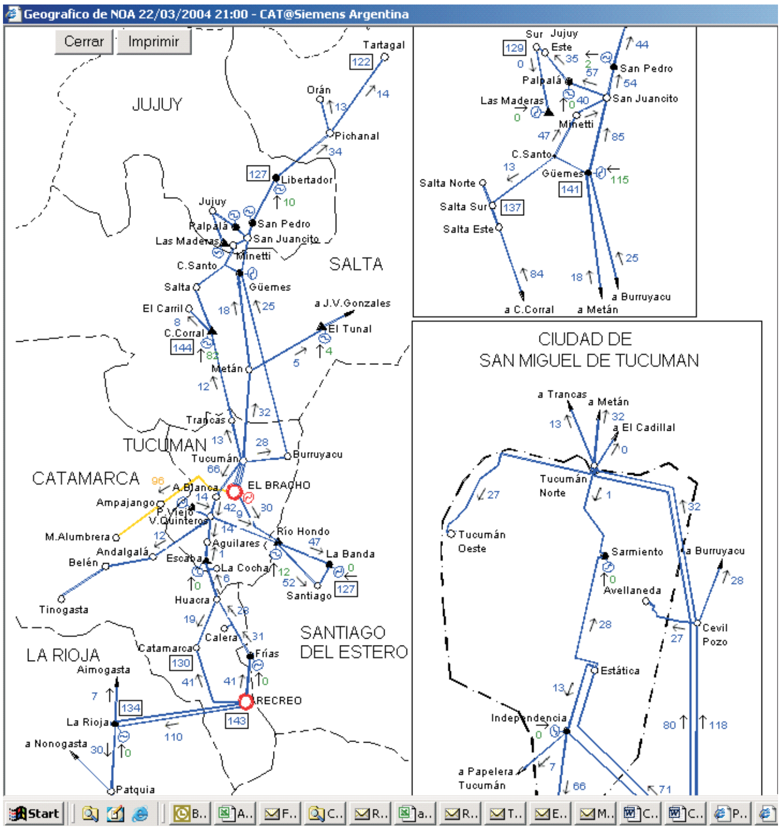

Fig. 1 Lage der Schaltanlage Cafayate

The Cafayate substation featured the following:

- Panel for a power transformer (132 kV/33kV, 20 MVA)
- HV circuit-breaker
- Medium-voltage switchgear with transformer panel and three panels for outgoing feeders, supplying the Cafayate area with power
- Isolated operation with local power generation as backup option only.

Communication between Cafayate – Pampa Grande, Pampa Grande – Cabra Corral and Cabra Corral – San Francisco substations is via Siemens Digital Power Line Carrier ESB2000i and an integrated SWT3000 teleprotection equipment. Four independent commands are transmitted via an interconnection data transmission channel.

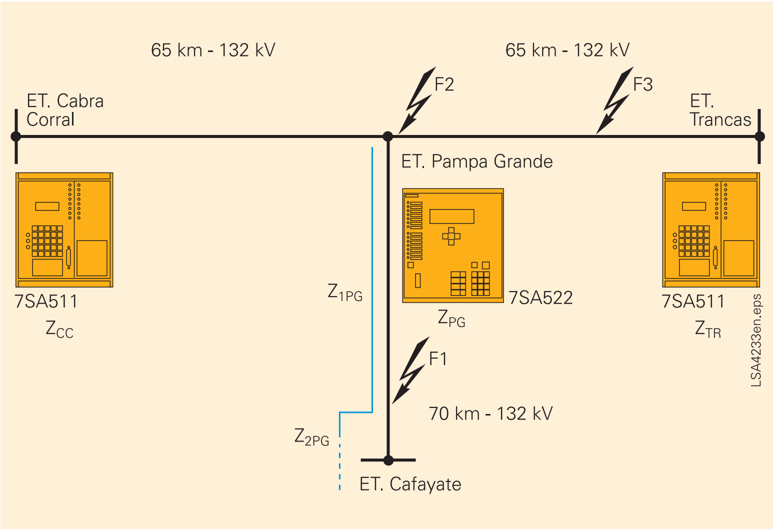

Fig. 2 Zone setting of 7SA522 relay

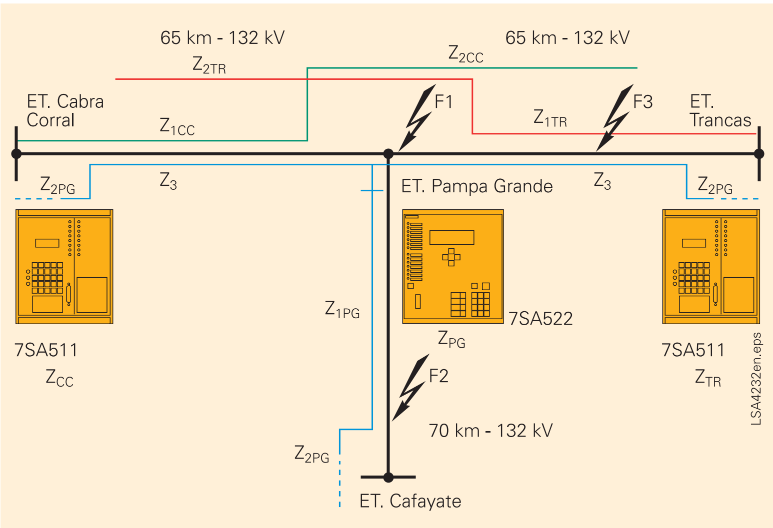

Fig. 3 Zone setting according to Criterion A

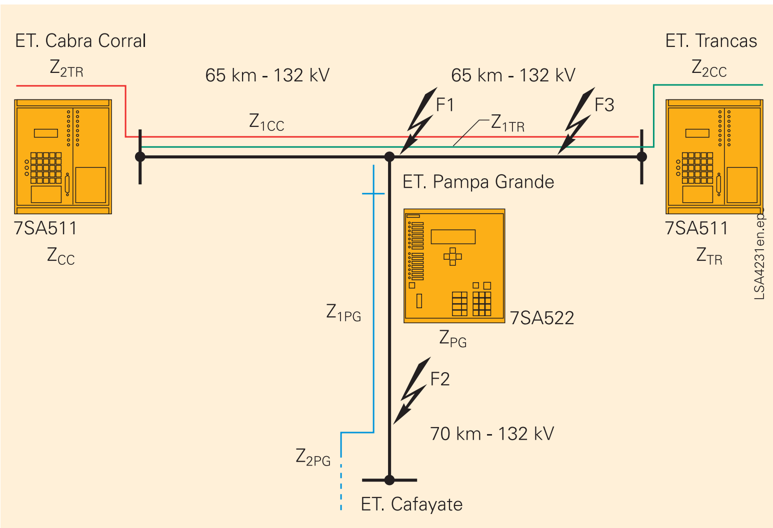

Fig. 4 Zone setting according to Criterion B

For the Cafayate substation Siemens offered an integrated solution, comprising:

- 7SJ63 multifunction relay for the 13.2 kV medium-voltage switchgear, including protection and control and measuring functions plus interfacing for telecontrol systems.
  The following protection functions are applied:
  - Directional and non-directional overcurrent protection
  - Auto-reclosure
  - Over/undervoltage protection and
  - Over/underfrequency protection
- 7UT633 relay for protection and control of the power transformer with differential protection for a three-winding transformer plus overcurrent protection as backup protection.

In one single panel EDESA integrated the transformer protection functions, the automatic voltage control, the thermal replica relay and the Buchholz protection. Control and protection can be either local or remote via telecontrol systems.

For the Pampa Grande substation the 7SA522 protection relay which covers a wide range of protection functions, has been chosen. It features the following:

- Non-switched distance protection with 6 measuring systems (full scheme)
- 5 independent distance zones
- Auto-reclosure (1 pole and 3 pole) (with ADT functionality)
- Synchro-check
- Switch-onto-fault
- High resistance earth-fault (directional or non-directional)
- Phase-overcurrent protection
- Power swing detection/blocking
- Teleprotection for distance protection (PUTT/POTT)
- Fault locator

Remote control is effected by DIGSI remote control query of the Pampa Grande 7SA522 distance protection. The operator staff may control and change the settings and download fault and event logs.

In the first zone the 7SA522 distance protection relay measures in the direction of the transmission line to Cafayate substation, which is 80 % of the line length. This means that the fault disconnection and clearance times for the transmission line sections from Pampa Grande to Cabra Corral and Trancas have to be kept to a minimum.

Among others, two main criteria had to be considered:

Criterion A (see Fig. 3)

1) Distance protection Z_{PG} (7SA522) measures in first zone (Z_1) 80 % of the line length in the direction to the Cafayate substation (forward). In the second zone (Z_2) the remaining 20 % of the line are measured and at the same time the relay serves as backup protection for the power transformer. In the third zone (Z_3) 60 % of the line length measured from Pampa Grande are measured in reverse direction.

2) 80 % of the line length Cabra Corral – Pampa Grande and Trancas - Pampa Grande are measured in the first zone (forward direction) by the distance protection relays Z_{CC} and Z_{TR}. An overreaching zone of 115 % is formed in the second zone Z_2 with the substation at the remote line end.

3) For the distance protection relays Z_{CC} and Z_{TR}, the settings of the independent zone Z_{1B} correspond to those of the second zone Z_2. ($Z_{1B} = Z_2$).

With these settings, different types of faults were analyzed (Fig. 3) with the protection relays showing the following behavior:

1) Fault F 1: Distance protection relay Z_{PG} trips in the first zone (Z_1) and since the other two protection relays are measuring in the second zone Z_2, Z_{PG} trips first in t_{Z1}.

2) Fault F 2: Distance protection relay Z_{PG} measures the fault in the third zone (Z_3) in reverse direction and sends a signal to the protection relays Z_{CC} and Z_{TR} to release to the independent zone Z_{1B} and both protection relays clear the fault .
This signifies: signal transmission time + trip time of Z_{1B} (t_{Z1B}) = reaction time.

3) Fault F 3: In this case protection relay Z_{TR} trips in minimum time (t_{Z1}) and the Z_{CC} receives the release signal for the independent zone Z_{1B}
This signifies: signal transmission time + trip time of Z_{1B} (t_{Z1B}) = reaction time.

Criterion B (see Fig. 4)

1) Distance protection Z_{PG} (7SA522) measures in first zone (Z_1) 80% of the line length in the direction to the Cafayate substation (forward). In the second zone (Z_2) the remaining 20 % of the line are measured and at the same time the relay serves as backup protection for the power transformer.

2) 120 % in direction of the lines Cabra Corral – Trancas and Trancas – Cabra Corral are measured by the distance protection relays Z_{CC} and Z_{TR} in the overreach zone (Z_{1B}). Both working in POTT teleprotection scheme (a release signal has to be received from the remote end so that the distance relay locally trips the circuit-breaker). The trip time for zone Z_{1B} of protection relays Z_{CC} and Z_{TR} should be greater than the trip time for the first zone of protection relay Z_{PG}.
This results in time selectivity between the transmission lines Pampa Grande – Cafayate and the other two transmission lines with regard to faults on the first line.

With these settings, different types of faults were analyzed (Fig. 4) with the protection relays showing the following behavior:

1) Fault F 1: Distance protection relay Z_{PG} trips in the first zone (Z_1). And because the other two protection relays have a longer time for tripping the first zone, relay Z_{PG} is the first to trip in t_{Z1}.

2) Fault F 2: Distance protection relays Z_{CC} and Z_{TR} measure the fault in overreach zone Z_{1B} and – after a release command - both protection relays clear the fault. Trip time therefore is: signal transmission time + trip time Z_{1B} (t_{Z1B})

3) Fault F 3: same as in 2)

After analyzing and evaluating the two criteria, criterion B was opted for, aiming at homogeneity within the system.

The special advantages

The distance protection 7SA522 provides the following:

- Minimized fault clearing time in the different sections of the transmission lines from Pampa Grande to the other substations.
- Unnecessary three-phase trips, caused by simultaneous single-phase faults in different phases on both transmission lines, are avoided.
- Service life of circuit-breaker is prolonged thanks to reduction of unsuccessful autoreclosures.

Conclusion

Since January 2004, the Pampa Grande and Cafayate substations have been in operation to the customer's full satisfaction.

EDESA has integrated the power supply for the city of Cafayate into the Argentinean power supply system. Thanks to the SIPROTEC protection relays, the Cafayate substation is now being protected by an optimal and cost-effective protection concept.

The Numerical Advantage in Protection Technology

Intelligent protection systems spare LEW power supply company expensive power system expansion

■ *The company*

Lechwerke AG (LEW) is one of the largest regional power supply companies in southern Germany. Its core business consists of electric power supply and all related services. The area supplied by its power supply system covers 8,245 square kilometers and is mostly located in the provincial administrative district of Swabia. LEW also supplies electric power to some adjacent portions of Upper Bavaria.

To provide power to its 885,000 directly and 600,000 indirectly supplied customers, LEW maintains a medium-voltage system 7,198 kilometers in length, a 380/220/110 kV high-voltage system with a total length of 2,429 kilometers, and 104 transformer substations.

■ *Initial situation*

The Lechhausen substation feeds a fairly large municipal utilities company. In normal operation, the energy demand is met over a 380 kV/110 kV system interconnection from the 380 kV system. A second system interconnection exists as a backup transformer in the Lechhausen substation but remains disconnected in normal operation.

A rise in the municipal utilities company's power demand created the risk that a failure of the 380 kV/110 kV supply transformer would cause trips on faults due to power system overloads in the 110 kV system. This would interrupt the supply to the connected municipal utilities company.

To increase the power transmission from the 110 kV system in the Lechhausen substation, a substantial and costly power system expansion would have been called for. Among other requirements, an additional overhead line would have had to be looped into the Lechhausen substation, and the substation would have had to be expanded by two additional switchgear feeders with circuit-breakers.

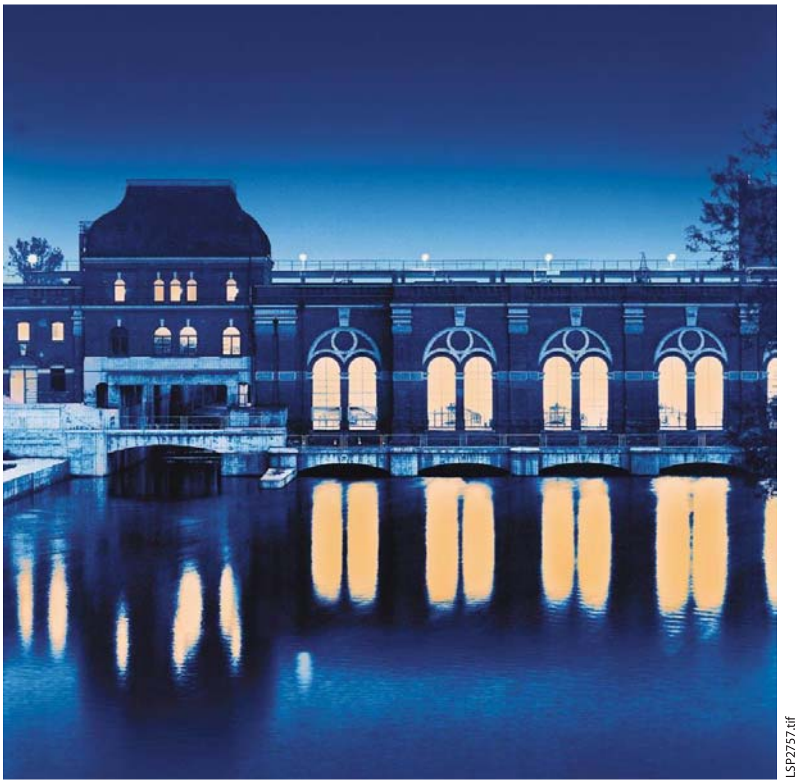

Fig. 1 Gersthofen hydro power plant of LEW

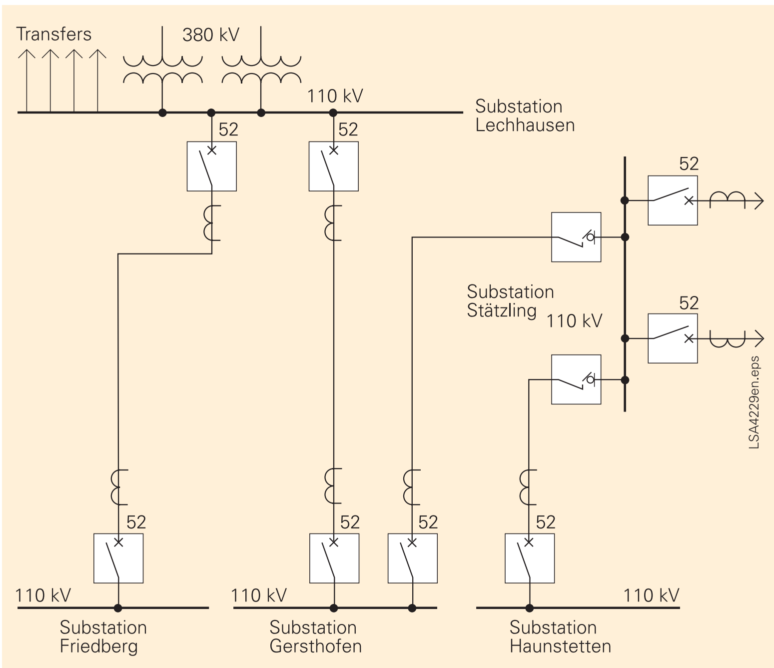

Fig. 2 110 kV power system configuration

■ The concept

In view of such high cost estimates, LEW developed an alternative concept that also effectively protects against a power failure – but at much less expense.

The solution was to integrate the Lechhausen substation via a dual tie line into the 110 kV power system, which resulted in a three and a four line-ends configuration. As a result, it was possible to increase the available level of power transferred from the 110 kV power system with the existing circuit-breakers and switchgear panels. A failure of the 380 kV/110 kV transformer can now be compensated by the 110 kV power system without causing power outages in the dependent municipal utilities company. The multi-end configuration also made it possible to increase the short-circuit power in the 110 kV power system and to optimize the load flow.

To provide selective and fast protection for this three and four line-end power system configuration it was necessary to expand the existing distance protection relays by a line differential protection relay capable of protecting even three and four line-ends.

The existing distance protection would not have been able to protect the new power system configuration selectively and swiftly in all cases. In combination with the line differential protection relay, the distance protection now also functions as backup protection.

Lechwerke decided in favor of the SIPROTEC 7SD52 multi-end differential protection relay, which can protect up to six line-ends. The existing distance protection was augmented by one 7SD52 differential protection relay per switchgear feeder.

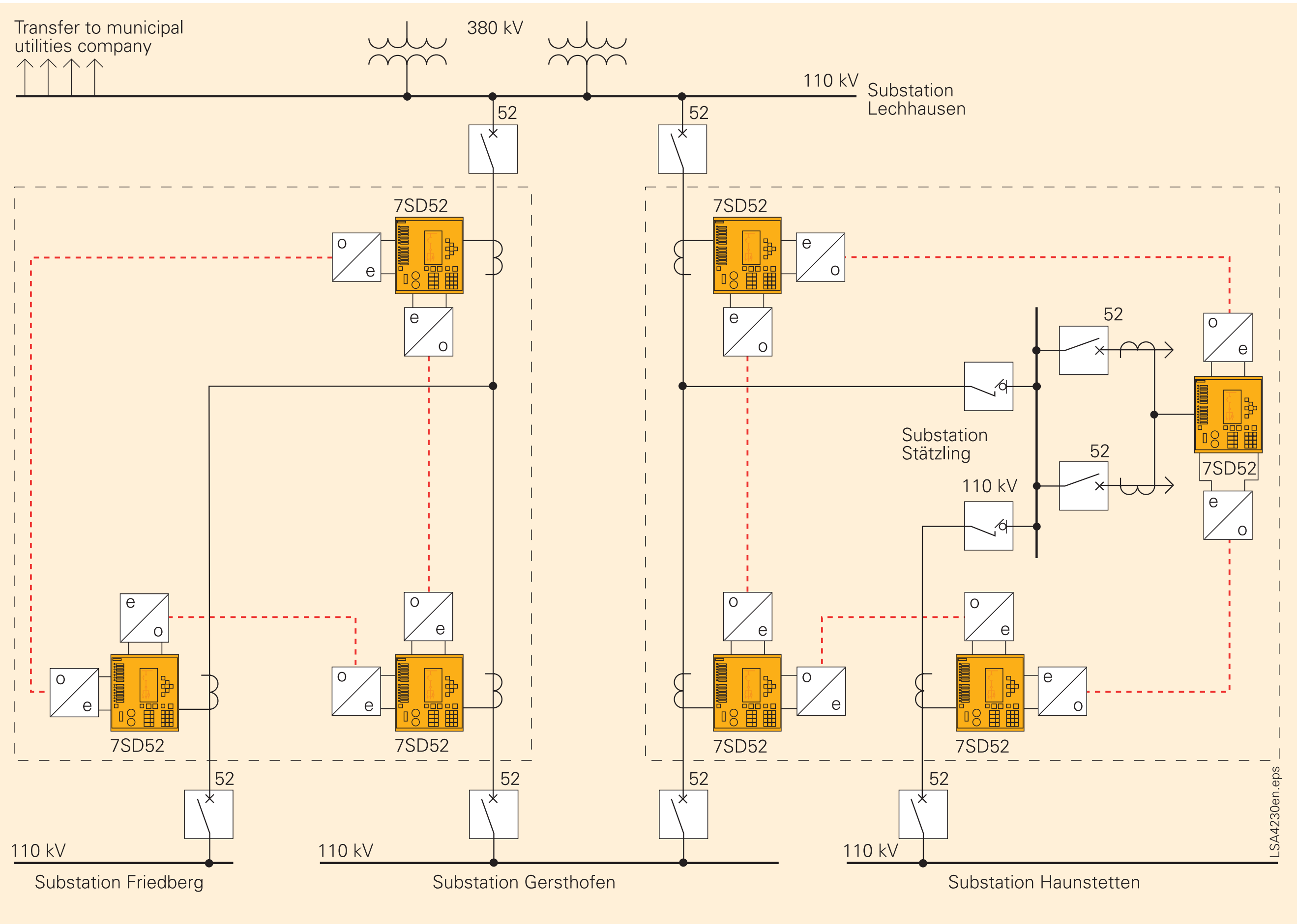

Fig. 3 Protection scheme of a three and four line-end configuration

No current transformers or circuit-breakers exist in the 110 kV lines at the Stätzling substation. If a fault occurs, the existing switch disconnectors in the feeders can't shut off the short-circuit current, which causes the line differential protection to trip the circuit-breakers of the transformers in such an event. The current is measured at the bushing-type current transformers of both transformers. The measured values are adjusted via a summation transformer and transmitted to the 7SD52. This adjustment via a summation transformer was feasible because the installed 7SD52 required very little power from the transformer.

Since no direct communication links exist between the different substations for the transmission of protection data, this is provided between the differential protection relays via a digital PCM (Pulse Code Modulation) communications network. The adaptation to the digital communications network in turn is implemented via external converters by means of a synchronous electrical X.21 interface to effect the connection to the communications devices. With these communication converters, two protection relays can communicate synchronously with each other and exchange large data volumes over long distances.

■ *The special advantages*

To further increase the availability of the system, Lechwerke decided to equip all of the installed 7SD52s with two R2R interfaces. As a result, each protection relay can exchange data with two neighboring relays – so that a ring topology can be established for the exchange of protection data.

Failure of a communications connection between two devices does not result in blocking of the differential protection function, since the devices detect this condition and re-route ring topology automatically to chain topology while the differential protection function is immediately reactivated.

■ *Conclusion*

Conversion of the existing 110 kV power system into a three and a four line-end configuration made it possible to increase the short-circuit power at the Lechhausen substation and to substantially improve the reliability of the power supply to the connected municipal utilities company, without requiring large investments in primary technology. The use of state-of-the-art SIPROTEC numerical protection technology made it possible to safely and selectively protect the resulting, complex power system configurations. The use of existing communication channels made it unnecessary to invest in new fiber-optic connections in the communications network.

SIPROTEC – Down in a Coalmine

Protection systems Deutsche Steinkohle AG can depend on

■ The company

Deutsche Steinkohle AG (DSK) resulted from the merger in 1998 of two mining companies, Ruhrkohle AG and Saarbergwerke AG. In 2003, the company sold 27 million metric tons of coal, most of it to German power supply companies.

■ The starting situation

Under-ground mining poses electric power requirements that differ from those in normal utilities' power systems. This is true with respect to protection systems. Protection relays must be able to respond to faults in a fail-safe manner, even in explosion-hazardous areas. Special requirements also pertain to communications in explosion-hazardous areas and to auxiliary power supply, since batteries are prohibited as a power source in underground mines . In upgrading the incoming supply to a 10 kV power system, DSK opted for a SIPROTEC 4-based design that meets these requirements completely.

■ The concept

The SIPROTEC 4 product range of protection relays is highly flexible and can be safely used in underground mines. The version used is the ATEX-compliant 7SJ62 relay for protection of explosion-protected motors with the elevated level "e" rating of explosion protection. When used in explosion-hazardous areas with methane gas and electrically conductive coal dust, devices must comply with the "explosion-proof enclosure" type of protection. To meet this requirement, they are installed in the BARTEC 8SN enclosed switchgear from Siemens.

■ The special advantages

Communication despite enclosure

The installation within the enclosed, explosion-proof switchgear means that it is not feasible to go online with the protection relay via a wire connection to the DIGSI computer. To communicate with the laptop through the sealed glass window, an infrared adapter is therefore connected to the front interface of the 7SJ62 and simulates a serial interface.

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Fig. 1 Coal mine of DSK

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Fig. 2 Siemens Bartec 8SN encapsulated switchgear

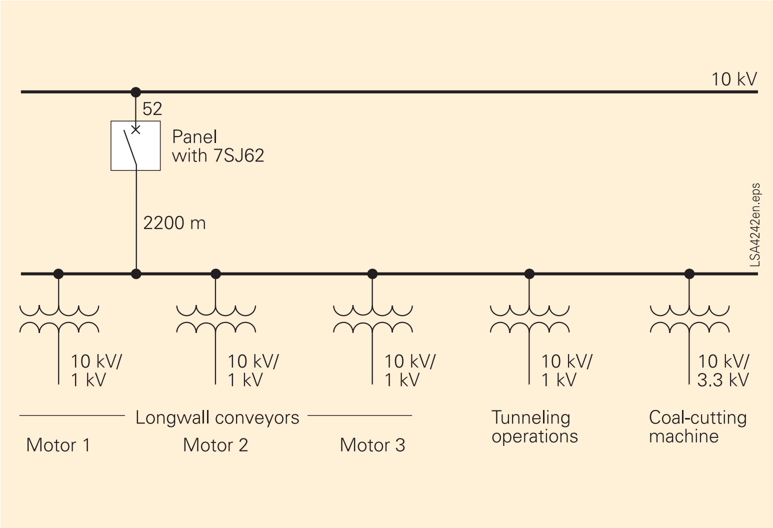

Fig. 3 Typical 10 kV power system in a coal mine

Communication with the world above

An intrinsically safe modem installed within the explosion-proof enclosure maintains communications to the outside world via the systems interface using PROFIBUS-FMS protocol. Actions such as readouts of operational information, switching events and protection settings can therefore be shifted above ground.

The protection relays are installed in a 10 kV switchgear panel. The motors for the belt conveyors, longwall conveyors, coal-cutting machine and tunneling operations in the longwall are located in the outgoing feeders. A characteristic feature is that these motors are constantly being relocated as the mining progresses. What's more, the long distances in the mine network to the coal face being cut pose special requirements that must be considered.

CFC logic detects short-circuits promptly

The basic rule of selecting a motor short-circuit setting above the highest starting current and below the 2-pole short-circuit level does not apply here. Due to the long distances, the short-circuit current may be lower than the starting current. The longwall conveyor motors are tuned to each other and start up sequentially within a short time interval, so that the total current continues to increase and exceeds the short-circuit level.

The use of CFC logic solved this problem: The pickup threshold is increased stepwise by detecting the motor start, so that no spurious tripping occurs yet a motor short-circuit can be detected promptly.

Fig. 4
Self-adaptation of triggering threshold during motor start

Visual display of information

The personnel on site should be able to obtain as much information as possible in visual form – without having to access operational messages or system fault messages by operating keys. To achieve this, SIPROTEC 4 relays can be additionally programmed by means of CFC logic blocks to cause optical indicator lights (LEDs) on the front plate to either blink or illuminate continuously, as desired. This means: In a 7SJ62 relay with 7 LEDs it is possible to display 14 different status indications.

Auxiliary power via voltage transformer

Another special aspect of underground mining is that batteries cannot be used for auxiliary power due to the explosion hazard. Protection relays are supplied through the voltage transformer (frequently only a single phase-to-phase voltage is available). However, tripping must be prompt if the voltage falls below the minimum level (<70%) to ensure that there is sufficient voltage to actuate the undervoltage coil.

Tripping assured to the n^{th} degree

With these factors in mind, a breaker-failure protection is also provided, in the event that the first undervoltage tripping signal fails to open the circuit-breaker.

If the first TRIP command is ineffective, the breaker-failure protection attempts to use a stored signal (lockout) to issue a TRIP signal to the same circuit-breaker. Reasons for the voltage dip may include:

- a voltage failure due to the incoming supply being shut off
- a voltage drop due to the starting of large motors
- a voltage dip due to a short-circuit

As a last resort, if the breaker-failure protection also fails or the supply voltage is already too low, the live-contact status of the protection relay trips via the undervoltage coil.

PE conductors provide fault detection

Since the supply cables are accessibly located along the longwall, there is always a possibility that they may suffer some minor impact damage. To detect such faults promptly before any critical damage is suffered by the phase cables, PE conductors are provided underneath the outer cable sheath. In the event of a fault, these conductors trigger alarms in the protection relay via the binary inputs, similar to the trip circuit supervision function.

No information loss

Supplying auxiliary power to the protection relays via voltage transformers rather than by battery voltage causes more frequent switching off of the SIPROTEC relays during operation. It is therefore all the more important that all essential process information remain stored in the protection relay, to be available to the operator for analysis once normal power is restored. Because even simple signals via the binary inputs can cause the circuit-breaker to trip, for instance if the environmental monitor issues a methane gas alarm.

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Fig. 5 Power supply in a coal mine

Automatic reconnect

When the protection relay is operational again and no further interlocks or messages requiring acknowledgment are outstanding, reconnections are established automatically. To prevent all loads from being reconnected to the supply simultaneously, which could cause large line voltage fluctuations even above ground, each 7SJ62 has stored its individual reconnect time in the CFC scheme and reconnects the respective circuit-breaker separately after a time delay of several seconds.

Conclusion

SIPROTEC relays have been used at DSK to implement a protection system that is more than adequate to meet the special requirements of coal mining.

Special underground requirements such as

- application in explosion-hazardous areas
- readout of fault records via infrared interface
- auxiliary supply of the relays by voltage transformers
- recording of fault-related data after supply voltage failure

were successfully met and solved optimally with SIPROTEC protection relays.

Fig. 6 Tunneling operation

Fig. 7 Coal-cutting machine at work

SIPROTEC 7SA6 with Auto-Reclosure on Mixed Lines

SIPROTEC 7SA6 with auto-reclosure on mixed lines

■ The company

With about 2,900 employees and sales of around EUR 1.3 billion, Stadtwerke Hannover AG is one of Germany's largest municipal utilities companies. Under the brand "enercity – positive energy", they offer power, water and services to private and commercial customers. In the Hanover region, municipal utilities company Stadtwerke Hannover provides around half a million people with electricity, natural gas, district heating and drinking water and is currently supplying about 8,000 delivery points nationwide. Thanks to their cooperation with various partners, municipal utilities company Stadtwerke Hannover is also able to promote customer-oriented offers on a national level. In the commercial customer sector, the company offers the full range of services associated with energy management, including consulting, planning, new construction and refurbishment, and plant operation. Their nationwide commitment is proving successful: 2002 was the first year that Stadtwerke Hannover sold more electricity outside its original service area than inside it. In 2003, they further increased sales to just under 19,500 GWh (service area: 3,285 GWh).

■ The starting situation

Stadtwerke Hannover, enercity requested the implementation of 7SA6 distance protection over mixed lines. This application is not limited to a specific plant but can be employed in a variety of applications. Mixed lines means that part of the section to be protected within a grading zone comprises cables and another section consists of overhead lines. The auto-reclosure (AR) function would be appropriate for the overhead line section only. The sections to be protected must be selected accordingly (see Fig. 2).

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Fig. 1 Trademark of municipal utilities company Stadtwerke Hannover

■ The concept

For sections with both cables and overhead lines, distance zone signals (resistance (R) and reactance (X)) can be used within a certain framework to differentiate between cable faults and overhead-line faults. With the appropriate interconnections by means of the programmable logic functions (CFC), auto-reclosure can be blocked when a fault occurs in the cable section.

■ Configuration

As usual, the line sections are grated in the 7SA6 distance protection relay into distance zones Z1, Z2, Z3 and Z5, depending on the power system connection. Zone Z1B is primarily used for the auto-reclosure function and for connection functions ("Hand-Ein" = manual close). Zone Z4 serves to measure and select the segments of cable or overhead line in the sections to be protected. Besides being used for the auto-reclosure function (AR), Zone Z1B is also employed for instantaneous switch-onto-fault tripping for the sections to be protected. The protection system must be tripped instantaneously when connecting to the section to be protected if, for example, the ground electrode is still inserted at the remote end. Alternatively, this functionality can also be implemented in the 7SA6 by means of the "instantaneous high-current tripping" function.

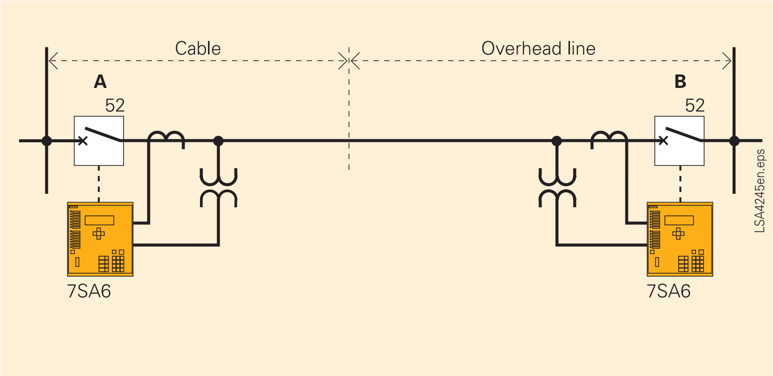


Fig. 2
Mixed-line configuration

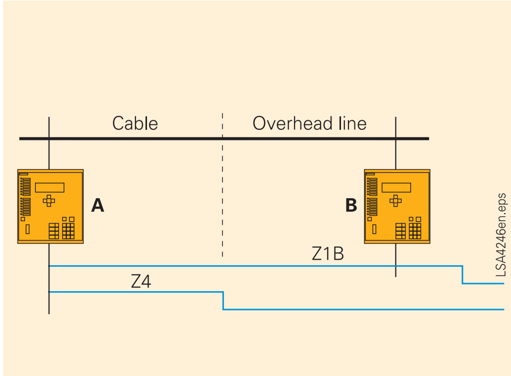


Fig. 3 Zone grading of distance protection relay **A**

This description of the application is based on a general section <A – B> with two 7SA6 distance protection relays. For the protection relay at installation location "A", the solution includes distance zones Z1B and Z4. The protection relay at installation location "B" can be configured for AR on mixed lines either by means of distance zone Z1B and instantaneous high-current tripping or, alternatively, in accordance with solution "A" with the grading of zones Z1B and Z4.

Settings for project planning in DIGSI

Firstly, the following entries must be made in the parameter set for the 7SA6 by means of parameterization in DIGSI.

Configuration matrix (Group: "Automatische WE" (auto-reclosure) or "Dis general"):

a	FNo. 2703	>Block AR	configured to "Destination CFC"
b	FNo. 3747	distance protection pickup in ZoneZ1B, L1E	configured to "Destination CFC"
c	FNo. 3748	distance protection pickup in Zone Z1B, L2E	configured to "Destination CFC"
d	FNo. 379	distance protection pickup in Zone Z1B, L3E	configured to "Destination CFC"
e	FNo. 3750	distance protection pickup in Zone Z1B, L12	configured to "Destination CFC"
f	FNo. 3751	distance protection pickup in Zone Z1B, L23	configured to "Destination CFC"
g	FNo. 3752	distance protection pickup in Zone Z1B, L31	configured to "Destination CFC"
h	FNr. 3759	distance protection pickup in Zone Z4	configured to "Destination CFC"

Parametrization: (Parameter group A, distance protection - polygon, zone Z4) parameter 1335 "Delay time T4"

Tripping time for zone Z4 (parameter 1335 = T4) has to be set to indefinite (T4 = ∞) because this zone is only used for selecting the cable or overhead line sections of this line. In this application, zone Z4 is to indicate only one pickup. Tripping is not relevant in this zone. Especially in the case of a single-pole auto-reclosure function this setting is important, because then tripping may only initiated via zone Z1B.

Creating the logic sequences

All that is left is to create, link and translate the corresponding CFC logic diagrams in DIGSI. The CFC priority class used is the "Fast" PLC Task (PLC0). The individual logic functions and their effect on the protected zone are described below.

For the section <A – B> described, appropriate allocations must be implemented in both distance protection relays for detecting the AR range on the overhead line.

Controlling auto-reclosure in 7SA6 for protection relay A

7SA6 – protection relay A

Zone Z4 is graded in accordance with the R and X values of the cable section. As usual, Zone Z1B is dimensioned to approx. 120% of the line length. Because AR should not be executed in the cable section, the overhead line section in Zone Z1B is selected by means of a CFC. The result of the CFC (FNo. 2703 : ">AR block") is that auto-reclosure is blocked when a fault occurs in the cable zone (Zone Z4), see Fig. 4.

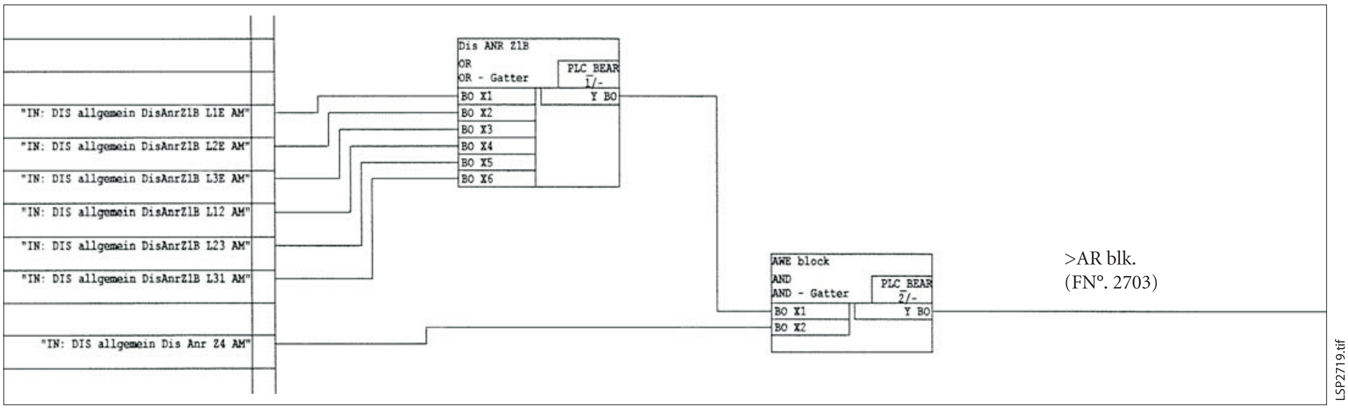
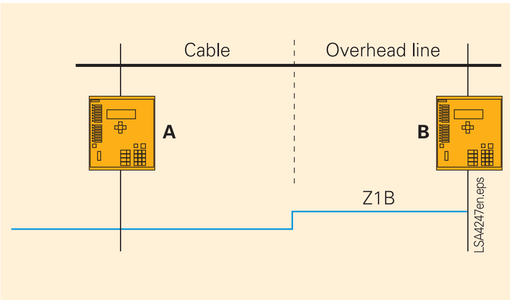


Fig. 4 CFC logic diagram for AR control for relay A

Controlling auto-reclosure in 7SA6 for protection relay B

Solution 1:

7SA6 with Zone Z1B and instantaneous high-current tripping:



Fig, 5 Setting of zone Z1B in relay B

7SA6 – protection relay B

Zone Z1B is graded in accordance with the R and X values of the overhead line on which the AR function should be executed. For instantaneous switch-onto-fault tripping, the instantaneous high-current tripping function is used in the 7SA6 for the full protection of the <A – B> section.

Solution 2:

7SA6 with grading of zones Z1B and Z4:

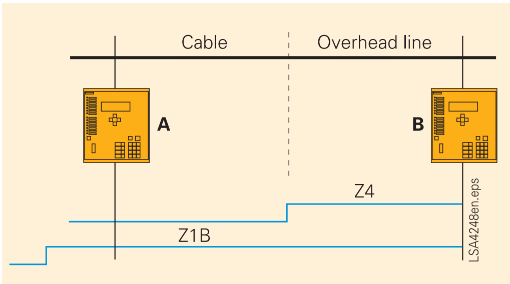


Fig. 6 Grading of zones Z1B and Z4 of relay B

7SA6 – protection relay B

Zone Z4 is graded in accordance with the R and X values of the overhead line. As usual, zone Z1B is dimensioned to approx. 120% of the line length. Because AR should not be executed in the cable section, the overhead line section in zone Z1B is selected by means of a CFC. The result of the CFC (FNo. 2703 : “>AR blk") is that auto-reclosure is blocked when a fault occurs in the cable section (i.e. pickup in Z1B and no pickup in Z4).

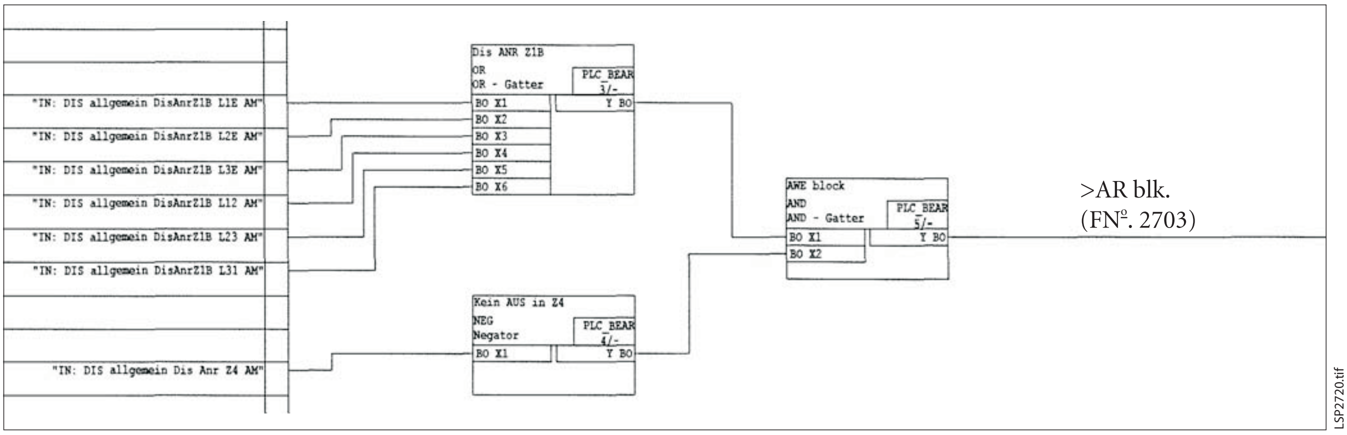


Fig. 7 CFC logic diagram for AR control for relay B

■ *The special advantages*

The division into two distance protection zones (Z1B and Z4) makes it easy to select the cable and overhead line sections in the event of a fault.

■ *From practical experience*

In practice, the auto-reclosure function can be executed on the overhead line only. A fault in the cable section immediately results in a lockout command.
A similar, slightly modified CFC function for application in an other distance zone was successfully implemented for the Stadtwerke Hannover AG.

■ *Conclusion*

In the past, sections could either be protected without any selectivity or else separate sections were required for the cable and overhead line sections. Today, thanks to CFC add-on logic, offered as standard feature of SIPROTEC the complete line length can be covered intelligently with 2 relays thus requiring much less primary technical outlay.

Greater Safety for Existing Technology

Potential savings through new concepts in protective relaying

■ The company

EVI – the power supply company in Hildesheim – is a regional utility company for electricity, gas, water, and local heat. It provides services to the approximately 110,000 residents of the city of Hildesheim. For power supply in the medium-voltage range, EVI operates a 20 kV power system as an all-cable system with about 500 stations, including main switching stations, power system protection stations, and transformer stations. Upstream supplier Avacon supplies the energy for this medium-voltage power system using three transformer substations. EVI operates its medium-voltage power system with impedance grounding at the star point.

■ The starting situation

A standard power system protection station from EVI is built as a three-feeder system equipped with two cable feeder and one transformer. Until now in these stations, a Siemens 7SA500 numerical distance protection relay has protected each of the outgoing cable feeders. A remote terminal unit records the information from the distance protection relay and the power system protection station using single-fiber wiring. The unit forwards the information to the power system control center through other gateways. EVI operates an extensive telecontrol network for transmitting the information.

In the monitoring direction, the scope of information of the standard power system protection station consists of the following messages: supply and protective voltage missing, DC voltage system malfunction, system control on site and device malfunction, distance protection relay, and fault locator.

The distance protection pickup and distance protection tripping are transmitted as measured values from each of the two existing distance protection relays. If protection trips, the fault location measured by the protection relay is also transmitted in this manner. Furthermore, each outgoing cable feeder transmits the present measured value of the outgoing current. In the control direction, information transmitted also includes CLOSE/TRIP commands for each of the two circuit-breakers and a reset command for transmitting the fault location of the distance protection. As a result, the total volume of information includes about 14 messages, 4 measured values, and 5 commands for each power system protection station.

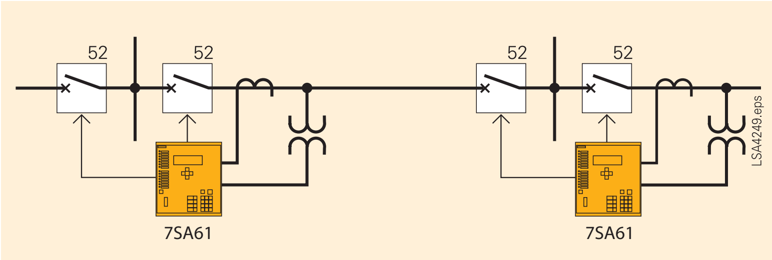


Fig. 1 Line configuration of EVI utility Hildesheim, Germany

The telecontrol systems is over 20 years old, and the protection relay system about 15 years. As a result, there has been an increased incidence of equipment failure in the past two years. The ongoing costs for repairs, spare parts, service and handling have continued to climb. The switch to modern engineering became economically necessary.

In switching to new equipment, the company looked for cost-effective standard solutions. Rather than replace the existing technology one-for-one with modern equipment, EVI established the following criteria for the modernization:

- Modernize 10 substations initially, using the same technology.
- Choose an optimal cost-to-performance ratio for the new technology.
- Use the same hardware for distance protection and telecontrol in these systems.
- Maintain at least the same functionality of the power system protection station while reducing the number of primary components in the substation.
- Replace the two existing distance protection relays with a single relay that ensures at least the same functionality.
- Avoid using single-conductor wiring between the distance protection and telecontrol.
- Use the standardized IEC 60870-5-103 interface to transmit the protection relay's information and measured operational values to a higher-level telecontrol unit.
- Specify a telecontrol unit that can record information from the protection relay via the standardized IEC 60870-5-103 interface and transmit this information and other data to a gateway via the standardized IEC 60870-5-101 interface.
- Connect the telecontrol units on a polling mode demand basis. This method will ensure optimal use of the communications line network resources and a low interface demand to the higher-level gateway.
- Specific new devices with easy, intuitive operation and parameterization, requiring a minimal training period.

The concept

A new concept was developed according to these criteria that calls for one distance protection relay for two outgoing cables. EVI selected the Siemens SIPROTEC4 7SA61 distance protection relay and a suitable telecontrol unit for transmitting.

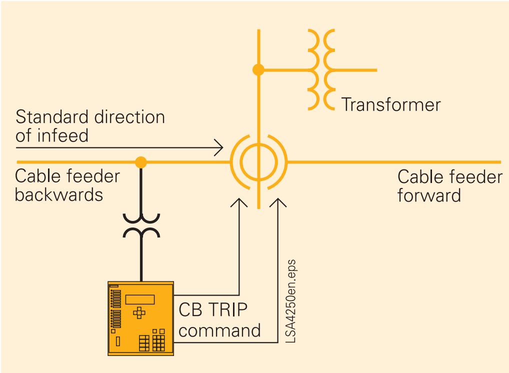


Fig. 2 Schematic diagram of the SIPROTEC 7SA61 distance protection relay connection

The new 7SA61 distance relay was to take over the tasks of the two old existing distance relays. As a result, the 7SA61 connects to one current-transformer assembly and only one outgoing feeder. The second current-transformer assembly in the other outgoing cable is no longer needed and is available for other systems. This configuration can be implemented in the EVI network because of the ring structure of the cable network, with the option of redundant feed-in from both ends.

Our experience with numerical protection relays has shown that the risk of an uncontrolled failure is low. Self-monitoring in the numerical protection relay is expected to lead to high availability. The low failure rate and the associated rapid delivery service from PTD PA strengthens the system.

If a fault current occurs, the new Siemens 7SA61 distance relay selectively trips the faulty line in the system for the forward or backward direction via the corresponding circuit-breaker.

For this purpose, the following parameters are set in the 7SA61 distance protection relay (see Fig. 3 and 4): The settings of the parameters of zones Z1 and Z2 indicate the forward direction, while the parameters of zones Z3 and Z4 indicate the reverse direction. In zone Z5 there is an X-value each for the forward and reverse directions. The R-value of zone 5 is always set to the larger R-value of the two cable runs regardless of the direction. This solution is acceptable, since this value deals with the grading in the second backup stage (grading: "Z1–Z2–Z5 (forward)") and "Z3–Z4–Z5 (reverse)"). In addition, the 7SA61 distance protection provides a directional and a non-directional time zone as the end time for grading.

If a fault occurs, the result is processed directionally in the distance protection. This directional information about the pickup and the tripping is generated in the 7SA61 protection relay for the first zone ("trip forward" = Z1, Z2, Z5 (forw)) and the second zone ("trip reverse" = Z3–Z4–Z5 (rev.)") using a CFC function, output to the appropriate circuit-breaker. The information is also forwarded to the telecontrol unit (RTU) over the IEC 60870-5-103 interface.

Circuit-breaker failure protection

When a fault occurs, if the associated circuit-breaker of the system does not trip after a set time of 100 ms in spite of the TRIP-command from the 7SA61 protection relay, and if at least 1.2 times the rated through-current is still flowing via the system's current transformer, the protection relay detects the situation and a logic function shuts off the adjacent circuit-breaker. This function serves as circuit-breaker failure and busbar protection.

Telecontrol connection of the power system protection station

Vital boundary conditions for the new telecontrol unit include the serial interfaces for unit connections in accordance with IEC 60870-5-101 and IEC 60870-5-103 protocols. The telecontrol connection is implemented on a polling mode basis on a line with up to five stations (see Fig. 5). This line connects to an interface of the higher-level gateway by means of the IEC 60870-5-101 protocol. The gateway's task is to concentrate information from telecontrol lines and telecontrol units and forward it to the control system.

The telecontrol system in the respective power system protection station transmits the information from the local input/output modules and the information from the Siemens distance protection relay connected via the IEC 60870-5-103 protocol to the gateway.

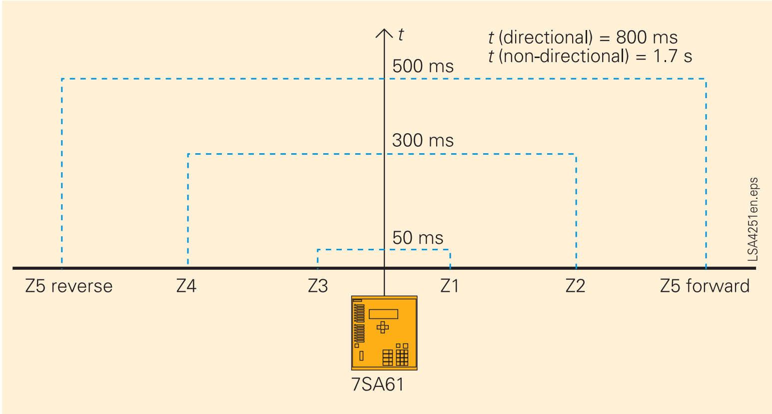


Fig. 3 Zone grading of the distance relay

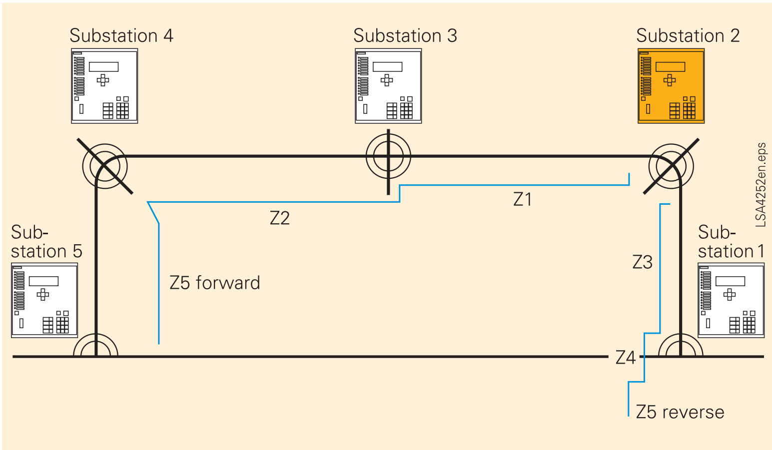


Fig. 4 Geographical zone grading of the distance zones using station 2 as an example

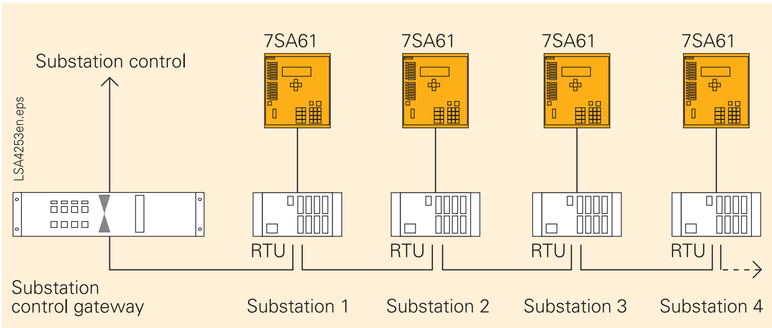


Fig. 5 Telecontrol unit (RTU) operating in polling mode with a protection connection

The special advantages

The tested, flexible technology allowed a power system protection station to be modernized in only three days. Little time was needed for wiring – especially when connecting the distance protection – since all information is transmitted by standard data cable via a serial RS485 interface.

When an event occurs, all information from the protection relay – such as pickup and tripping information, operational and fault signals, and the measured value of the identified fault location – is transferred to the telecontrol unit over the IEC-103 interface. The R- and X-values of fault locator are transmitted to the control center over the serial interface. All information is available quickly, so users can analyze the fault location quickly and correctly regarding the direction according to the mathematical sign of the transmitted value.

The standardized measured-value message with the values for *I*, *U*, *P*, *Q*, as well as the frequency, is transmitted cyclically from the protection relay. Due to the very high accuracy of the 16 bits for digital transmission of the measured values, these values are now – for the first time – also conveyed from each of the modernized power system protection stations to the control center. The control center integrates these values in load management.

After the power system protection station was modernized, primary and secondary tests ensured proper functioning for protection and precise telecontrol system and transmission of the information for all sorts of faults.

From practical experience

A fault in EVI's 20-kV medium-voltage system provided real-world confirmation for the solution. Two days after one power system protection station was modernized, a phase-to-earth fault in an outgoing transformer station in the 20 kV network "tested" all functions of the telecontrol and protection relaying system. The protection correctly detected and processed the fault in the network and trip the faulty the station. The system properly recorded, processed, and transmitted all fault-related information to the control center, and so it was possible to remedy the fault quickly.

Conclusion

Conversion to the new SIPROTEC protection system has paid off for EVI in many respects. The safety of the network increased significantly without requiring replacement of a large part of the existing systems, and without exceeding the budget. The solution also clearly improved the system's transparency in cases of fault. EVI can now analyze, trace, and clear faults more quickly.

FO Differential Protection Communicates via Existing Telephone Wires

Differential protection over conventional pilot wires at the Varel paper and board factory

■ *The company*

The paper and board factory Varel in the north of Germany (see Fig. 1) occupies the region supplied by the Weser-Ems power supply company (EWE). The company operates its own power generation plant, which runs on natural gas and biogas, to produce heat and power.

■ *The starting situation*

A new switchgear has been installed on the factory campus. A 20 kV double feeder safe-guards the factory's power supply, and can exchange power over two approximately 0.5 km long feeder cables.

The power supply company recommended differential protection relay 7SD51 to protect the cables. The relay had already proved viable for the protection of short cables, and for reasons of standardization it made sense to specify it here as well.

However, no fiber-optic cables had been laid along the cable routes, only conventional telephone wire pairs. This created a problem, since 7SD51 relied on fiber-optic cables or communication networks for transmission, exchanging data between the devices by means of asynchronous serial messages at 14.4/19.2 Kbps.

■ *The concept*

In mid-2001, a communications converter 7XV5662-0AC00 was rolled out for the SIPROTEC 4 differential protection relays 7SD52 / 7SD610. This made it possible for the first time to transmit synchronous serial differential protection messages with virtually no delay, thereby closing a technical loophole.

Depending on the cross-section of the pilot wires that have been laid, it is now possible to bridge long distances (see Table 1).

The converter connects to the differential protection relay with noise-immune 62.5/125 µm multi-mode fiber-optic cables up to a maximum distance of 1.5 km., with ST connectors at both ends. Two screw terminals connect the pilot wires to the converter, so there is no need to observe polarity.

Fig. 1 Varel paper factory

The dielectric strength of the converter with respect to the pilot wires is 5 kV. Consequently overvoltages induced in the parallel pilot wires by short-circuits in the cable do not result in flashovers at the converter and so do not impair the protection function. Voltages as high as 20 kV can be obtained with external isolation transformers 7XR9516.

This made the converter ideal for the application in Varel. One further challenge remained: since the device was tailored to the application with 7SD52/7SD610, it was designed only to transmit synchronous serial data at 128 Kbps on the pilot wire.

Data on pilot wires with bridgeable distances for the communication converter					
AWG	Diameter mm	Cross section mm^2	Ohm/km (0 Hz)	Ohm/km (80 kHz)	Max. distance U ↔ K
10	2.59	5.27	3.38	18.39	38.1
11	2.3	4.15	4.28	20.84	33.6
12	2.05	3.30	5.39	23.55	29.7
13	1.8	2.54	6.99	27.06	25.9
14	1.63	2.09	8.53	30.12	23.2
15	1.45	1.65	10.78	34.21	20.5
16	1.29	1.31	13.62	38.91	18.0
17	1.15	1.04	17.14	44.22	15.8
18	1.02	0.82	21.78	50.64	13.8
19	0.91	0.65	27.37	57.74	12.1
20	0.81	0.52	34.54	66.17	10.6
21	0.72	0.41	43.72	76.18	9.2
22	0.64	0.32	55.33	88.01	8.0
23	0.57	0.26	69.76	101.86	6.9
24	0.51	0.20	87.13	117.73	5.9
25	0.45	0.16	111.92	139.47	5.0
26	0.41	0.13	134.82	159.04	4.4
27	0.36	0.10	174.87	192.88	3.6
28	0.32	0.08	221.32	232.45	3.0

Table 1: Data of standard pilot wires

Resistance with modulation frequency of the converter
Data for a twisted telephone wire pair

The challenge for Siemens Power Automation Division was to expand the existing converter for the transmission of asynchronous serial data, opening up a broad field of other applications, such as the transmission of serial protocols including IEC 60870-5-103/101, DNP 3.0, and MODBUS. Together with the two-channel binary transducer 7XV5653, binary signals for comparing the distance or overcurrent-time protection signals could be exchanged via pilot wires.

An analysis of the converter hardware and firmware showed that this function could be implemented successfully on the existing hardware. The asynchronous transmission function could only be implemented in the converter firmware; it could be developed swiftly within a few weeks.

Tests successful

In January 2003 the converter with adapted firmware was available for the first tests. Long-term laboratory trials tested the converter with the 7SD51 and verified its capabilities. At the asynchronous baud rate of 19.2 Kbps, tests recorded no errors in the messages and found 100% reliability, typical of transmissions with differential protection. The message delay with the protection relay amounted to only 0.8 ms, which allows a command time of 25 ms, equivalent to that of a direct fiber-optic cable link.

In comparison, 1996 trials transferring data over dedicated line modems achieved a minimum 50 ms command time, with a delay time of 25 ms. This solution also failed to meet the EMC requirements and therefore could not be used for real-time protection data transmission over pilot wires. Not until seven years later was a marketable solution available that allowed protection data to be transferred virtually without delay.

In May 2003, the converter was released for delivery under the designation 7XV5662-0AC01.

■ The special advantages

Transmission over conventional pilot wires

The converter makes it possible to transfer asynchronous, serial data from 300 bps to 38.4 Kbps over pilot wires without noise interference. The values for the 7XV5662-0AC01, subjected to comprehensive tests before its market rollout, apply to the bridgeable transmission distance (see Table 1) and noise immunity.

Fast commissioning

With the support of the sales and marketing divisions, Power Automation Division installed the protection system (configuration as shown in Fig. 2) at the customer's facility. The 7SD51 protection relays had already been installed, and the brand new converters were delivered for commissioning. The communication converter was connected to the protection relay via a short fiber-optic cable, with ST plug connectors attaching to the converter and FSMA connectors attaching to the protection relay. The pilot wires were connected to the converter. The entire section was commissioned successfully within a few hours. The protection relay's integrated commissioning help functions aided in checking the correct connection to the current transformers and to the pilot wires.

Minimum time expenditure for parameterization

Compared to the commissioning of conventional wire differential protection, the probability of faults and the time taken for commissioning was reduced considerably. Only three parameters, the current transformation ratios and the measured delay 0.8 ms, need to be set in the protection relay (Fig. 3). All other parameters could remain at their default setting. The converter adapts itself to the serial data rate of the protection relay and only requires the setting of the master and slave mode via a jumper in the relay. This setting needs to be made for only one relay, which minimizes the time needed for parameterization.

■ Conclusion

With a special converter, it was possible to use the stipulated SIPROTEC differential protection relay 7SD51 for the paper factory in Varel and transfer asynchronous serial data over conventional pilot wires. The protection system has been in service since May 2003, to the customer's full satisfaction.

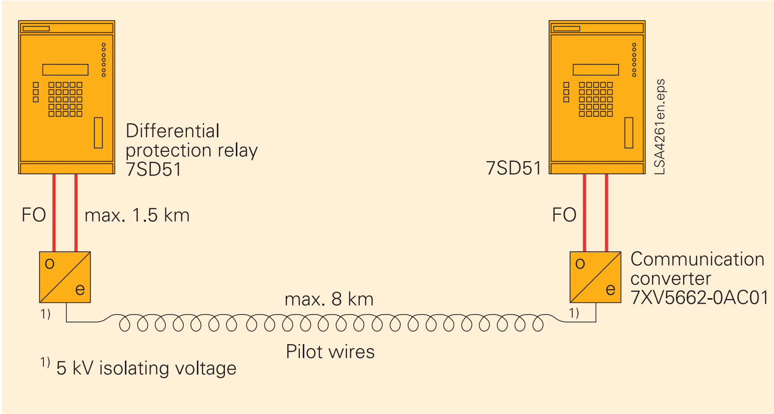


Fig. 2 Differential protection with communication converter

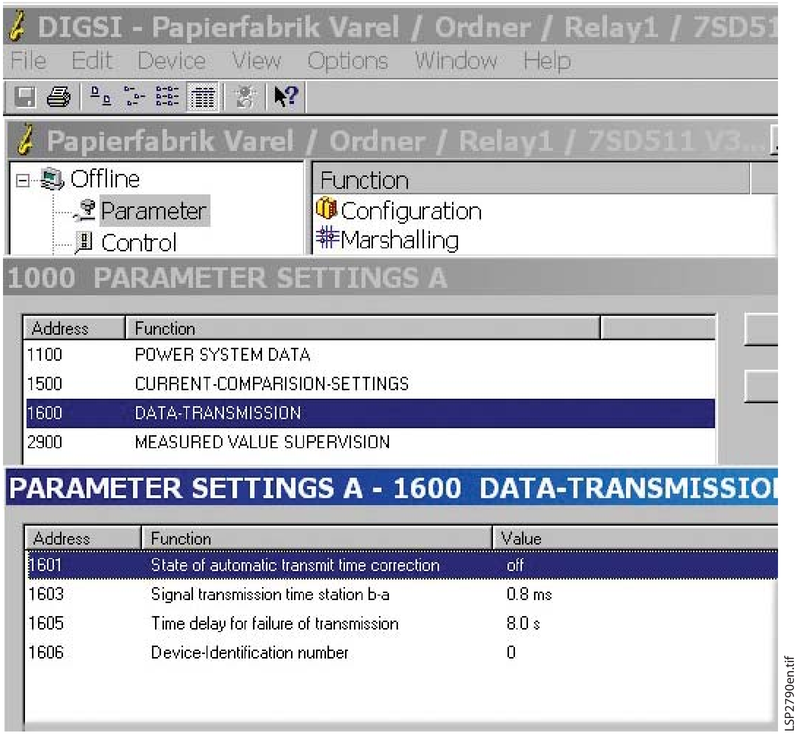


Fig. 3 Setting parameters in DIGSI

Everything under control

SIPROTEC 7UT635 differential protection for Allgäuer Überlandwerke

■ The company

Power for Allgäu – Allgäuer Überlandwerke GmbH (AÜW) is committed to it, supplying electricity to more than 80,000 customers.
AÜW considers itself to be an energy service provider, because, in addition to simple delivery, they offer customers a variety of services related to power supply.

The starting situation

Transformers with phase-angle regulation and regulation in quadrature are used to regulate the voltage and power flow in power supply systems. These are special transformers. Until now, it has not been possible to use 7UT5 and 7UT6 differential protection unless the protection relay was configured to be relatively insensitive. The measurement algorithm is designed for a vector group compensation of N*300 (N=0,1 to 11) and is preset to vector group 0 as per the transformer's rating plate. The problem is that the transformer with phase-angle regulation generates an angular shift that deviates from zero.

The transformer with phase-angle regulation (see Fig. 2) comprises a tap changer on side 1 and is responsible for in-phase control.

A sensitive configuration guarantees protection

Quadrature control is performed on side 2 where an out-of-phase voltage is added to the longitudinal voltage of the transformer winding. The overview in Fig. 2 shows, for example, that a phase L3 or L2 transverse voltage is added to Phase L1, depending on the tap position of the quadrature transformer. The amount of transverse voltage can be controlled, resulting in an angular shift between overvoltage and undervoltage that is no longer 0 degrees but may be as high as max. ±35°. Because control can be in a positive or negative direction as a function of the power flow, significant differential currents already result under normal conditions. In the event of a short-circuit, a fault outside the protected zone can result in an unwanted operation of the protection relay – even if the relay is configured with a rated current approx. four times less sensitive than a normal differential protection relay.

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Fig. 1 Transformer with phase-angle regulation

In Fig. 3, a fault of this type is shown in the protection relay's tripping characteristic and, with the selected setting, results in unwanted protection operation. Configuring the protection relay with an even less sensitive setting would have compromised the entire concept of differential protection.

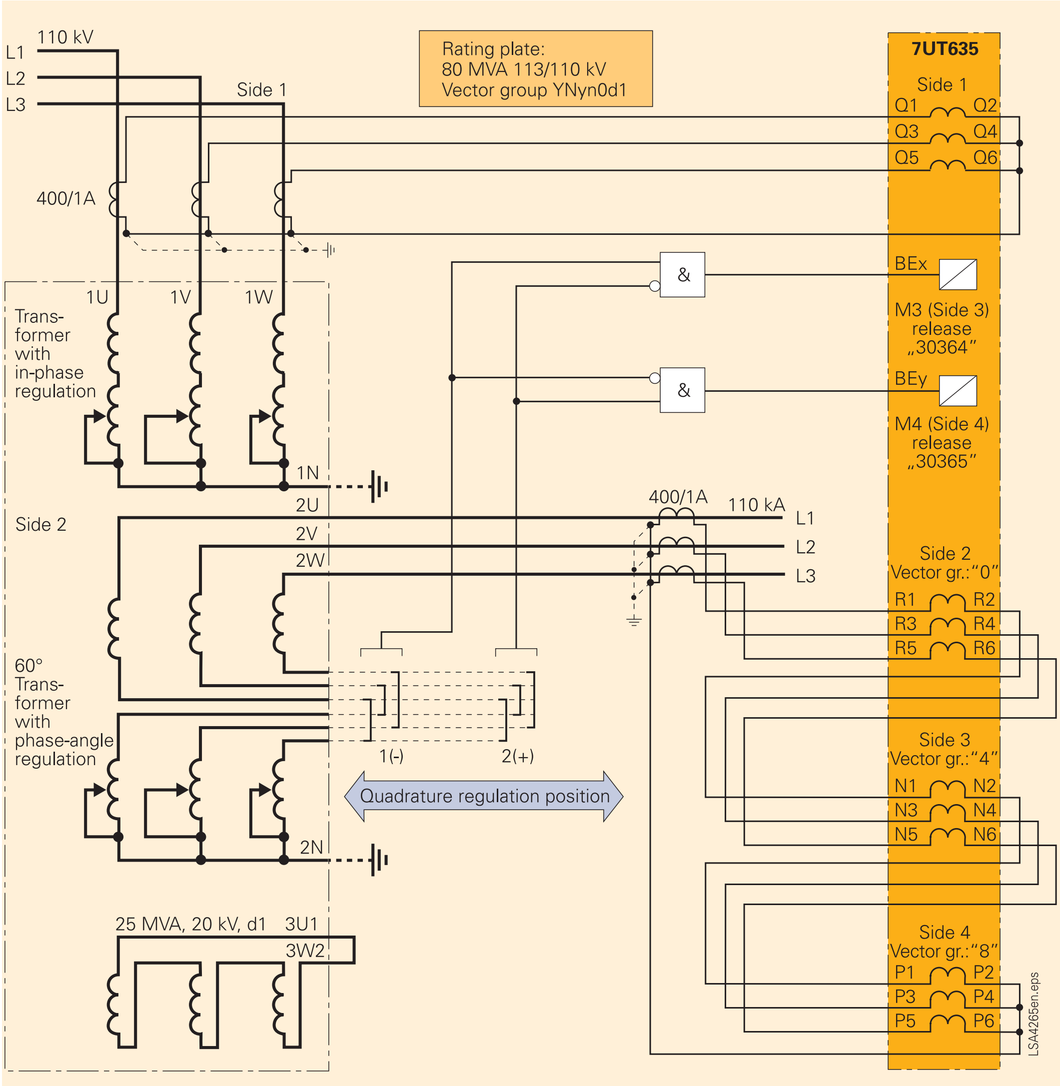

Fig. 2 Transformer with phase-angle regulation connected to 7UT635

The concept

For the purpose of analyzing the problem, the transformer with phase-angle regulation with its extensive control range was mathematically simulated in the computer. The mathematical model makes it possible to calculate the currents on side 1 and side 2 of the transformer. The 7UT635 protection relay measures these currents (connection as per Fig. 2). The vector group adaptation and differential protection algorithm are also mapped on the computer, with the result that the currents calculated are used directly as input variables for the protection system simulation. With the aid of a test set, the currents calculated can also be output to a 7UT6 protection relay and fed into the protection relay at side 1 and side 2 via analog amplifiers. This systematic method serves to map transformer and protection system behavior.

In addition, the results of the simulation could be compared to faults that the customer has already recorded by means of fault recorders, thus providing another opportunity to test the model.

The solution was intended to operate without any modification of the measurement method or of the protection relay's vector group compensation, and to be adapted to the existing device.

Compensation by parameterization

The task was to compensate for the large phase angle rotation of the transformer with phase-angle regulation by means of circuitry and parameterization, while taking into account the positive and negative control range.

For this purpose, the current measured on side 2 was fed to two additional input windings in the device. Fig. 2 shows the interfacing. The vector group and data for these windings are now configured so that the behavior of the phase-angle transformer can be largely compensated in the device.

SIPROTEC 7UT63 selective short-circuit protection

The protection relay selected was the 7UT635 offering 3 additional windings, 2 of which are used. The transformer with phase-angle regulation is parameterized like a four-winding transformer. Side 3 measures the current for the positive control range and side 4 for the negative control range. For the 7UT613/7UT635, the current measurement inputs for the sides can be connected and disconnected via a binary input. This product feature can be used here to great advantage.

In accordance with the basic solution approach, protection relay parameterization was now developed for the customer's transformer and transferred to the device using DIGSI. The configuration data appears in Fig. 4.

■ *The special advantages*

Optimized for phase shifting

Parameterization for the protection relay was optimized for a ±17.5° phase shift by the phase-angle transformer. For this angle, the longitudinal voltage to be parameterized for winding 2 and the transverse voltage to be parameterized for winding 3/4 can be calculated from the transformer data to yield a differential current equal to zero. The vector group for winding 3/4 is set to 4/8 and optimally emulates the quadrature control response for the operating point selected. Superimposing the currents measured at the windings yields a 17.5° phase shift for the operating point selected. Angles that deviate from 17.5 degrees result in a small differential current that must fall below the pickup value.

Testing the protection

The sensitivity of the protection was configured so that it would no longer be possible for spurious pickup to occur at a ±35° phase shift, corresponding to a mismatch of 17.5° with the operating point. This is achieved with a setting of 0.6 I_N, a value that still provides adequate security.
The result is twice the sensitivity of a conventional parameterization. The performance of the protection relay can be tested by outputting various operating and fault scenarios; all important data can be read from the fault record. Fig. 5 shows the optimal response to a fault in the tripping characteristic, which was still resulting in unwanted operation in Fig. 2. Now, high stability with external faults has been achieved even with a sensitive setting of the differential protection relay.

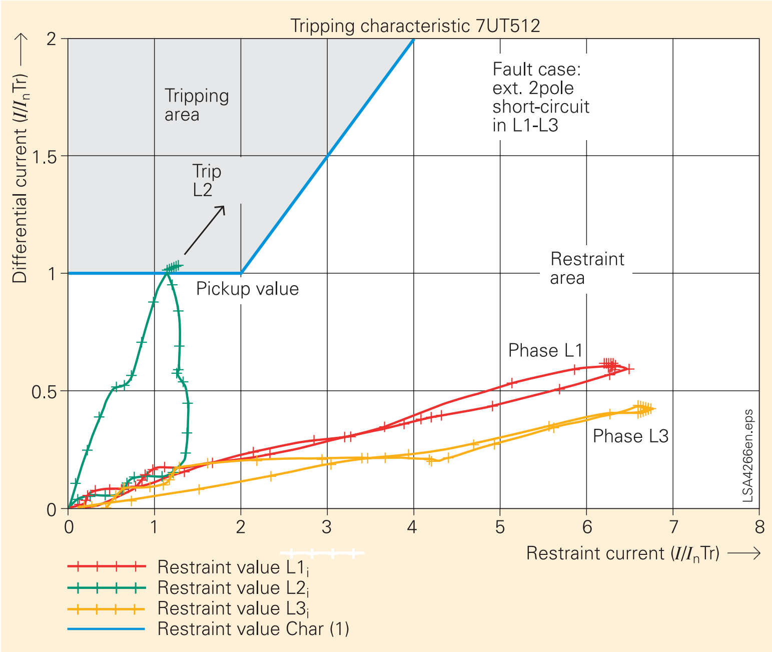

Fig. 3 Tripping characteristic without compensation of phase regulation

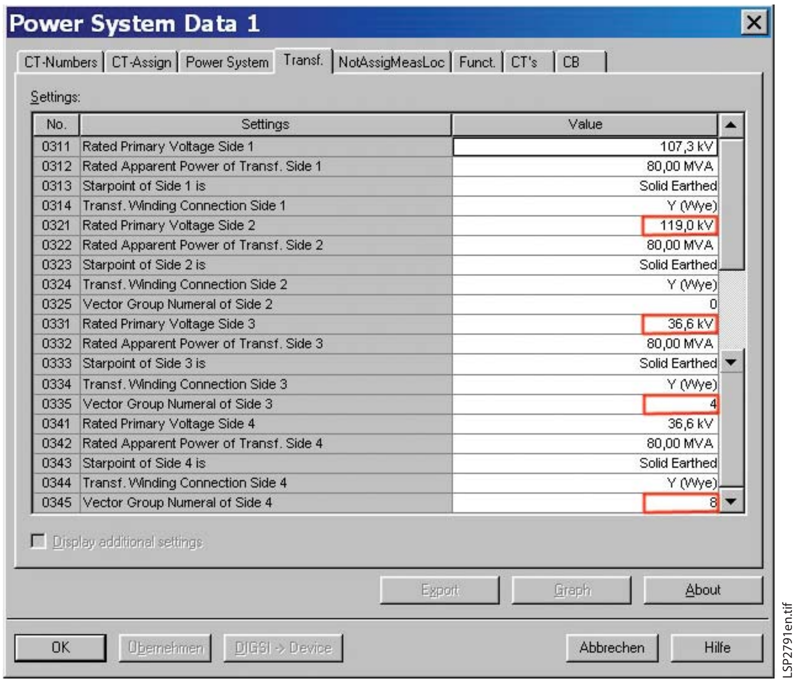

Fig. 4 Parameterizing of windings 1 to 3 (setting for winding 3 are valid for winding 4, too)

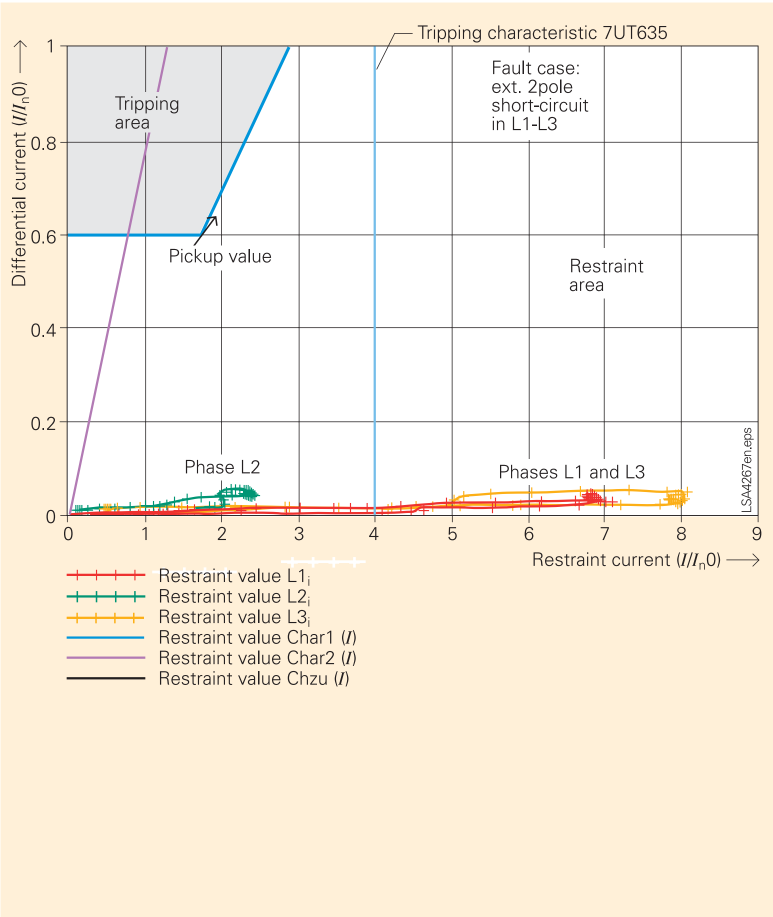

Fig. 5 Tripping characteristic with compensation of phase shifting

Control via binary inputs

Connection and disconnection of the measurement inputs is controlled via binary inputs. Fig. 6 shows the DIGSI 4 configuration matrix with the signals releasing the measuring points. In a positive control range (>2(+)) from 0 to 35°, measurement input 4 is released; in a negative control range (< 1(-)) from 0 to -35°, measurement input 3 is released. The transfer is by means of signals from the phase-angle transformer tap changer when the power flow changes from a positive direction (position 2+) to a negative direction (position 1-). In the range from (2+) to (1-), both inputs are blocked and the differential protection operates as a two-winding transformer with vector group 0.

Conclusion:

An elegant solution was found by using the SIPROTEC 7UT635 to compensate the large phase-angle rotation of the transformer with phase-angle regulation by means of circuitry and parameterization. A sgnificantly more sensitive setting was selected for the differential protection thus providing a reliable sensitive protection for the complete control range. This advantage can also be applied to all the other transformers with regulation in quadrature. The only requirement is that parameterization be adapted to the object to be protected..

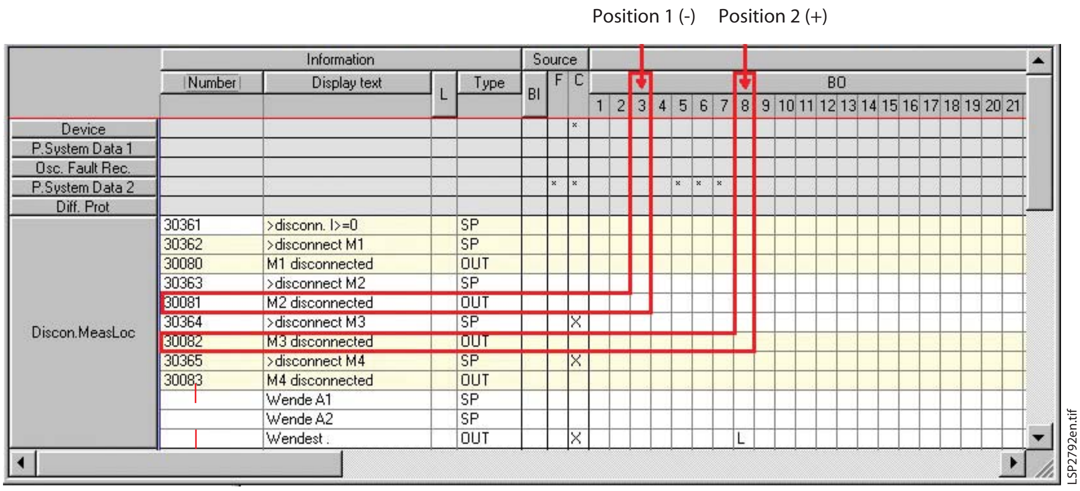

Fig. 6 Control of measuring elements via binary inputs (marshalling in DIGSI configuration matrix)

Precise Remote Interrogation over Long Distances

Satellite and power line carriers transmit protection data in Peru

■ The company

In Peru, legal requirements call for the strict separation of power generation companies and power transmission companies. As a transmission company and former central power system company, ISA (Interconexión Eléctrica S.A.) is responsible for the coordination, operation, and administration of the interconnected system for the whole country.

■ The starting situation

The Siemens regional company in Columbia equipped six substations in Peru with SIPROTEC protection relays (generations V2, V3, and V4). A PC equipped with DIGSI 4 (Fig. 1) operates the relays from one substation. The core of the system includes the PC, passive series 7XV5 converters, and the active mini star coupler 7XV5550, which matches the serial data rate for relays of different protection relay generations. DIGSI 4 directly supports the setting of these relays, which allows the user to easily operate, from one substation, the relays at all the different locations. The user can use the central system PC to evaluate and administer all data pertaining to a protection relay.

ISA wanted to operate the substations centrally from the station in the capital, Lima, in order to avoid long and sometimes hazardous journeys to the substations. The plan was to establish a connection to the substations using leased lines over specially installed communication routes. ISA also intended to implement control functions and voice transmission over these routes, dividing the bandwidth of 64 Kbps between the different services. Two substations were linked to the capital via leased satellite links (see Fig. 2).

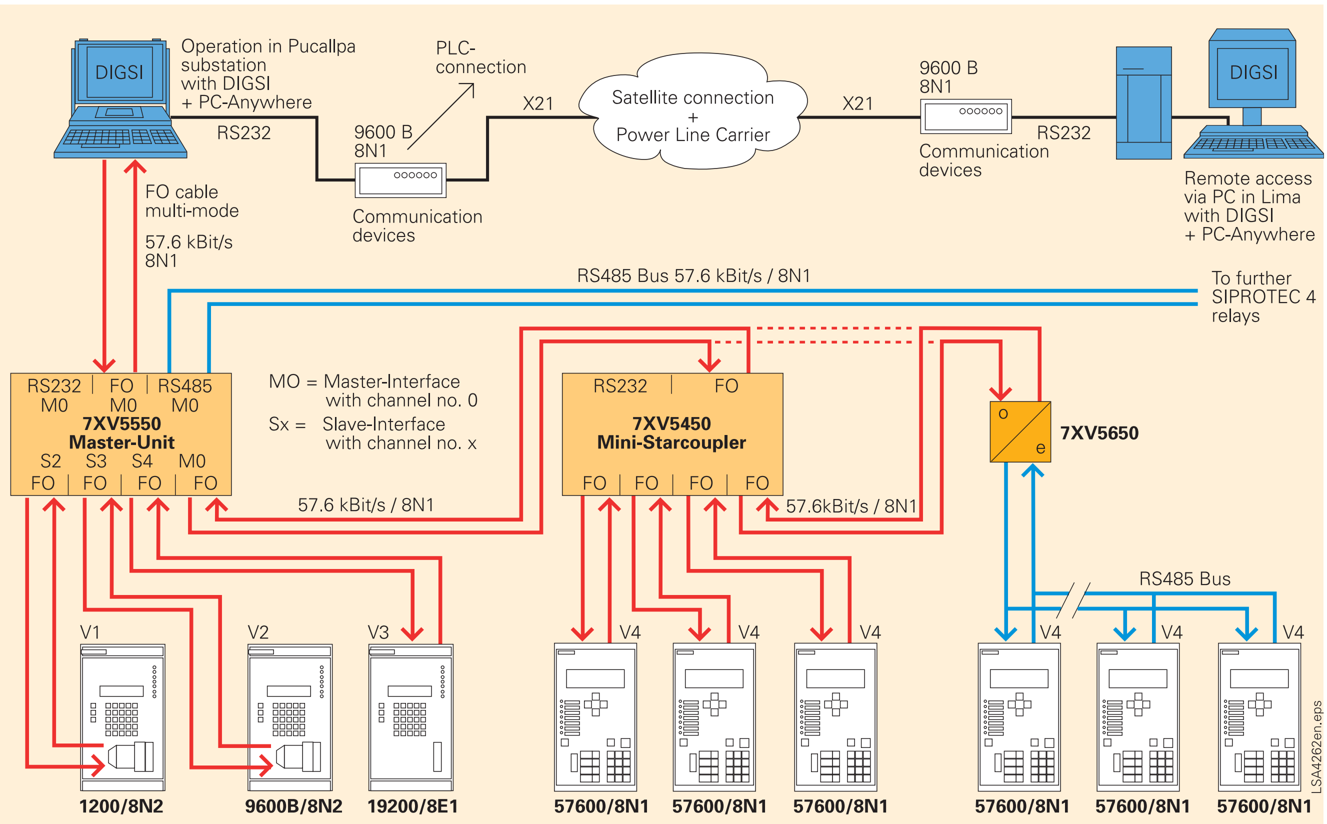

Fig. 1 Long distance interrogation for Pucallpa substation

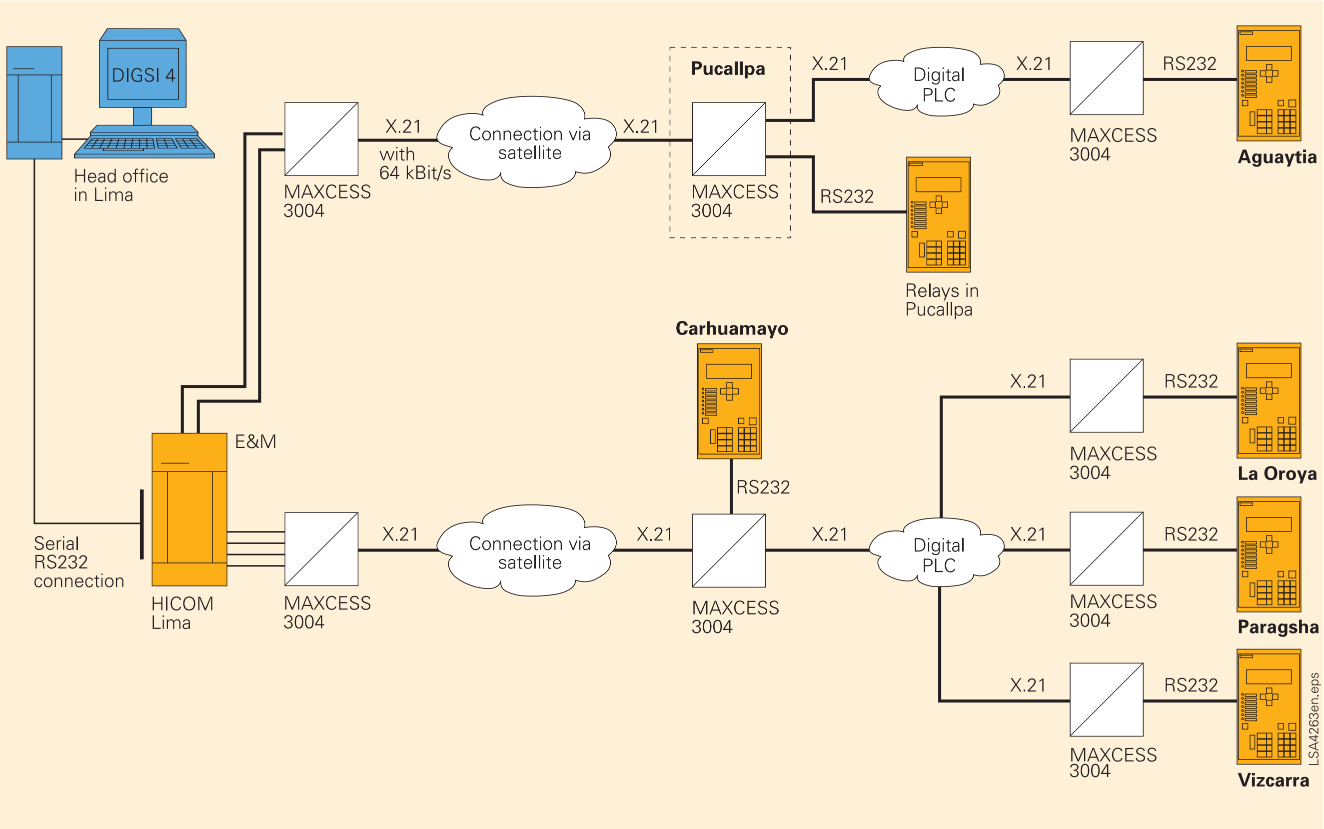

Fig. 2 Substation overview in Peru

One substation is located in Carhuamayo at an altitude of 4,400 m in the Andes (Fig.2), the other in Pucallpa in the middle of the tropical rain forest. Four additional substations are connected to these two substations over distances of up to 140 km using a digital power line carrier (PLC) over an extra-high-voltage line. Siemens PTD EM installed PLC links to transfer data at a maximum rate of 76.8 kbps via the high-voltage line. All links appeared to be adequate for the transmission of protection data with DIGSI, which is specified with a data rate ranging from 9.6 kbps (V3 devices) to 57.6 Kbps (V4 devices).

After installing the system, however, it became apparent that it was not possible to establish stable connections to the protection relays, even though the solution worked in theory and the reliable technology had been tested. This turn of events cast doubt on the entire concept of operating the relays centrally from Lima using DIGSI 4.

■ *The concept*

In order to analyze the fault and to devise a solution, Siemens set up a test system in a laboratory in Nuremberg, using the same power link system, communications cable simulators, and typical protection relays (V2, V3, and V4).

According to the measurements made on the test system, the delay over the PLC routes was approximately 110 ms. The satellite link added another 220 ms delay, resulting in a total delay in one direction of approximately 440 ms when a satellite link and two PLC routes were in series. Because of the structure of the serial DIGSI protocol, which is a Siemens-specific expansion of the IEC 61850-5-103 protocol, an acknowledged data package between Lima and the remote substations took about 1 second. This delay, and the gaps between the data, were not planned for in the protocol and timing concept for either the equipment or DIGSI, and was preventing a stable high-performance link. It was therefore necessary to develop and implement a different concept based on the infrastructure already installed, in order to avoid additional investments.

The Automation division of Siemens A&D provided the solution: the remote control software PC-Anywhere, which allows complete control of remote PCs. The idea was to have the central PC in Lima control the central PC already installed in each substation. By dialing into each substation's central PC, the operator in Lima can monitor the remote station's status, and can start the locally installed DIGSI from the substation PC.

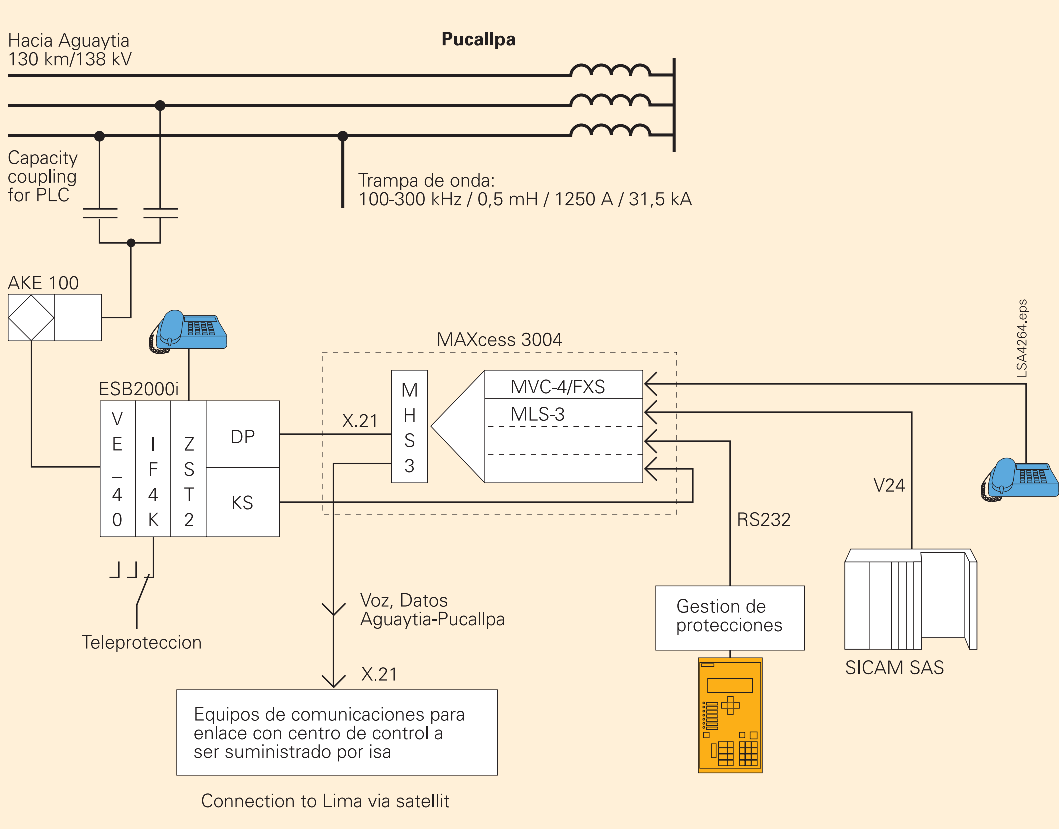

Fig. 3 Communication devices in Pucallpa

The special advantages

Once PC-Anywhere was installed, the operator undertook the first tests from Lima. The local link to the protection relays functioned. The application is configured as follows:

- PC-Anywhere establishes the connection between the central PC in Lima to the substation PC via the selected dedicated connection. The data is transferred via the satellite link and the PLC route.
- DIGSI 4 operates on the substation's central PC, which is now completely remote-controlled from Lima.
- A connection to a SIPROTEC protection relay with DIGSI 4 is established. The protection data is transferred at the maximum data rate via the serial links in the substation. Since DIGSI is installed locally, no delays occur.
- Protection data is stored using a quality recorder in COMTRADE format. Alternatively, all protection data for a device, as well as the entire substation's data, can be stored in a compressed Dex file. DIGSI supports this file export, which can be used for the analysis of protection data anywhere in the world.
- PC-Anywhere transfers files to Lima; data can be exchanged between PCs
- DIGSI 4, installed on the PC in Lima, allows for the importing and analysis of the data files in DIGSI and SIGRA. The protection data can be administered and analyzed centrally.

From practical experience

The test setup in the laboratory made it possible to plan the local installation in minute detail. This considerably simplified the work of the team of technicians from PTD PA 13, PTD EM personnel, the operator, and Siemens Columbia. Given the difficult travel conditions between the substations – the thin air and icy cold of the installation at 4,400 m altitude in Carhuamayo, the tropical temperatures in the rain forest in Pucallpa – extensive preparation in Germany reduced costs and avoided the need for improvisation.

Conclusion

The customer was highly satisfied with the solution. As a result, Siemens used this solution for further substations and implemented complete remote operation of protection relays of different generations over the communication routes. The operator can now operate substations remotely and control protection and control functions centrally.

This solution can be used for slow modem links with long delays, such as GSM links. In principle, DIGSI can be remote-controlled anywhere in the world using a variety of communication paths supported by the remote control software. With data transfer via PLC, communication is possible over long distances, since the high-voltage line is already routed to the substation. This means that numerical protection relays in remote substations may be operated centrally. Other protection and control functions can be integrated in the concept and multiplexed by means of the common data link (see Fig.3).

Setting up Automatic Switchover

Automatic switchover for incoming feeders

The company

The customer is a petrochemical company. The company's critical control processes are characterized by high energy consumption and high operating reliability requirements.

The starting situation

The project objective was to implement load transfer between busbars A and B in a switchgear unit. The customer requested automatic switchover without interruption, with the following characteristics:

- In the event of undervoltage on busbar A, circuit-breaker CB–QA trips, automatically disconnecting the bus sectionalizer CB–QC. This restores the power on bus A after a finite interruption time.
- In the event of undervoltage on busbar B, automatic transfer is performed in the same way as described above.
- When the power is restored to the tripped incoming feeder, the associated circuit-breaker (e.g. –QA) has to be closed manually. This is only permitted through the synchro-check relay. The bus sectionalizer CB (-QC) then automatically trips, provided the selector switch –S100 is in position –QC.

The requirements of the customer also included manual transfer without interruption in the following cases:

- In the initial status, incoming feeders A (-QA) and B (-QB) are closed and bus sectionalizer (-QC) is open.
- Undervoltage is detected on one of the two incoming feeders. The bus sectionalizer can be closed only when a release command is provided by the associated synchro-check relay.
- After the bus sectionalizer has been closed for a certain definite time, one of the circuit-breakers opens automatically, depending on the position of the selector switch.

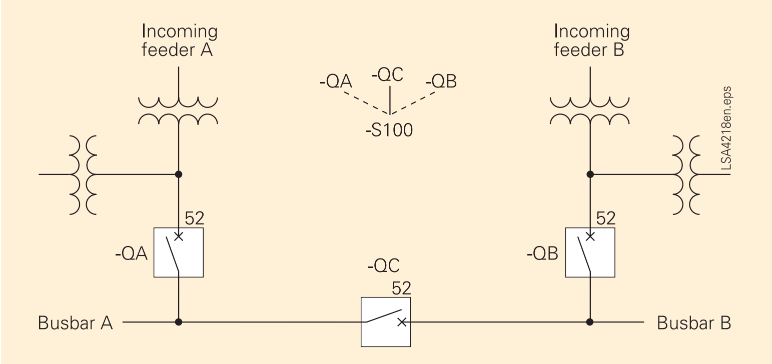

Fig. 1

The concept

The solution involves control of each circuit-breaker by a SIPROTEC 4 relay. Undervoltage detection is implemented as a function inside the incoming feeder relays. Communication between the relays is hardwired via the relay inputs and outputs. The information from the selector switch –S100 is forwarded to the relay of the bus sectionalizer.

Each relay has been programmed to control its connected circuit-breaker and to output command signals to the two other SIPROTEC 4 relays. The automated system also accepts manual commands and can operate with a separate synchro-check relay.

Conclusion

This solution was installed in 2002 and has been functioning correctly ever since. The same solution has also been implemented for 33 kV, 6.6 kV, and 400 V switchgear with SIPROTEC 7SJ63 and 7SJ62 relays

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Fig. 2
33 kV 8DB GIS, with CBs protected and controlled by 7SJ63

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Fig. 3
6.6 kV 8BK AIS, with CBs protected and controlled by 7SJ63

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Fig. 4
400 V SIVACON, with CBs protected and controlled by 7SJ62

Energy for the Island

Malta power plant system solution with dynamic load shedding

■ The company

Enemalta, the state-owned utility of Malta, holds a monopoly position on the Mediterranean island. The power supply region covers the entire 320 square km island, which lies 90 km south of Sicily, 290 km north of Africa, and almost exactly equidistant from Gibraltar and Alexandria in the middle of the countries bordering the Mediterranean Sea.

After a colorful history, Malta achieved formal independence in 1964 and final independence in 1979, when the last British troops withdrew.

In a referendum, the Maltese decided to join the European Union in May 2004.

The island of Malta is making many investments to prepare for its new role in the European Union – including its role as the bridge to North Africa.

■ The starting situation

Since Malta currently still does not have any connections to the mainland and is supplied by only two power stations, it is an island power systems in the truest sense of the word.

Because the summer of 2003 was extraordinarily hot, Enemalta was not always able to ensure a steady power supply. The utility needs to expand its capacities and improve operational reliability and availability of the Marsa power station.

Malta is made up of stony ground and has few natural groundwater resources that could store precipitation, which is meager anyway. As a result, the growing need for drinking water can be met predominantly through desalination plants. These vitally important stations account for a major part of energy needs. Other major loads are airconditioners in the tourism industry and in Maltese homes, shipyards, harbors, and fish processing plants.

Relying on two power stations, Delimara and Marsa, Malta's power engineering is in a weak position. If one generator fails during peak loads, serious network disturbances may occur.

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Fig. 1 Traditional transportation still exists in Malta, but it is mainly for tourists.

■ The concept

As Enemalta makes necessary investments, the first step in strengthening the Marsa power plant should be to modernize the generator protection with synchronization and to modernize the two associated primary distribution switchgear for power distribution with appropriate power system protection and busbar protection.

Enemalta places great importance on the availability of the power-engineering parts of the power plant. In addition to a reliable protection concept, which includes a redundant station communications bus, redundant master units should also be provided. In the case a generator fails, then load shedding, prioritized in advance, must dynamically balance the decrease in electrical energy to ensure the stability of the power system.

Siemens was able to successfully win out over its competition through its overall technological solution.

The special advantages

Siemens was awarded the contract for several reasons, including fulfillment of the specification, the favorable cost/performance ratio, and our partnership with the customer. However, the integration of all protection components for the generators, busbars, lines, and transformers plus the network into a complete system was also very important. What also helped was great teamwork with our colleagues from our Medium-Voltage division from the time the bid was prepared until the contract was awarded. The Siemens solution integrates components for primary distribution switchgear, generator protection (7UM62), busbar protection (7SS52), power system protection (7SJ63 and 7UT612/13), and dynamic load shedding into a complete system.

New dynamic load shedding concept

Ultimately, the decisive factor for the awarding of the contract was PTD PA's plan to implement a completely new dynamic load shedding concept in a power station for the first time. The combination of distributed logic in the SIPROTEC 4 protection and master units and the new calculation procedure before any fault event makes it possible to have response times of less than 50 ms for dynamic load shedding.

Partnership to success

During the project launch meeting in March 2004, the customer and the Siemens project managers discussed open items together and clarified them on site by mutual agreement. Together they agreed on the new parts and the parts to be expanded in the power station.

The launch meeting also included a project organization chart with responsibilities and contacts, as well as a mutually determined schedule with fixed milestones for Siemens and the customer, thus laying the basis for successful project implementation.

Conclusion

By modernizing the Marsa power station, Siemens is making an important contribution toward improving the power-engineering infrastructure of new EU member state, Malta, which is on the right path to becoming the hub of the Mediterranean.

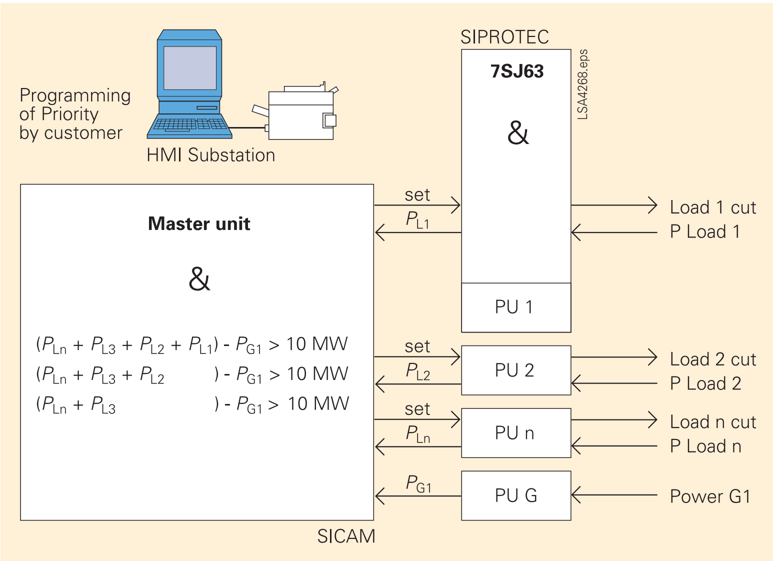

Fig. 2 Dynamic load shedding concept

Safety in a New Dimension

SIPROTEC 4 ensures safe operation of the Three Gorges hydroelectric power plant

■ The project

In 1992, the Chinese National People's Congress decided to build the Three Gorges Dam on the Yangtse, Asia's longest river. Work on the project began five years later in the province of Hubei near the cities of Sandouping and Yichang, located close to the Three Gorges, with the construction of the dam and hydroelectric power plant.

In its final stage, the dam will be 185 meters high and 2305 meters wide. The resulting lake will stretch for about 660 kilometers to form the world's largest reservoir. The first, partial filling of the reservoir began in June 2003, and final completion is planned in 2009.

China intends to meet three objectives with this project:

- Generating electric power
- Increasing navigability of the Yangtse (previously limited to only 2,800 kilometers).
- Providing flood control for the entire region

The world's largest hydroelectric power plant

The final expansion of the Three Gorges power plant will be designed to supply about 9% of China's entire electric power. 26 turbines and generators with an output of 18,200 MW will be feeding power into the nation's power system. Each of the turbines has been designed for an output of 700 MW. By the completion of the first section late in 2004, 14 generators were connected to the power system.

Siemens PTD has supplied many of the primary systems components. This included for instance 14 generator transformers with a nominal capacity of 840 MVA and high-voltage of 550 kV. PTD High Voltage Division is also supplying 550-kV HVDC systems for the reliable transmission of the electric power.

■ The starting situation

The construction of a hydroelectric power plant is a continuous technical and logistical challenge since a host of variables must be included in the planning. The enormous dimensions of this hydroelectric power plant and the enormous forces to be liberated called for solutions that were tailored to this project, especially with regard to safety. The Francis turbine has a diameter of 9.4 meters, and water flows through it at a rate of 996 cubic meters per second. An entire orchestra could be seated within the generator stator (having an inner diameter of 18.5 meters). See Figs. 3 to 5.

On the other hand, there were also requirements for extremely compact designs, for instance of the generator transformers. For the Three Gorges project, these were produced in Nuremberg and transported to the construction site by ship.

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Fig. 1 Three Gorges of Yangtse River

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Fig. 2 Expansion stage of the dam

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Vast energy reserves

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Fig. 3
Turbine shaft

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Fig. 4 Turbine wheel

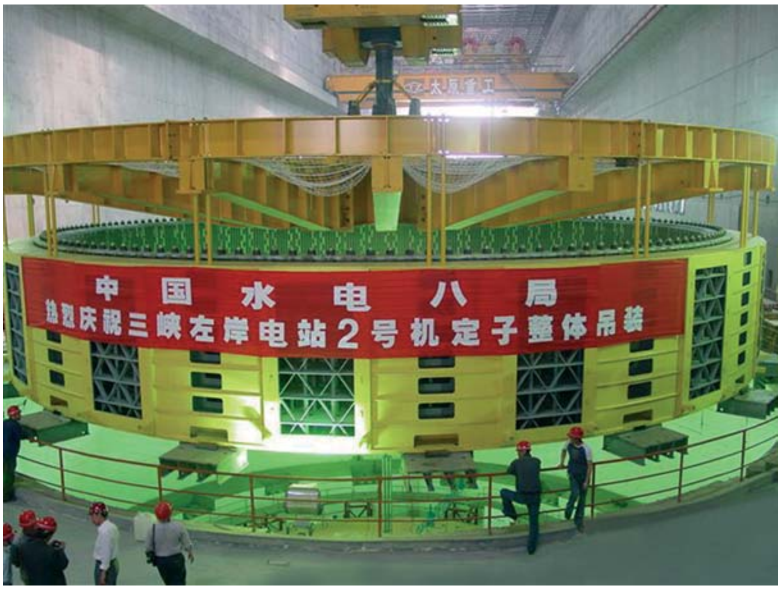

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Fig. 5 The generator stator is lowered into position

The concept

SIPROTEC 4 provided the latest in protection systems. These systems protect both the generator and the generator transformer including the power system connection. As usual, Power Automation Division supplied the protection cubicles, extensive documentation and the protection settings report. The initial shipment for 6 generators included 12 protection cubicles.

The use of high-performance protection relays from Siemens made it possible to achieve a uniform redundancy concept and to apply the n-1 principle with few relays (2 x 7UM622, 5 x 7UT612 and 2 x 7SJ611). Fig. 6 illustrates the basic design of the protection concept. The two 7UM622s protect the generator and provide backup protection for the generator transformer or the power system (impedance protection or high-voltage side overcurrent protection). The maximum functionality was selected from the available range of functions, and the great majority of functions were activated. As a result, events that are reliably detected by the relays include stator earth (ground) faults (90 % and 100 % with the 20 Hz principle), rotor earth (ground) faults (1-3 Hz measuring principle), short-circuits (differential, impedance and overcurrent protection), excessive loads (overload and negative-sequence protection) and excitation or regulation faults (underexcitation, overexcitation and frequency protection). To prevent damage to the power station unit resulting from effective power swings, out-of-step protection is also provided.

Two 7UT612 relays provide the main protection for the generator transformer and one each 7UT612 provides the main protection for the 15 MVA station service transformer and for the 6.6 MVA excitation current transformer. In the relays for the generator transformer, not only differential protection but also overcurrent protection is provided at the transformer star-point to deal with high-voltage-side earth faults.

The fifth 7UT612 was additionally provided as transverse differential protection at the generator to detect winding faults. This protection principle is a special requirement in hydro power generators. To handle the large rated currents (approx. 24,000 A) the stator winding for each phase is composed of several phase windings. As a result, several rods per phase are located in a single slot. Insulation faults between the rods represent a winding fault, which can cause large circulating currents resulting in enormous damage to the generator. Transverse differential protection provides the required sensitivity, speed and stability to guard against this hazard.

An alternative, simpler solution is to detect the equalizing current between the two star points of the subdivided stator winding. This is provided by the sensitive earth current function in the 7UM62. This function provides redundancy to the transverse differential protection.

Another unique feature of the protection for the power station unit is the processing of external signals, e.g. from the Buchholz relay, oil monitor, SF_6 pressure monitor at the bushings, and other signals related to the machinery. To provide this functionality, these signals were routed directly to the binary inputs of the 7UM relays.

The integrated logic functions (CFC) made it possible to provide the required interlocks and logic connections. An additional benefit of this approach was a reduction in circuitry and elimination of external auxiliary relays.

The different switches must be actuated in accordance with encountered fault conditions. The logical coordination and required tripping programs are provided through the programmable software matrix. As a result, the circuit-breakers can be triggered directly by the binary outputs.

Communications are not included in the illustration. The protection settings and the data readouts in a fault incident are performed by protection experts using DIGSI directly at the relayss. Messages and measured values with relevance to the operating personnel are transmitted via PROFIBUS DP to the power plant control system, where they are displayed.

Sales and marketing

The protection concept is defined, the required protection relays selected and the entire proposal generated to correspond to the customer's bid invitation. The feature that sets hydroelectric power plants and especially the Three Gorges project apart is the long implementation time.

As a result, even product development must be included in the project duration to ensure that the technology remains up-to-date. As a case in point, at the outset of the Three Gorges project, SIPROTEC 4 protection relays had just been introduced, and the advantages of this technology were unfamiliar even in expert circles. It was therefore critically important to meet development schedules and product quality requirements.

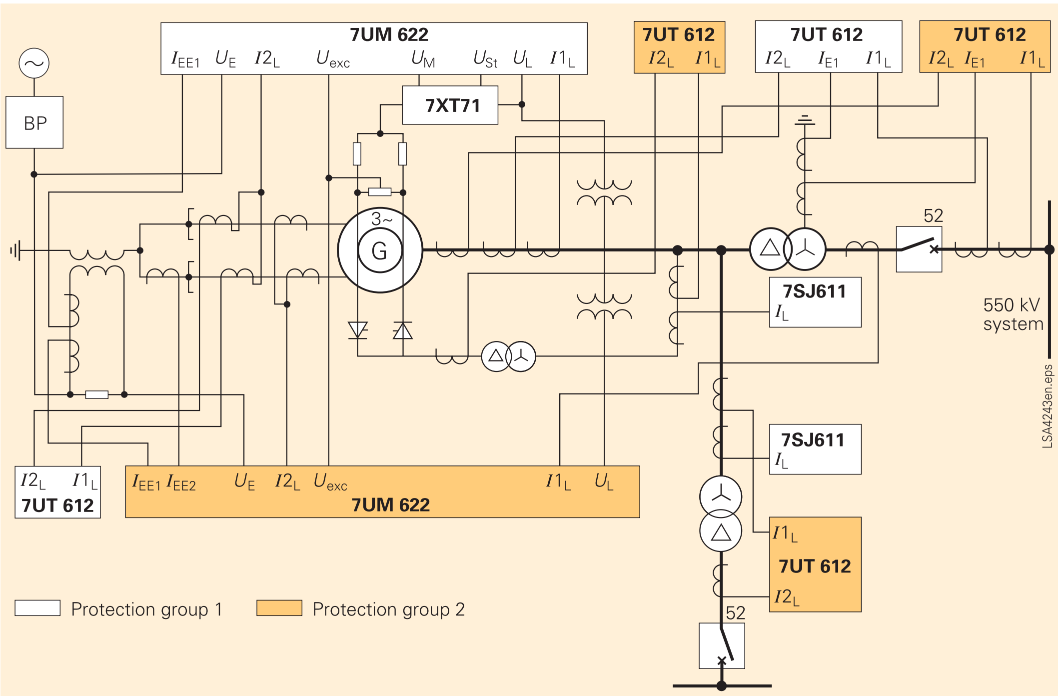


Fig. 6 Protection concept, single-line diagram

■ The special advantages

Systems business is teamwork

Systems business means delivering systems to the customer on time and at the required quality level. This often means that the effort has to be coordinated among many different companies, subprojects and individuals. Within Siemens, the main effort is divided among the following corporate functions:

Engineering

Detail work begins after the order has been awarded. Obviously this includes detailed specifications for the product design and systems configurations of the components that make up the order. One detail that had to be confirmed for the Three Gorges project was the design of the current transformers. The specific conditions of this project required an optimum balance in meeting economy requirements, space constraints for the current transformer, and dynamic specifications (non-saturated time). The current transformer on the output side for instance has a transformation ratio of 30,000 A to 1 A. To achieve this, 30,000 turns had to be accommodated on several cores without interfering with the transmission characteristics. This challenge was met by designing two linearized TPY cores in addition to a 5P100 10 VA closed core.

Defining the settings was another important part of the engineering project. All setting parameters must be clearly documented in a settings report.

Given the special features of hydroelectric power plants and the dimensional constraints of the primary system (for instance in the case of the generator transformers), the accurate detection of all operational conditions as well as potential hazards called for abundant experience. In addition, the required CFC logic modules needed to be developed and of course tested.

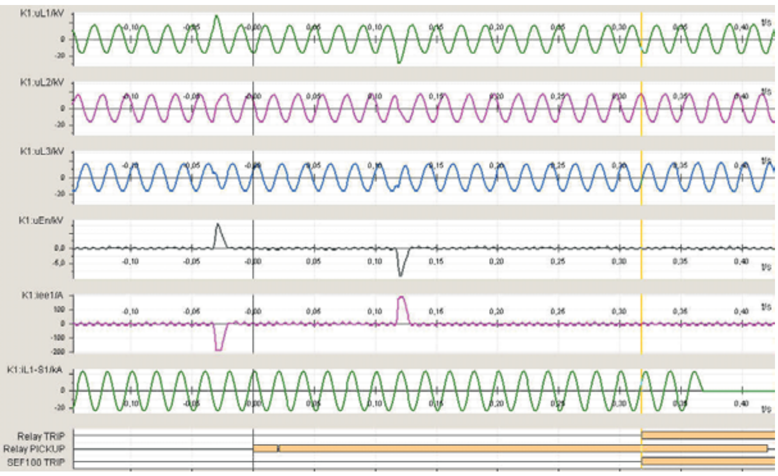
These efforts result in a parameter set generated in DIGSI. The required connection changes (BI, BO, LED, CFC and serial interfaces) must also be implemented in accordance with the circuit manual.

Project implementation

In this sphere, the focus is on coordinating all the tasks and resolving any open questions. Specifically, this includes ordering the equipment and coordinating the delivery schedule with the plant, coordinating the assembly of the cubicles, resolving interfaces, all the controlling, and of course customer support (e.g. during the cubicle acceptance testing). Project-specific training must also be provided for the intended operators to ensure a trouble-free commissioning process.

Since the power station control and protection systems as well as the communications solutions were supplied by different manufacturers, representative devices were used in the integration tests. What's more, a comprehensive test of the entire protection system was performed at the Siemens location in Fürth (see Fig. 8). As a result, the integration of the individual components with the overall system at the construction site proceeded smoothly.

Fig. 7
SIGRA printout of the actuation of the protection system



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From practical experience

To the amazement of all participants, during trial operation the first actuation of a protection relay was caused by the 100% stator earth-fault protection. What had happened? During operation of the generator another protection relay was active, which was designed to monitor the insulation resistance of the stator under operating conditions. This relay caused an earth fault, which was reliably detected and deactivated by the 100% protection function in accordance with the 20 Hz measuring principle.

The tripping on fault provided an opportunity to demonstrate to the customer the effectiveness of the protection scheme provided by Siemens, as well as the benefits of numerical technology. The information stored in the protection made it easy to analyze the fault. Every response of the protection function is logged with milliseconds-accuracy in the fault event buffer, and the momentary values of the analog input values and associated binary tracings are oscillographically recorded in the fault record. The powerful SIGRA tool is used to evaluate the fault record. Fig. 7 illustrates the processed fault record. Clearly visible are the two spikes in the displacement voltage and in the earth current, as well as a phase-angle shift in the conductor-earth voltages. The binary tracings reveal the response of the protection function, showing both the relay pickup and tripping.

Fig. 8 Testing the generator protection cubicles

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■ *Conclusion*

Despite the vast scope of this project and the challenges of integrating components by many diverse manufacturers, there was no delay in the construction or commissioning phase. One reason was certainly the unique flexibility of Siemens technology for electric power unit protection; another the excellent teamwork of all participants, such as sales and marketing, engineering, project implementation, production and development, as well as close collaboration with the construction project.

High Power Station Available and Reliability

Protection and control as a unified system for hydroelectric power plants of Energie AG Oberösterreich

■ The company

Energy AG Oberösterreich is the leading infrastructural company in the Upper Austria economic region. The company's core business is generating electric power at market prices in an environmentally sound way. Generating customer satisfaction through appropriate pricing, support and services is the company's foremost commercial objective. In addition to its core business, the company is also active in the business segments of energy services, heat, gas, telecommunications, waste removal and water/sewage.


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■ The starting situation

The Grossarl power station of Energie AG Oberösterreich was built in 1917. It is located in Salzburg's Grossarl Valley and uses the water of the Grossarler Ache River. Two Francis turbine sets are installed in the powerhouse, which was renovated in 1966. The two synchronous generators feed power into the 30 kV busbar system in a unit connection arrangement. From there the power is fed into the power system via two 30 kV line branches. Fig. 1 and Table 1 provide a general view of the substation as well as power station data.

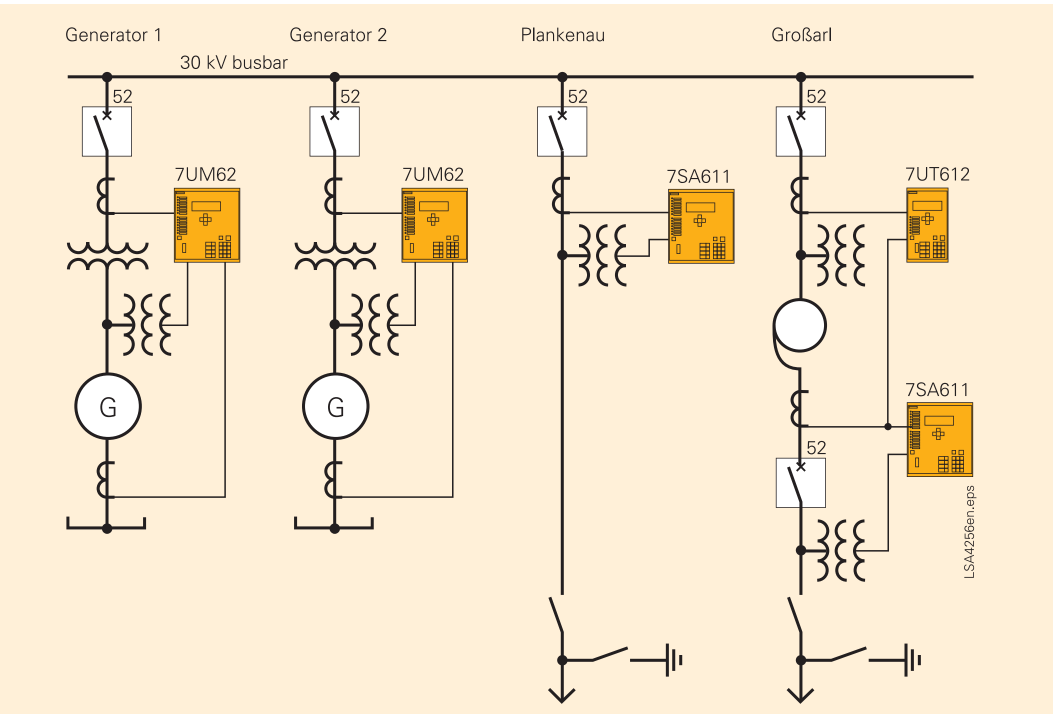

Fig. 1 Power station overview


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Fig. 2 Existing switchgear panels with protection relays

The old protection and control design consisted of a multitude of individual components, such as relays, operator control elements, indicators and transducers (Fig. 2) that were interconnected by numerous copper wires and cables.

	Machine 1(2)
Turbine	Francis
Rated power	3.18 MW
Speed	750 RPM
Generator	Three-phase synchronous
Rated power	3.80 MVA
Rated voltage	6.30 kV
Rated current	348 A

Table 1: Power station data

Essential power station components were replaced in 2002. These included electrical and mechanical protection relays, machine automation, control room equipment and the excitation system. This modernization project was designed to include a state-of-the-art protection and control system to meet present and future needs.

The concept

Electrical safety of power stations requires protection equipment with a high degree of flexibility and functionality. Building on the experience gained with V3 relays, an innovative protection system was created in SIPROTEC 4 that provides entirely new opportunities of integrating protection and automation functions. Communication via PROFIBUS-DP provides a trouble-free link with power station control systems.

In-depth protection

Complete power station unit protection is provided by a SIPROTEC 7UM62 multifunction generator, motor and transformer protection relay. Backup protection is provided by a built-in, transformer current-fed overcurrent-time protection relay with capacitor release (Fig. 3).

The existing Bütow transformer continues to be used for stator earth-fault protection, but the control of the load resistors is now provided by the CFC function in the 7UM62. The Bütow transformer generates a displacement voltage even during earth-fault-free operation, so that 100% stator earth-fault protection can be provided without additional equipment.

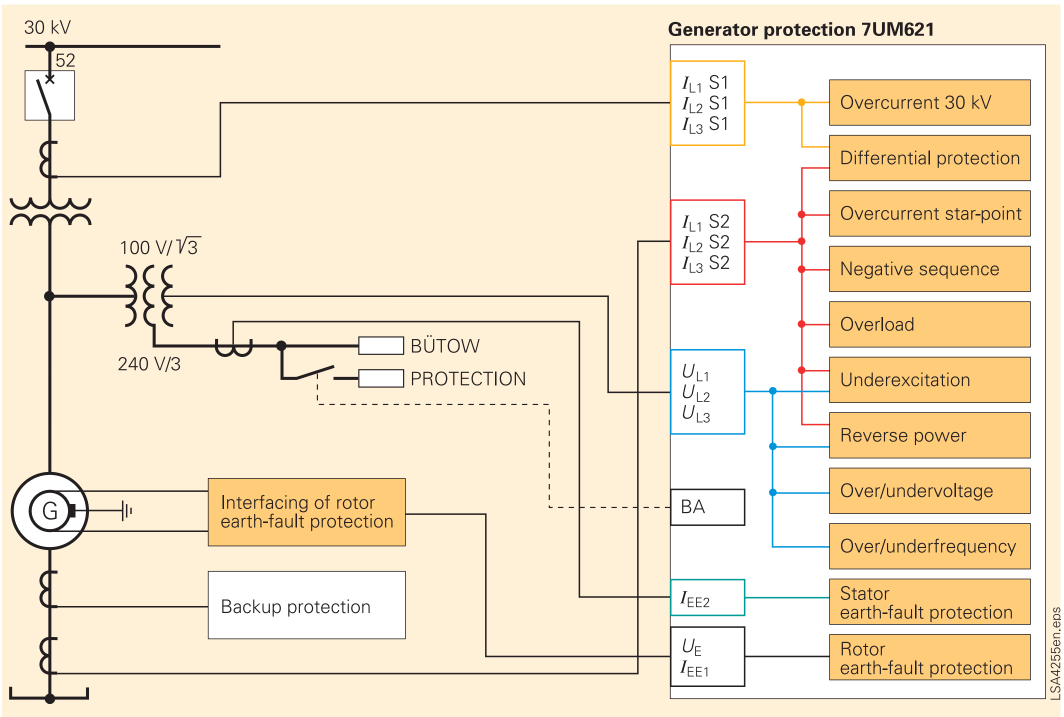

Fig. 3
Concept of generator protection

Capability of remote operation

The 30 kV lines are protected by a SIPROTEC 7SA611 distance protection relay. All protection relays are connected to a modem via the RS485 service interface (Fig. 4). This linkage provides access to the full range of DIGSI functionality, such as changing parameters, reading operational and fault messages, indication of operational measured values etc. even from a remote location. Remote maintenance and fast fault correction are greatly facilitated as a result.

A solid foundation: SIMATIC S7

The protection and control system (Fig. 4) is based on SIMATIC S7. Protection and control tasks of the Grossarl power station are divided among three control units that are interconnected via MPI bus. A separate control unit is provided for each machine set and for the general section. One programmable logic controller (PLC) per machine provides the functions of machine automation, mechanical protection and connection of the generator protection via PROFIBUS-DP for transmission of messages and measured values.

Another PLC for the general section controls the 30 kV line feeders, provides connection of the line protection relays via PROFIBUS-DP, and operates the interface to the power station control room (remote control).

Redundant system

Two touch panels are provided for operation, display of measured values and monitoring (alarm and event lists). Each touch panel can control both machine sets as well as both line feeders. This arrangement provides redundancy in the event of a touch panel failure.

■ *The special advantages*

Touch panels provide flexibility

The use of SIMATIC S7 provided a standardized product for the power station protection and control. Operation by touch panels provides greater flexibility to accommodate changes and eliminates the need to install multiple operator control and indicator devices.

Simplified engineering and commissioning

The connection of the SIPROTEC 4 protection relays to SIMATIC S7 via PROFIBUS eliminates the need for externally mounted measurement transducers as well as for analog and binary inputs to the PLC. The elimination of these hardware components also reduces the engineering and commissioning effort and cost.

This simplification of the installation and wiring also drastically shortened the conversion phase.

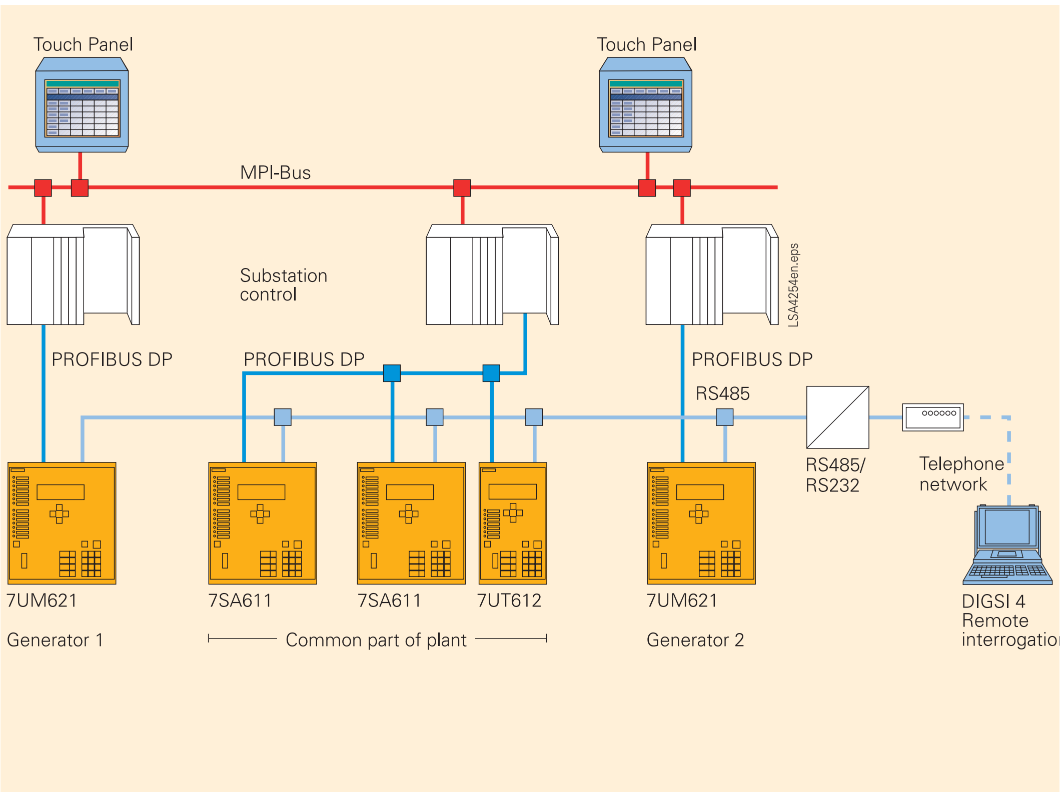

Fig. 4 Interconnection to power plant control system

Uniform equipment operation

The uniform protection design with SIPROTEC 4 relays is advantageous as it supports uniform operation of the generator and line protection and provides the capability of remote maintenance.

High plant availability

The extensive self-monitoring of the system components results in substantial improvement in plant availability and reliability.

■ *Conclusion*

A cost-optimized, state-of-the-art protection and control system was implemented during the modernization of individual power station components at the Grossarl power station of Energie AG Oberösterreich.
Of great advantage were not only the trouble-free integration into the power station control system but also SIPROTEC multifunction protection relays' compact design.

Good Connections between Sweden and Germany

Quality recording in static VAr compensators SVC

■ The company

The shareholders in Baltic Cable AB, founded in 1991, are the Norwegian power supply company Statkraft, the E.ON energy services group, and the Swedish company Sydkraft.

■ The starting situation

Since 1994, Baltic Cable has exchanged electricity between Germany and Sweden by means of a 250-kilometer-long (160 miles) direct-current link. The 450 kV high-voltage, direct-current transmission system (HVDCT) has one converter station in Kruseberg and one in Herrenwyk. The HVDCT system was designed with a transmission capacity of ± 600 MW. Contrary to original plans, however, the system is now linked to the 110 kV power system, because of changes in the European energy market. In order to guarantee dynamic operation of this transmission cable, despite the considerably lower short-circuit power at this voltage level, E.ON is undertaking various expansions based on a network study.

The corresponding 400 kV transforming station, in direct proximity to the HVDCT converter station, connects to the 220 kV transforming station in Lübeck via a 10 km long cable. E.ON ordered a 380/220 kV transformer with a rating of 350 MVA from Siemens, which is required for the Siems station.

■ The concept

A static VAr compensator (SVC) is being installed to guarantee the voltage quality. Since the HVDCT converter station has a high dynamic performance, the compensation system needed to have at least the same dynamic performance. To stabilize the system voltage in case of a change in the power transmitted over the HVDC cable, the system had to provide equivalently high inductive (voltage reduction) or capacitive reactive (voltage increase) power. In order to implement these regulating processes quickly, the SVC relies on high-speed power electronics systems.

When completed, the SVC will consist of a three-phase 400/18 kV transformer, which links to the transmission system at the Siems transformer station, and four subcomponents installed in the 18 kV area.

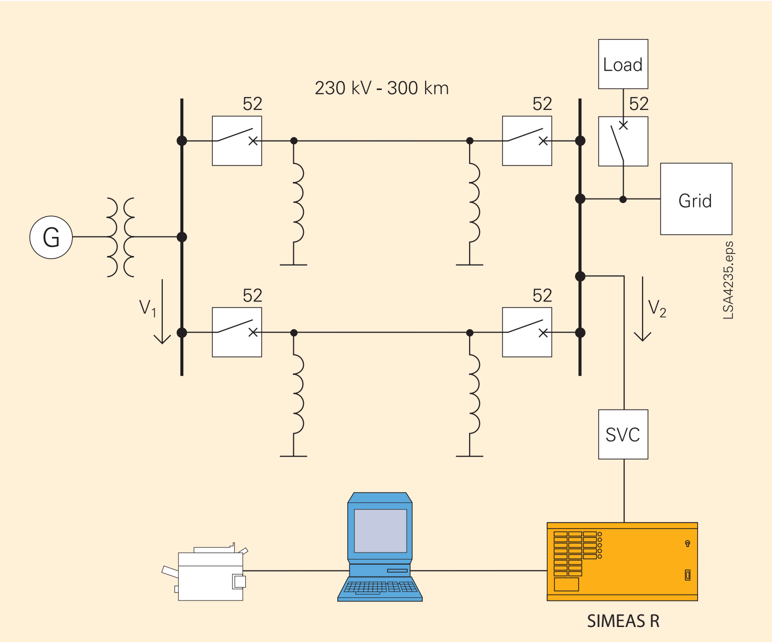

Fig. 1 Quality recording in static VAr compensator

■ The special advantages

The four subcomponents of the SVC system cover a control range from +200 to -100 MVar for the voltages and times described in the specification.

Inductor is infinitely variable

One of the four medium-voltage components is a power-thyristor-controlled reactor. The reactor (reactance coil) generates an inductive current. Since the reactor is the only infinitely variable unit connected to the power electronics system, it is designed to cover the entire control range of the SVC system, from +200 to -100 MVar.

Capacitor unit generates reactive power

The second component is a capacitor unit. The system section can be switched in or disconnected via the connected power electronics system so that leading reactive power can be generated if needed.

Reactive power generator serves dual functions

The third and fourth units are leading reactive power generators. They also double as filters in order to avoid any harmonic feedback in the SVC, and are therefore permanently connected.
An equipment building houses the power electronics system and the control and protection equipment that operate the system.

SIMEAS R guarantees reliable voltage quality

In order to log the correct functioning of the SVC system with the corresponding power system requirements and to determine the cause of any fault, the protection and control concept includes a SIMEAS R quality recorder. The availability of the SVC system is a condition of the commercial contract, and Siemens had to provide proof of availability. At the same time, a high degree of recording accuracy is important, since the SVC control is designed to operate at an accuracy of better than 0.5 % in order to guarantee the voltage quality.

The quality recorder provided in the Siems SVC records the primary voltage and currents on the 400 kV side. It also records the reactive power and the harmonic voltages on the primary side, the voltage on the transformer secondary side, the currents of the individual medium-voltage components, and various protection and control signals.

Data analysis and archiving

For analyzing and archiving data, an evaluation station is connected to the SIMEAS R. The substation includes a PC equipped with OSCOP P software and a printer.

Conclusion

Quality recording in the SVC documents the power quality. Due to the recording of the correct functioning of the SVC, it is possible to easily and quickly locate a fault and its cause.
The data base of the SIMEAS R is the basis for the commercial contract. It serves as a proof for the availability of the plant.

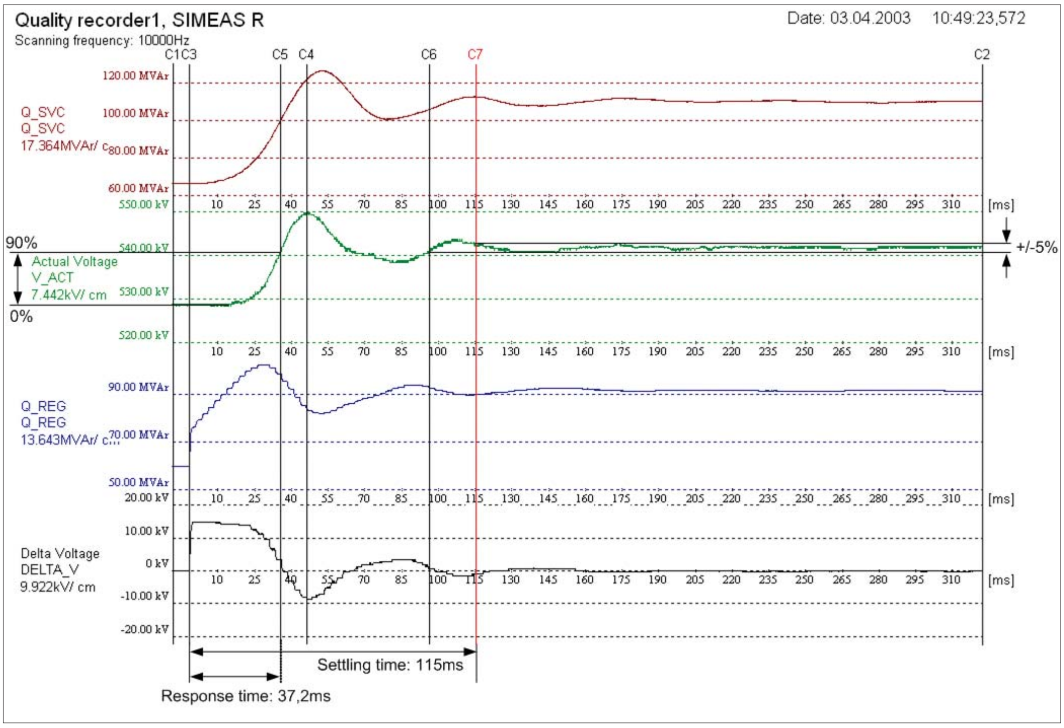

Fig. 2
Example of a quality record

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Moyle Interconnector - Forming a Bridge between Great Britain and Ireland

Fault recording for HVDC transmission systems

■ *The company*

Two power supply companies have joined forces to build a bridge between Northern Ireland and Scotland by means of the Moyle DC Interconnector. In order to meet rising energy demands, Northern Ireland Electricity (NIE) had to expand its 275 kV three-phase system in Northern Ireland. Scottish Power, Scotland's national power supply company, provided the connection to the Scottish three-phase system.

■ *The starting situation*

The exchange with Scotland proved to be the most economical, safe and ecological solution for obtaining the necessary power. The Moyle transmission project will enhance the security of supply to the Emerald Isle while also improving NIE's competitive position.

This HVDC interconnection, known as the Moyle Interconnector, is a dual-monopole system. Each of the 250 MW poles is designed for bi-directional power transfer. Two submarine cables through the channel will bridge the 64 km gap between Scotland and Ireland.

Each converter station has a rated power of 250 MW at 250 kV DC. The HVDC thyristor valves are equipped with direct-light-triggered thyristors with integrated overvoltage protection.

■ *The concept*

For this project, Siemens Power Transmission and Distribution supplied electronic equipment including a number of SIMEAS R fault recorders for the two converter stations located at Auchencrosh in Ayrshire (Scotland) and Ballycronan More in County Antrim (Northern Ireland).

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Fig. 1 HVDC power station in Ireland

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Fig. 2 "Moyle Interconnection" between Scotland and Northern Ireland

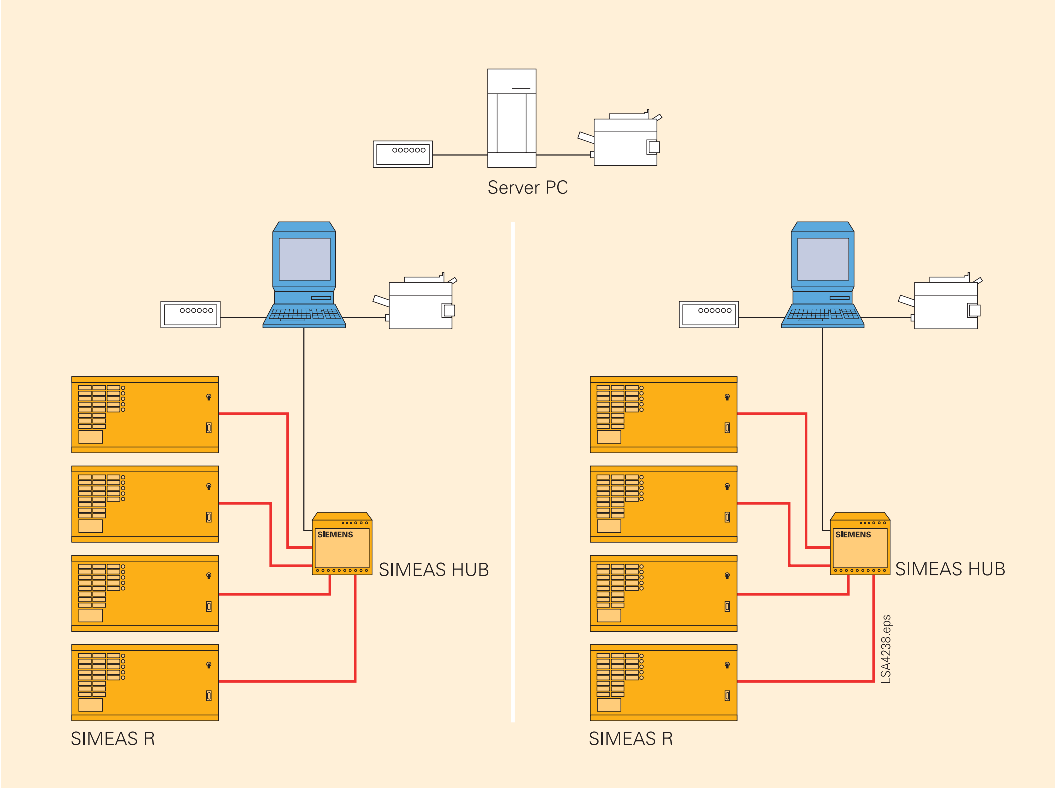

Fig. 3 Configuration of the fault recording systems

The special advantages

Fast on-site analysis

Each station contains several SIMEAS R ZE32/64 recorders with various recording modules (DAUs). The SIMEAS R recorders are connected to the local evaluation station via an Ethernet interface. Each local evaluation station comprises a PC, local printer and modem, providing for fast onsite analysis. It is also possible to simultaneously transmit the data to a higher-level evaluation station automatically via the telephone line. In the event of a fault, the SIMEAS R recorders are started by a network trigger and serve to record all analog and binary signals.

Data evaluation and archiving

The evaluation station and server PC are available for evaluating, analyzing and archiving the fault records. The OSCOP P system program is installed on the individual PCs and provides automatic remote data transmission, archiving and diagnostic output of measured-value files. The OSCOP P software is also used for parameterizing SIMEAS R and has extensive calculation, filter and statistics functions.

Data from the individual SIMEAS R fault recorders is retrieved and stored on the individual PCs. These PCs operate with OSCOP P in automatic mode, meaning they automatically retrieve the fault records from the individual SIMEAS R recorders and automatically store them in the OSCOP P data base.

One device-many functions

When a fault occurs, SIMEAS R records and documents all DC and AC values, as well as individual binary values such as trips, HV breaker positions and critical alarms. It also records and documents tests. But this isn’t all SIMEAS R can do: It provides commissioning tools for optimally configuring protection and control, plus it generates fault logs for tracing the causes of plant failures and, if appropriate, implements preventive measures.

■ *From practical experience*
SIMEAS R Records

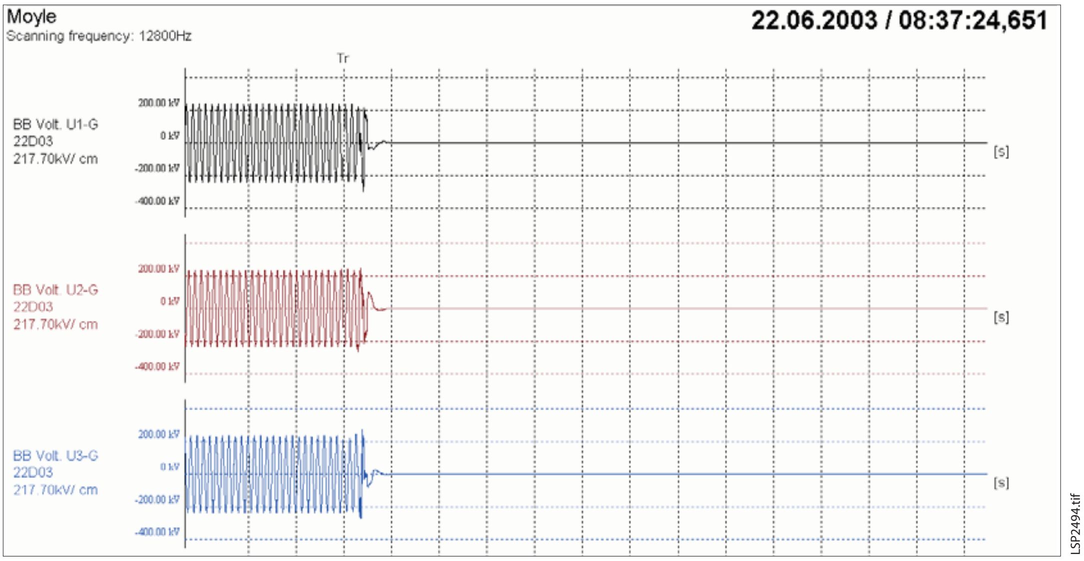

Fig. 4 Example of SIMEAS R record

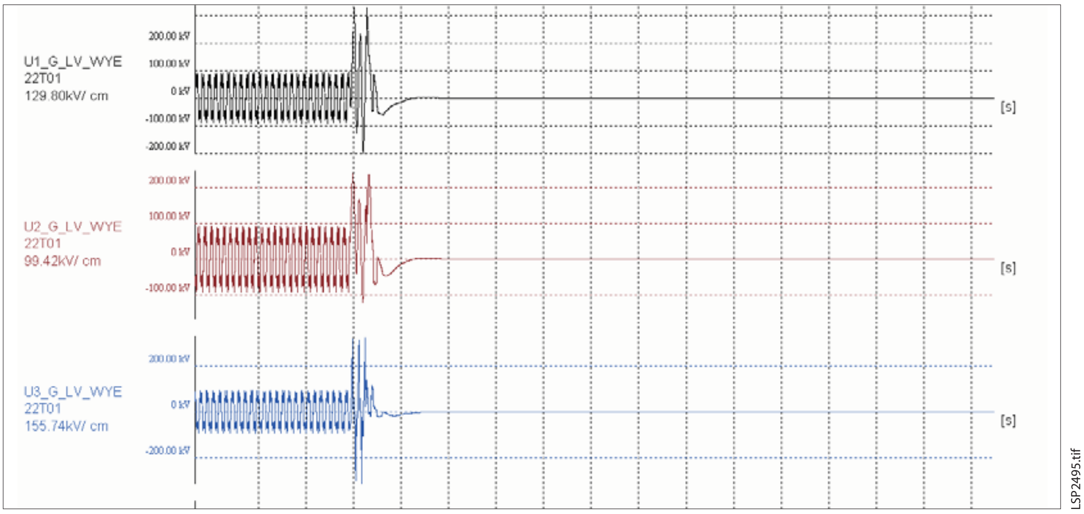

Fig. 5 Example of SIMEAS R record

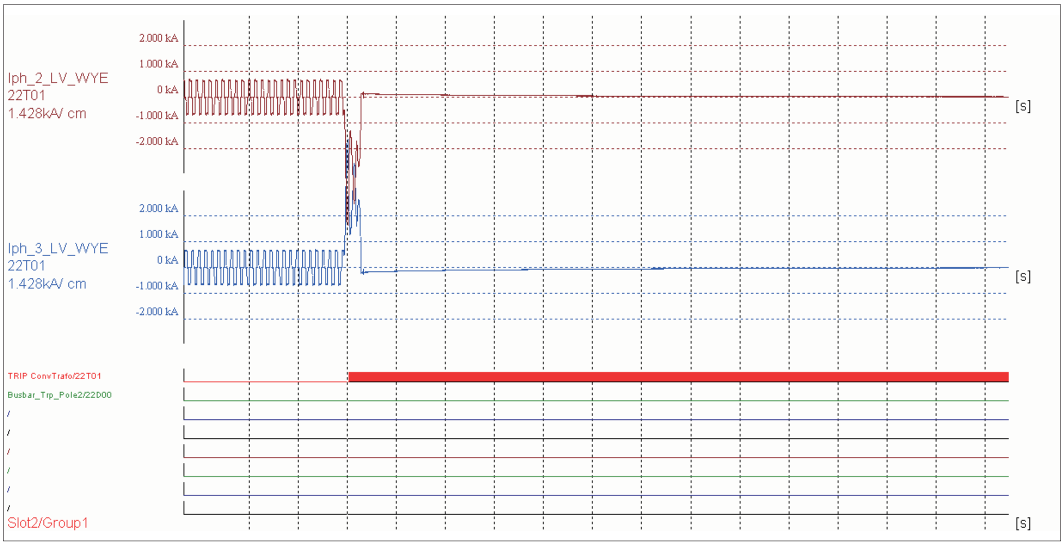

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Fig. 6 Example of SIMEAS R record

Conclusion

The Moyle Interconnector links the power supply systems of Scotland and Northern Ireland using an HVDC interconnection, thereby improving the stability of the power supply in Northern Ireland. SIMEAS R digital fault recorders are also used. Their numerous functions permit a fast and reliable identification of weak points using only one device.

Reliable Research

Fault recorder system at CERN

■ *The company*

CERN ("Centre Européenne de Recherche Nucléaire") is the most important European organization for nuclear research and is financed by 20 member states.

CERN has been responsible for important discoveries within the microcosm of the smallest particles. To make such research possible, CERN operates several particle accelerators requiring a large amount of energy.

■ *The starting situation*

On the French side, CERN is supplied with electrical power by EdF – RTE (400 kV) and on the Swiss side by EOS. They also receive emergency power from the 16 kV power supply system of SI Geneva. In addition, CERN operates internal emergency generator sets. Power is distributed internally via the Prévessin station by means of a 16 kV ring. According to their own indications, CERN operates approx. 7000 medium-voltage cells.

The quality of the power supply is extremely important. Any fluctuation or fault can falsify research results and delay research projects for months.

No possibility of integration into the telephone network

In the past, CERN relied on the fault recording systems at the individual power supply points for obtaining the necessary data in the event of a power failure. Fault recorders from various manufacturers are used, including Siemens OSCILLOSTORE systems operated autonomously at 5 infeed stations. Integration in the customer's own telephone network was planned, but the network proved obsolete and could not safely be used for a reliable transmission of fault data.

Time-intensive evaluation

When a fault occurred, technicians had to drive to a station before they could access the data and start analysis. This evaluation method, which had developed over time, was time-intensive and highly inefficient. Because the fault recorders used came from different manufacturers, it was not possible to combine data in a single system software.

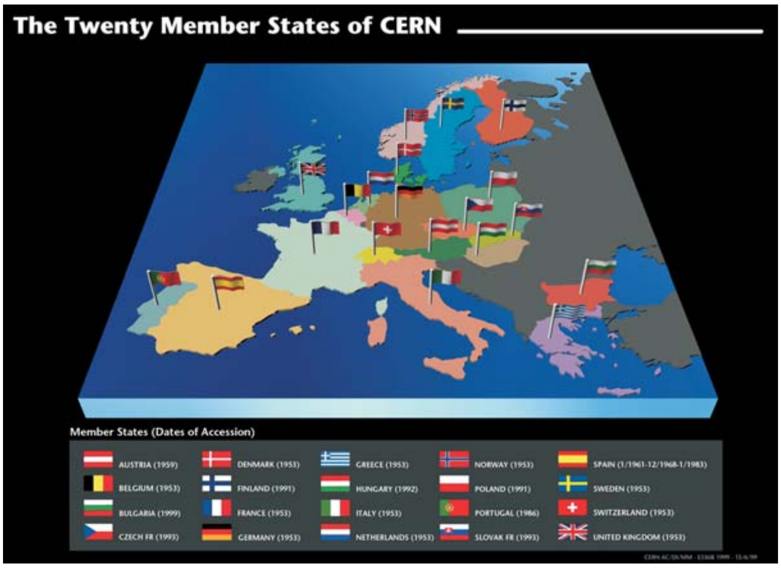

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Fig. 1 CERN member states

CERN's requirement: All data must be concentrated and analyzed centrally.

■ *The concept*

Siemens Power Automation Division developed a suitable concept that permits centralized evaluation without necessitating the replacement of existing devices. As a further advantage, the proposed solution allows a future system expansions.

Centralized data

The solution serves to concentrate the data at the customer's head office. This placed special demands on the communication concept. It was the customer's requirement that no additional electronic components are to be installed in the particle accelerators, because they might falsify the research results.

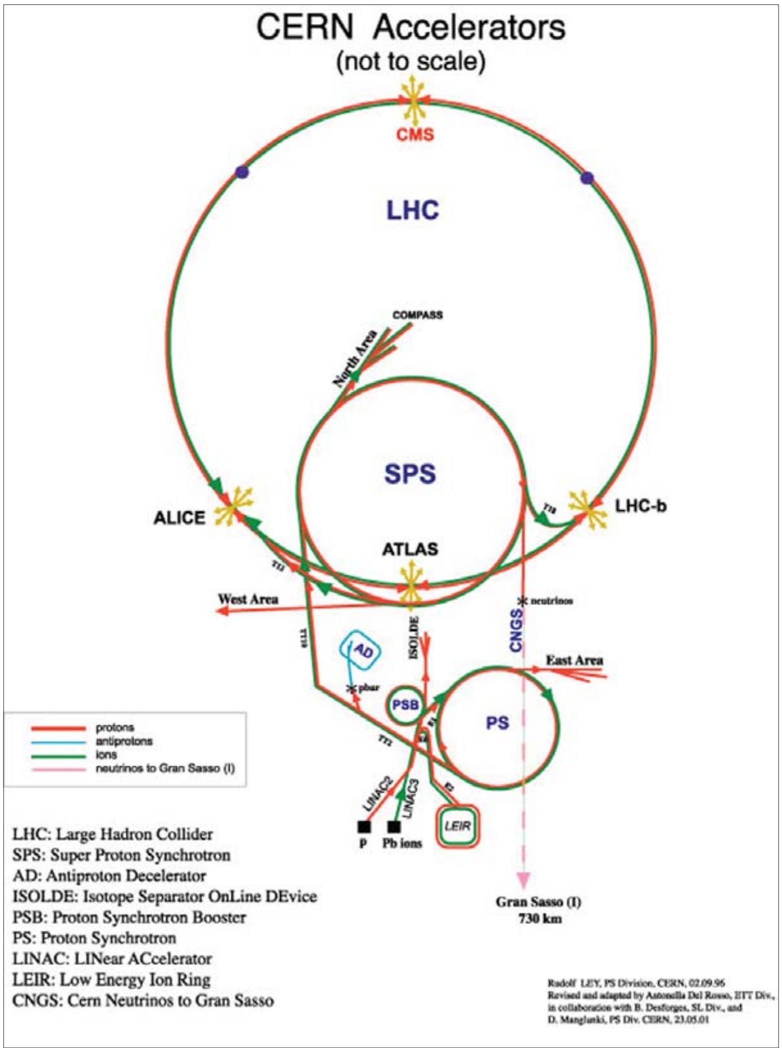

Fig. 2 CERN, schematic diagram

Connection via interfaces

The device located furthest from the head office is about 14 km away. The demands on the communication links could be met only by employing mono-mode fiber-optic cables (1320 nm). The old-model fault recording devices currently in use were not bus- or network-capable. A point-to-point connection to a star configuration had to be set up for each device to provide a sufficient number of serial interfaces at the data collection center.

The solution implemented includes a DAKON 98 data concentrator at the customer's head office with an appropriate number of serial interfaces. It was possible to integrate all existing Siemens fault recorders in a global concept by means of converters connected to 1320 nm fiber-optic cables. Fig. 5 provides a detailed diagram of the communication link.

The old fault recording systems were adapted to the new communication options. This required a partial replacement of the firmware as well as a re-parameterization.

The special advantages

Easy to expand

The Siemens concept permits the cost-effective and user-friendly integration of potential expansions. In addition, the DAKON 98 system used makes it possible for a higher-level office to access the recorded and stored data.

CERN considers this future-oriented concept to be the ideal solution. They eagerly promoted the conversion and also replaced the non-Siemens fault recorders with SIMEAS R.

Flexibility in data synchronization

An evaluation station that can be set up at a separate location was connected to DAKON 98. At this station, data synchronization can be performed either manually or automatically and more extensive fault analyses can be conducted using the OSCOP P system software.

Future-proof system

CERN plans to expand the current fault monitoring system to include power quality analysis with SICARO PQ. They must also be able to include data from other users in the analysis, which requires converting to a client-server system architecture. This conversion can easily be performed using the OSCOP P system software.

Conclusion

A fault recording system was installed at CERN, permitting the concentration and analysis of all data and making it possible to take fast and effective action in the event of a fault. This is extremely important to CERN, because their research work cannot be safely conducted unless high power quality is guaranteed. Moreover, future system expansions are possible and easy to implement.

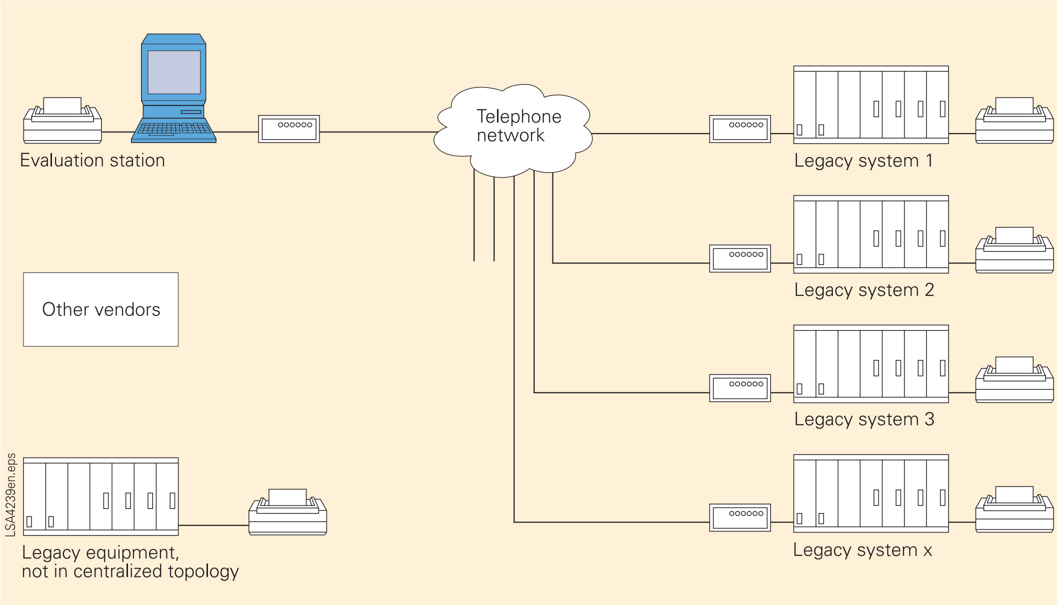

Fig. 3 Technical configuration before modernization

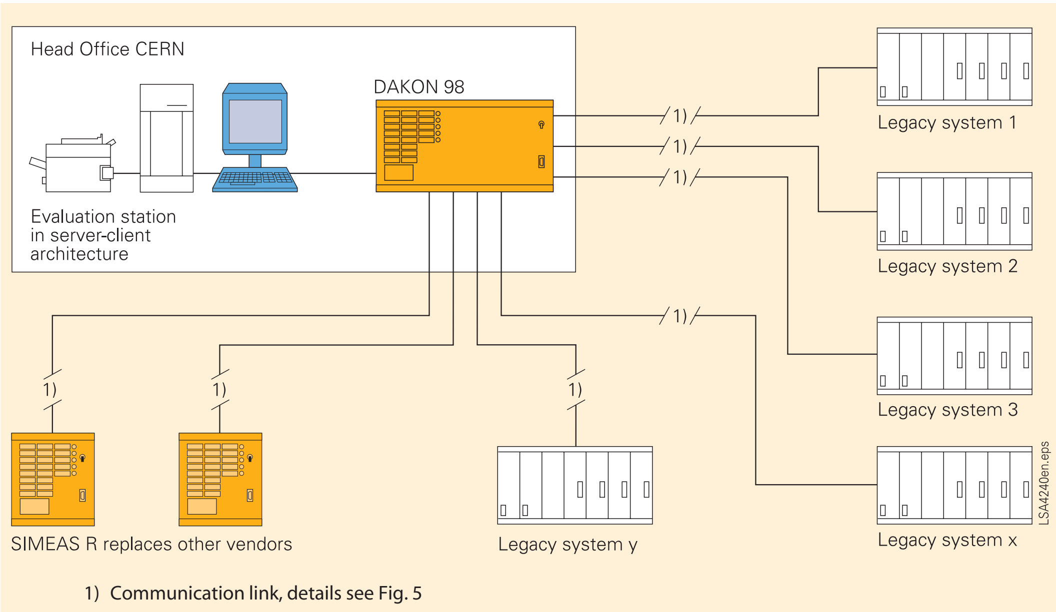

Fig. 4 Enhanced fault recording system of CERN

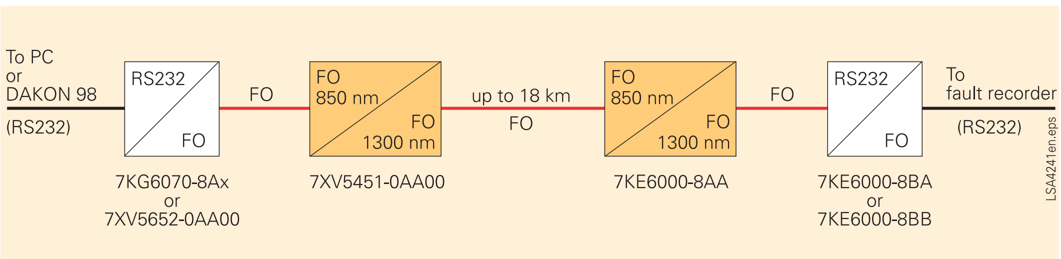

Fig. 5 Schematic diagram of a communication link

Maximum Success through Minimal Downtimes

Fault analysis in Zurich using fault recorders and protection relays

■ *The company*

Power production, transport and distribution – as one Switzerland's few power companies, Elektrizitätswerke Zürich (ews) (Zurich electricity utility) offers all three from a single source. ewz supplies power and provides all related services, not just to Zurich but to about a third of the Kanton Graubünden; altogether, the company delivers power to approx. 240,000 customers, making it one of the 10 largest power stations in Switzerland.

The majority of ewz's power is generated by hydroelectric power plants in Graubünden and on the Limmat River. Using a power systems of over 700 kilometers of extra-high voltage overhead lines, power is fed via various nodes from Graubünden to the four connecting substations on the outskirts of Zurich, and from there is distributed via a 4000 kilometer cable system to the 17 substations in the various districts. These substations are connected to 670 transformer stations that supply power to all private and commercial customers as well as public facilities and municipal lighting.

■ *The starting situation*

Every fault that occurs in the power supply system of a large, densely-populated city with correspondingly high energy requirements is a major challenge for municipal utilities companies. Everyone affected wants to know as quickly as possible when and how power supply will be restored.

Quick assessments are especially difficult to make because today, the protection relays and fault recorders installed in most of the switchgear of many power supply companies came from different manufacturers. This problem is compounded by the fact that in a large number of cases, different technologies were also installed (such as electromechanical and numerical protection relays) that frequently belong to different generations (such as SIPROTEC 3 and 4 relays).

The result: A single power system fault suffices to trip several protection relays simultaneously. Whether one or more protection relays are tripped depends on the type of fault. Resolving the fault sometimes involves starting up operating software (such as DIGSI) from different manufacturers , retrieving the data from the IEDs (Intelligent Electronic Devices) and performing a complete analysis.

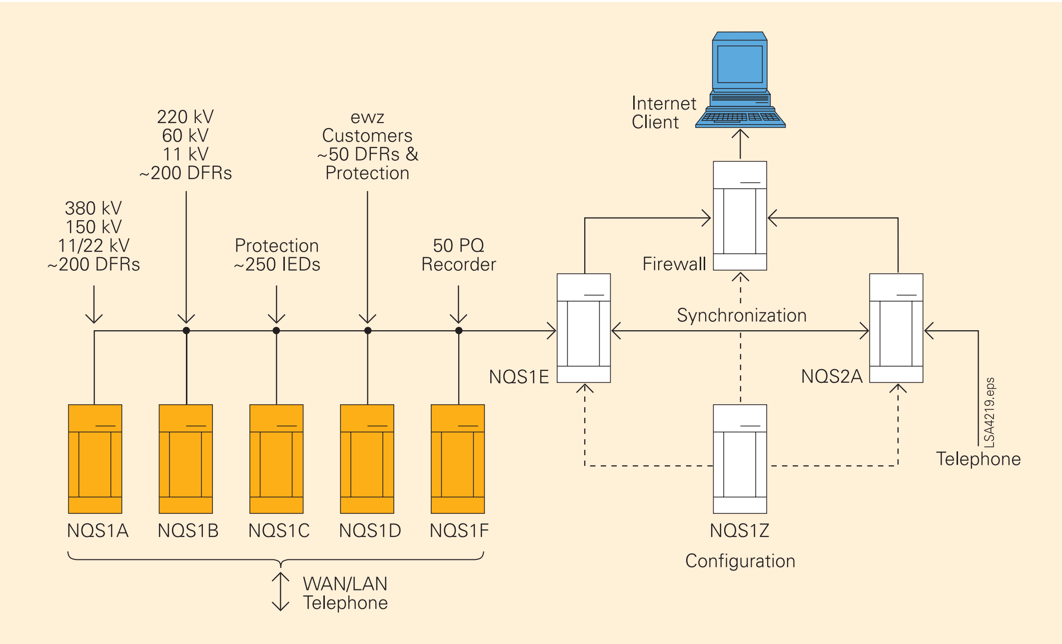

Fig. 1 Server PC configuration and the number of connected devices

The concept

Zurich needed a solution that would make the evaluation of fault logs as quick and easy as possible. In the present case, ewz was able to achieve an extremely intelligent and effective result by installing the Network Quality Analysis System (NQS), which can reduce fault resolution time to less than 30 minutes and usually to as little as 15 minutes. The complete system, which monitors the greater Zurich area, includes 8 high-capacity servers, 400 fault recorders (SIMEAS R and P531), 250 numerical protection relays and 50 SIMEAS Q power quality recorders. These are supplemented by 50 additional devices (40 P531 and 10 SIMEAS Q) belonging to other power supply companies but whose data is also analyzed by ewz.

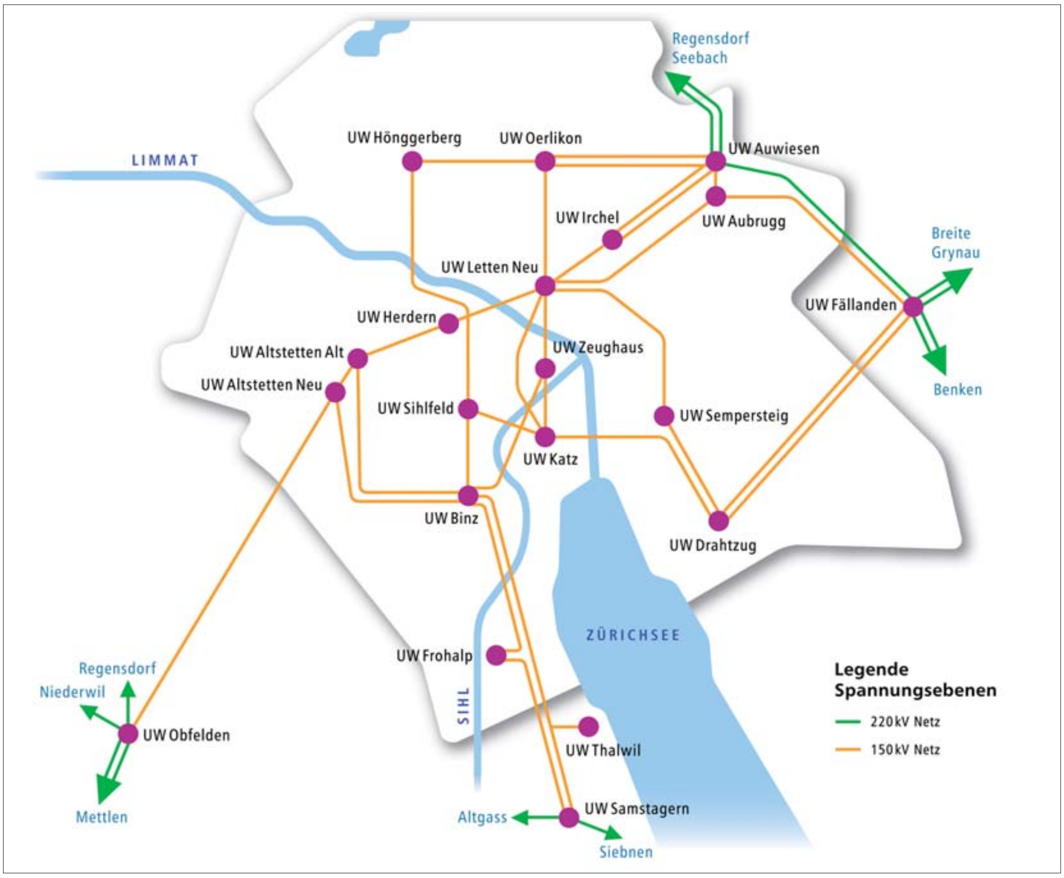

Fig. 2 Distribution system of ewz

Function of the NQS

Every ewz substation has at least one DAKON to which some or all of its IEDs are connected. A DAKON is an industrial PC with the OSCOP P software program that automatically retrieves the fault data recorded by the IEDs and stores it in a separate data base.

All of ewz's DAKONs are connected to the central server (see Fig. 1) via two independent communication channels (Ethernet and telephone, making it a redundant system), thus ensuring that all 750 devices belonging to ewz are indirectly connected to the main office. The OSCOP P software program also runs on the server PCs shown in Fig. 1. This program automatically retrieves all the data on the connected DAKONs and stores it in a separate data base.

Additional OSCOP P modules analyze the data, so that station engineers are presented only with the finished report. The servers are able to make these reports available on the Internet or Intranet in HTML format. Depending on parameterization, the reports can also be forwarded to individuals by fax or e-mail. In special cases, supervisors can also be instantly notified by SMS (text message).

The special advantages

The NQS is the only system in the world to provide a special feature known as "complex analysis". The OSCOP P system program sorts all the records in a time window and uses various methods to calculate fault locations. After several iterations, the location of the first fault is finally determined and all the consequences identified, meaning significant time savings because the station engineer does not have to perform the analysis manually. One advantage of this direct identification of the original fault is that the unaffected service sections can be started up immediately. A further benefit is faster fault correction, making it possible, for example, to minimize the production downtimes of an industrial plant.

From practical experience

As shown in Fig. 3, the NQS analyzes all the fault records and power quality data from the connected IEDs. Thus, for example, a production fault in an industrial complex can be located. In this case it is caused only by voltage dips provoked by a short-circuit in another power system section.

Conclusion

This project involves the world's first fault analysis system with automatic data collection, data analysis and report distribution. These innovations are beneficial, not just to ewz, the power supply company, but to the entire region. Faster fault correction saves the operator money while drastically reducing downtimes for local industry.

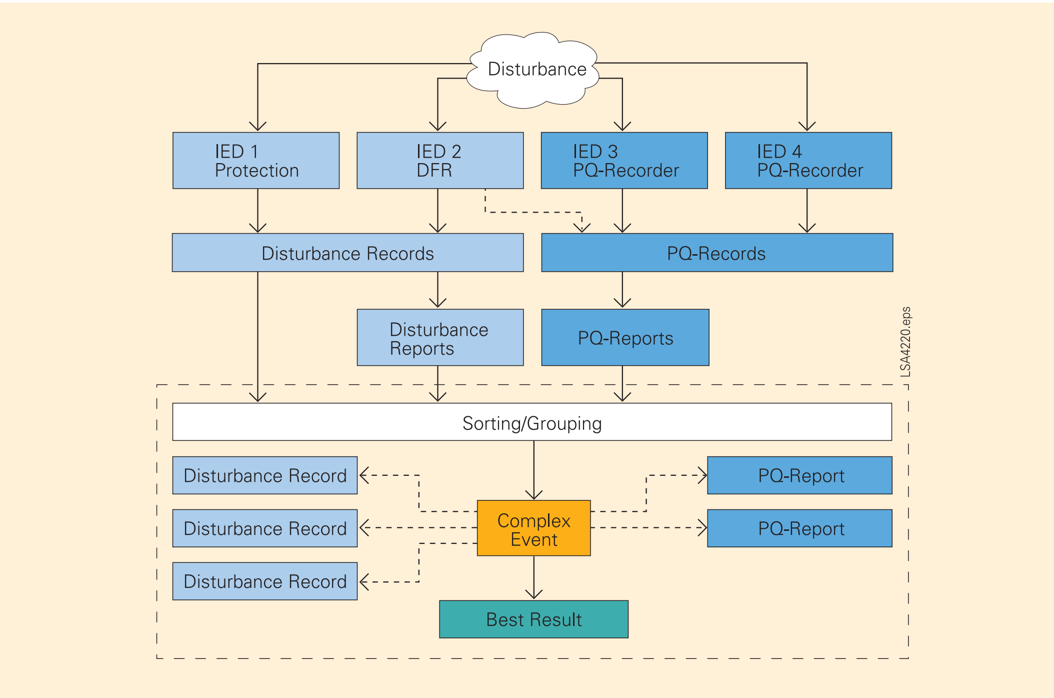

Fig. 3 Data flow for fault evaluation

Uniform Power Quality Recording via a Wide-Area Network (WAN)

Fault and power quality recording at Pfalzwerke AG

■ The company

Established on December 17, 1912 as a small utility, Pfalzwerke AG is nowadays the number one energy provider in the Pfalz and Saar-Pfalz regions. Pfalzwerke AG supplies power to about 280,000 private and 1500 commercial customers over an area of 6000 square kilometers that includes over 8000 kilometers of power lines and about 4000 substations.

To cope with the constantly growing demands on the power supply, strict environmental regulations and rising energy costs, new methods and technologies are needed. Pfalzwerke AG has recognized current trends and invests more and more in new technologies and solutions so that they are able to provide electrical energy in a proper way. Regenerative power sources such as wind power and photovoltaic systems, among others, are increasingly being employed to generate power. Nevertheless, the use of these technologies as well as deregulation have placed special demands on the overall power supply. Through area-wide monitoring of the power supply, it is possible to determine problems and their causes and to initiate the proper measures to clear them. Among other things, the recording and analysis of power quality according EN 50160 plays an important part.

■ The starting situation

In preparation for future challenges, a joint solution was developed for the area-wide monitoring of network quality. The goal of this project was to integrate the fault recorder system into Pfalzwerke's communication network in such a way that data should be transferred exclusively via the corporate WAN. This wide-area network has a special feature: All data transfer is performed in parallel, including the Internet, Intranet, MS Office applications, Voice over IP (phoning via TCP/IP), data communication by the fault recorder, PQ monitoring, etc. In the case of measuring points that cannot be connected to the WAN, data will primarily be transmitted via GSM modems.

Fig. 1 Web page of Pfalzwerke

Fig. 2 Service area of Pfalzwerke AG

■ The concept

A special implementation concept was developed based on the large volume of data (fault records and mean values). It is integrated in the communication network such that, on the one hand, time-critical fault records can be transmitted and analyzed as quickly as possible and, on the other hand, no interferences with any of the other services operating via the WAN can occure.

On-site tests

In order to guarantee the performance of the solution developed, operating scenarios were jointly designed with experts at Pfalzwerke AG and then tested on the customer system. The tested features included the transmission speed of fault records with simultaneous restriction of the communication bandwidth.

Time-optimized analysis

The SIMEAS fault recorder and the OSCOP P program for retrieving and processing records provide area-wide monitoring of power quality (PQ). Integration of the power quality recorder in the corporate WAN permits the time-optimized analysis of faults in the power supply and the implementation of countermeasures to clear them.

Fault record transmission

The SIMEAS R fault recorder and PQ monitoring system are set up so that one SIMEAS R 16/32 with the maximum configuration (4 VCDAUs) is installed in each substation and linked to the WAN.

Each SIMEAS R is connected to the communication network via the internal network card. SIMEAS R fault recorders are parameterized in callback mode. This means that after a fault is recorded, a call is placed to the appropriate server and the fault record is transmitted.

The special advantages

Data collection and server operation – centralized organization, decentralized execution

Data collection, i.e. the retrieval (gathering) and storage of data from the individual SIMEAS R fault recorders, is organized centrally. The data is retrieved by 8 servers that are installed in one station and connected to the WAN.

To ensure the highest degree of operational reliability, the server hardware is based on currently available technology. This means high computing power, a large RAM and, above all, a redundant storage system with backup functions.

Division of labor among eight servers

To make the transfer of fault records from a SIMEAS R recorder in the bay to the appropriate server in the station as fast as possible, the fault and mean value records are retrieved and distributed separately to the different servers. In concrete terms, this means that 4 servers are used exclusively for retrieving and storing fault records and 4 servers are used exclusively for retrieving mean value records. This ensures that the retrieval of a fault record will not be blocked by a simultaneous mean value record retrieval. In addition, sufficient storage space is available for the recorded values in the OSCOP P data base on the individual servers.

Automatic data retrieval and storage

The individual servers operate with OSCOP P in automatic mode. In other words, the servers automatically retrieve the fault and mean values from the individual SIMEAS R recorders and automatically store them in their data base.

Collection of mean values – easily implemented using PCs

PCs running OSCOP P in DAKON mode collect mean values from the individual SIMEAS Q mean-value recorders. They query the individual SIMEAS Q recorders via modems. At the other end (SIMEAS Q side), GSM modems are used.

Evaluation – when and where you want it

The fault records are evaluated by means of evaluation PCs connected to the server system via LAN. These PCs can be connected anywhere in the communication network, which also ensures that SIMEAS R can be parameterized from any point in the communication network. Whenever necessary, the evaluation PCs access the individual servers and retrieve the fault records for purposes of analysis.

Any number of OSCOP P clients can also be installed in the communication network. These clients have only read-access to the fault data stored in the servers. The system and devices cannot be parameterized from a client. This has the advantage that each user can access the data he or she needs.

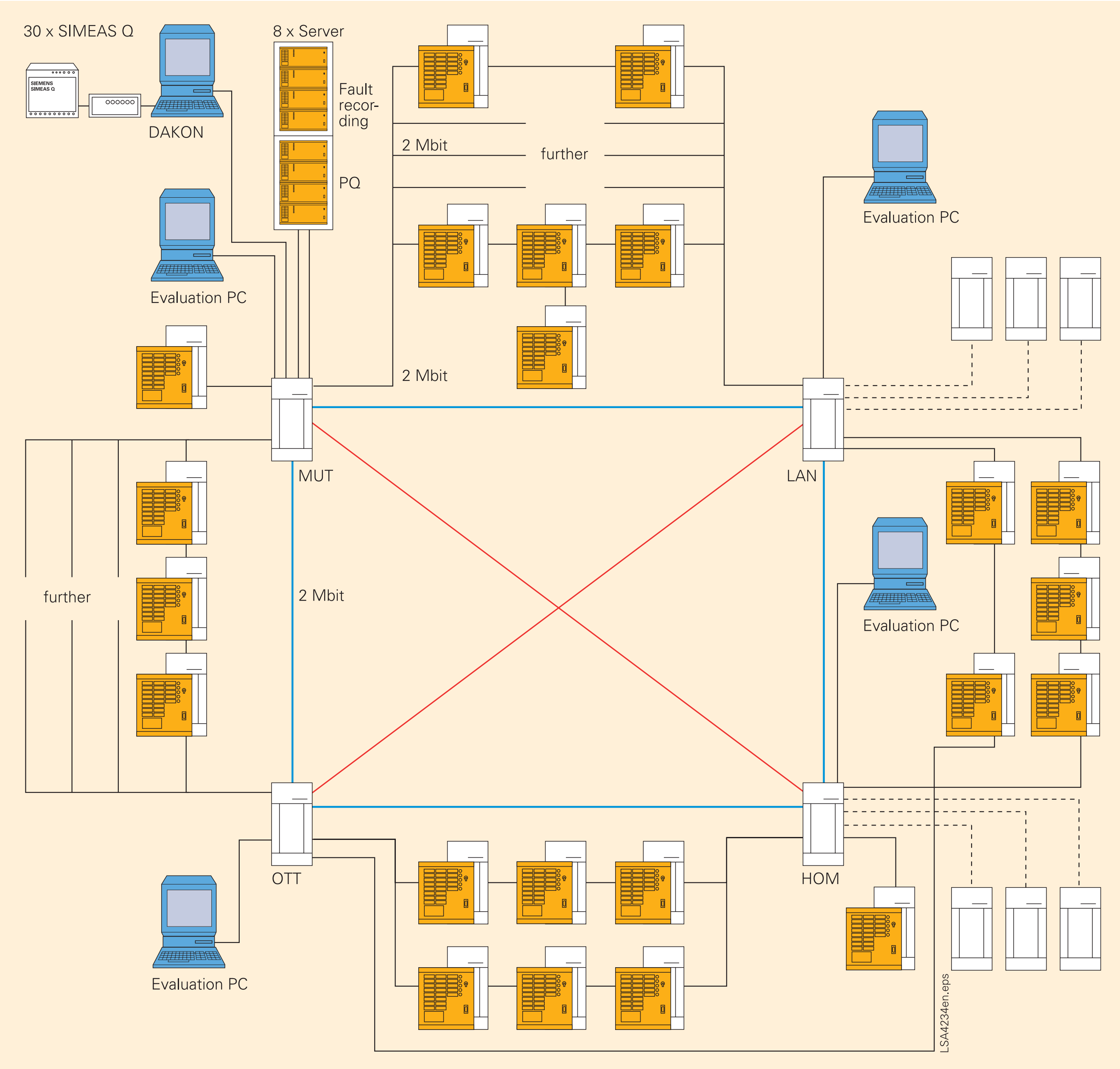

Fig. 3 System architecture of the SIMEAS R and OSCOP P fault recording system

System overview

- One SIMEAS R is installed in each substation and transfers its fault records and mean values to a central server via the WAN. In the maximum configuration, up to 60 SIMEAS R recorders can be connected to the system for monitoring the 110 kV and 20 kV level.
- Four servers (fault recording) are installed for handling SIMEAS R fault records and another four servers (PQ) for retrieving the mean values from the SIMEAS R and SIMEAS Q recorders.
- Most of the SIMEAS Q recorders are connected to a DAKON PC via a GSM modem. The PC transfers its mean values to the central mean-value servers. In the maximum configuration, up to 30 SIMEAS Q recorders can be connected to the system.
- Evaluation PCs are installed in the WAN for analyzing the fault and mean value records.
- SICARO PQ is operated in automatic mode for the purpose of analyzing power quality.

Conclusion

Competent support and consulting provided by the Siemens Power Transmission and Distribution staff – from the design phase to rollout – guaranteed Pfalzwerke an optimal solution based on the customer's requirements.

The particular challenge of this project was to integrate the fault recorders into an existing WAN. The most important consideration was the amount of time it took for a fault to occur, be recorded, be transmitted and, finally, for the fault record to appear on the screen. Based on the tests performed on the customer system, all parties came to have full confidence in the performance and reliability of the solution offered.

The SIMEAS R and OSCOP P fault recording system provides Pfalzwerke AG with a uniform system for monitoring and analyzing power quality. In addition, its modular design sets no limits on future expansions.

Intelligent Technology Provides Optimal Data Security

Monitoring the data center of the DEVK insurance company in Cologne

■ The company

DEVK is one of the largest insurance companies in Germany, offering all types of insurance policies as well as investment services for real property and securities. Over three million customers in Germany rely on DEVK's services.

■ The starting situation

All the company's business processes converge in the central data center in Cologne, where information is stored and evaluated. DEVK has engaged Siemens PTD Power Automation Division to protect the company's servers and backup system from failure of the power supply.

■ The concept

Continuous power supply is ensured by SIMEAS R, a system developed by PTD Power Automation Division. If the municipal power supply fails, an uninterruptible power supply (UPS) with two redundant 125 kVA battery banks initially provides power to the server. At the same time, a diesel generator starts, which normally takes over the full load within 60 seconds.
A special device monitors the charge state of the batteries of the UPS system, allowing users to detect problems with the batteries early and take countermeasures quickly.

Installing a digital fault record system with SIMEAS R is ideal for documenting all power supply problems that occur during operation. SIMEAS R can continuously measure and log the course of voltages and currents at the medium-voltage level (10 kV) and also at the low-voltage level at the output of the UPS system. The system can record exactly the effects of external short-circuits near the location, and analyze the impact of the resulting voltage dips on the UPS system. It also monitors the UPS system to determine whether every changeover from the outside supply system to the UPS system takes place without interruption.

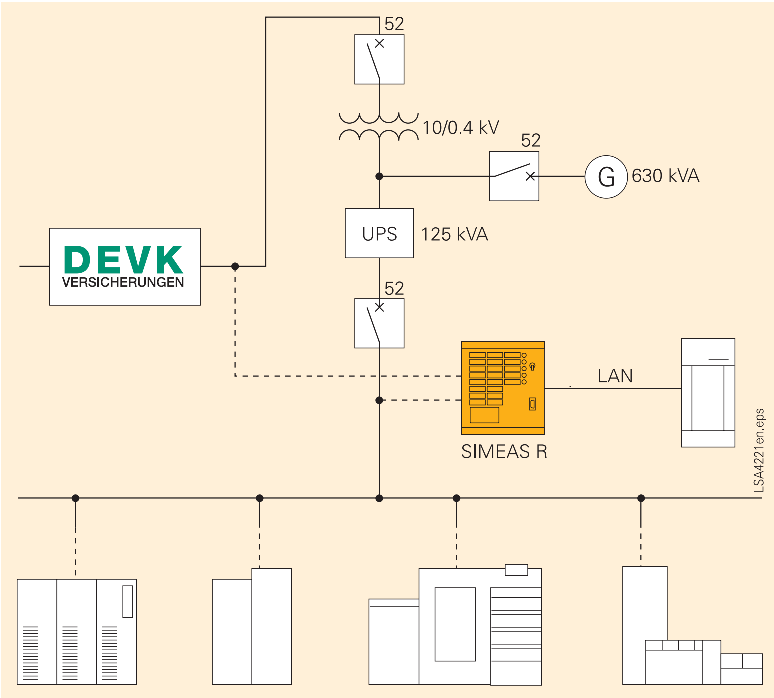

Fig. 1 Block diagram of installed UPS and emergency generator

Fig. 2 Diesel generator at DEVK

The special advantages

Task distribution according to competences

One of the technicians' tasks at DEVK is to keep the data server and the backup systems running smoothly. However, the technicians can neither control the quality of power supply from the municipal utilities company nor the UPS system. Analyzing the data from the SIMEAS R requires a great deal of experience, which the DEVK engineers do not have yet and – due to cost-related reasons – do not plan to build up.

In response, DEVK hired ewz (Elektrizitätswerke Zürich, Zurich electricity utility) to take over analyzing the SIMEAS R data. This arrangement allows each partner to concentrate on its own strengths, creating a real "WIN-WIN" situation: ewz retrieves the SIMEAS R data using a modem connection, while DEVK continues to retrieve the same data via the Ethernet interface and store it on its own PC. As a result, the DEVK technicians can concentrate on rapid fault clearance, while ewz analyzes the data to determine the exact cause of the fault. ewz provides its reports to the DEVK technicians immediately. According to all participants, only the fault recorder system "SIMEAS R + OSCOP P" met the necessary technical requirements.


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Fig. 3 DEVK data center

Conclusion

SIMEAS R made it possible to ensure permanent monitoring of the power supply, guaranteeing and protecting the functioning of DEVK's data bases and the data center. Distributing the tasks according to expertise not only brought about quick and smooth commissioning of the system, but also reduced DEVK's costs significantly.

Moving Securely into the Future

Area-wide fault recording using state-of-the-art technology

■ The company

As the largest power supply company in the region delivering power to the greater Nuernberg area, N-ERGIE supplies electricity to about 650,000 customers. Each year, N-ERGIE provides an average of 7,300 million kWh of power to a 7,500 km^2 service area.

■ The starting situation

As an operator in its service area, N-ERGIE needed a state-of-the-art, cost-effective method for recording faults in order to ensure reliable power system management. Because the hardcopy recorders currently in use were both maintenance- and labor-intensive, N-ERGIE was looking for a future-oriented fault monitoring system. They had complete confidence in the expertise and technology of Siemens PTD Power Automation Division.

■ The concept

The only way to efficiently reduce maintenance and operating costs is through the automatic monitoring of power transmission equipment. To ensure reliable power quality monitoring for the entire service area, N-ERGIE will employ 48 digital SIMEAS R fault recorders and 35 existing OSCILLOSTORE P531 fault recorders in the medium- and high-voltage power systems. In addition, state-of-the-art recording technology will support research into the causes of faults and failures in the power supply system.

■ The special advantages

Detection of power anomalies

Detailed fault records can now be used to obtain additional, important information on the fault history, even in the case of complex error profiles, thus permitting targeted research into the fault's origins and providing a basis for effective prevention.

Support for fault clearance

Information supplied by the recording system directly supports fault clearance experts in localizing the fault. Resultant costs are significantly reduced when the location and origin of a fault are quickly pinpointed.

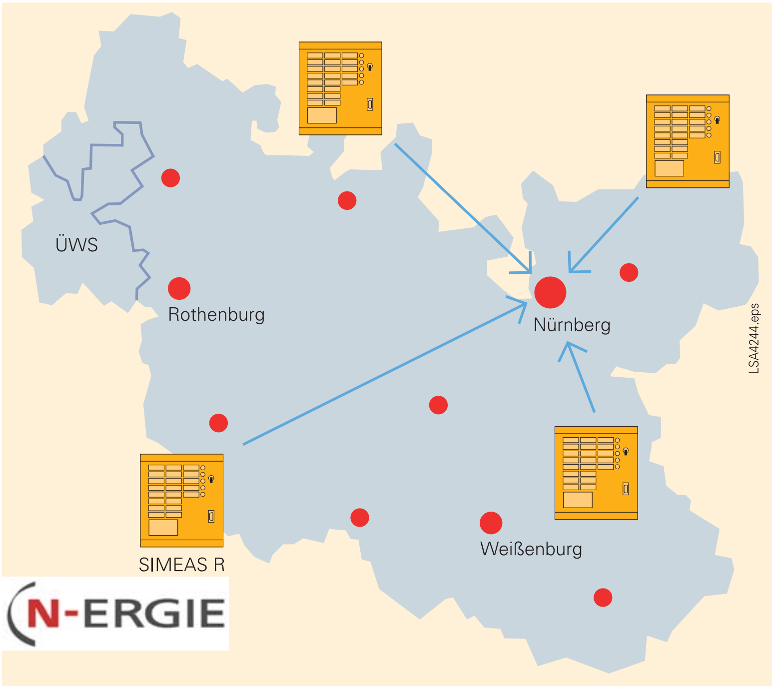

Fig. 1 Service area of N-ERGIE

Load forecasts

The mean-value recorder generates daily, weekly and even annual load curves. The values derived can serve to generate a much more precise forecast for the future – a money-saving advantage when purchasing power.

Protection monitoring

Older substations in particular still have protection relays without fault recording or without long-distance transmission capability. Any information on the cause and history of the fault is completely lost. In such cases, SIMEAS R recordings may be used to verify the correct functioning of the protection relays, e.g. correct tripping behavior/tripping time of the relays.

Additional benefits are achieved by swapping out fault records to the COMTRADE format. This general standard makes it possible, for example, to perform additional tests using Omicron test equipment. Analyses from the fault records also yield important information for optimizing equipment.

Four integrated recorder functions and decentralized data storage mean faster access to all essential data in the event of a fault. Only SIMEAS R can handle such high volumes of data, thanks to its data compression procedure. And excellent system integrity ensures that the extreme ambient conditions under which power is supplied are always taken into account.

■ From practical experience

This section describes the sequence of events and exact fault detection process for a complex fault recorded by an OSCILLOSTORE P531. A single-phase-to-earth fault on L3 developed into a two-phase-to-earth fault between L2 and L3:

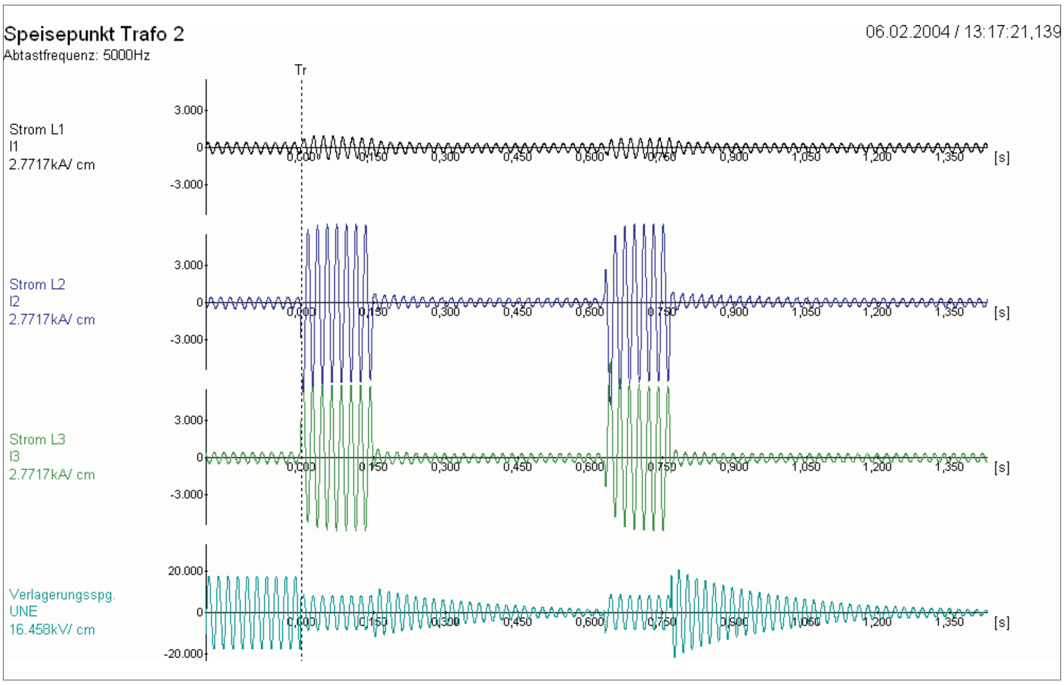

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Fig. 2 Fault record of a complex disturbance

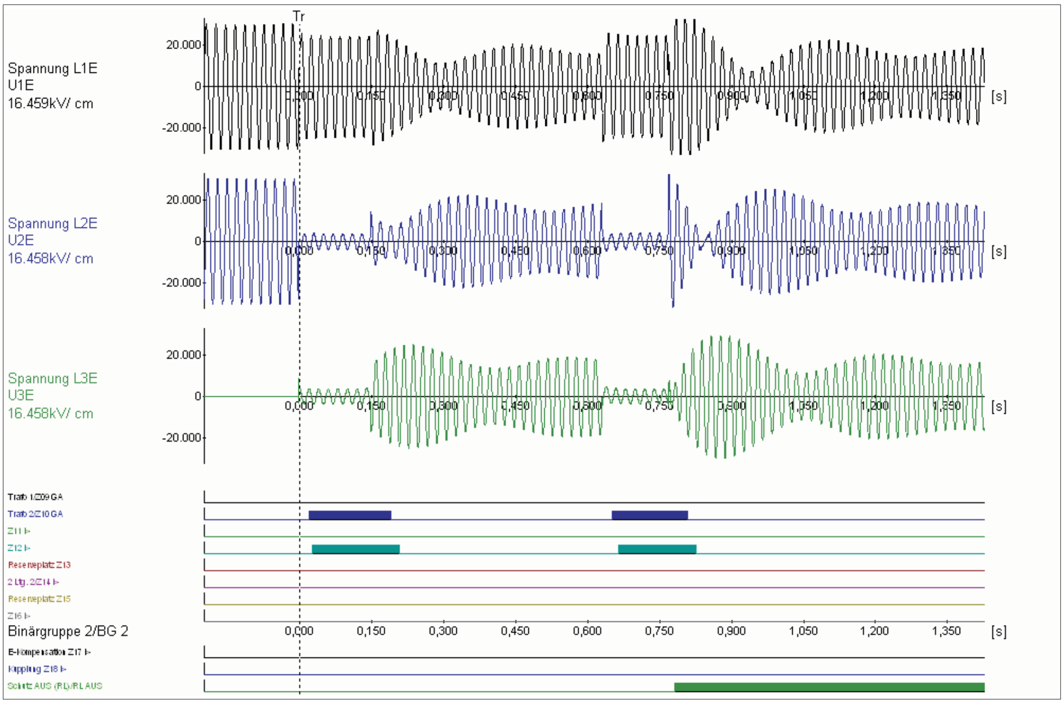

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Fig. 3 Example of a fault record

Procedural description

1. Background: Single-phase-to-earth fault on L3, U_{3E} suffered a near total breakdown, U_{1E} and U_{2E} increased by the cube root to approx. 21.3 kV. The displacement voltage U_{NE} rose to 12.5 kV.

2. A two-phase-to-earth fault between L2 and L3 was added (time on trigger line Tr), short-circuit current approx. 4.7 kA. Both the electromechanical distance protection (overcurrent tripping) in the relevant outgoing feeder in bay 12 and the higher-level numerical distance protection (impedance tripping) in the incoming transformer feeder in bay 10 were tripped (see binary traces).
   Feeder protection was tripped instantaneously (approx. 140 ms) and reclosed automatically (duration approx. 460 ms). During this time, the short-circuit current was interrupted and only operating current continued to flow through the remaining system (approx. 400 A).

3. Auto-reclosure (AR) was followed by automatic connection. However, the fault was still present. Both the feeder protection and the higher-level transformer distance protection were re-tripped (see binary traces).
   The outgoing feeder was then instantaneously (approx. 120 ms) and finally tripped (failed AR) – see binary trace protection AUS of the loop feeder (LF).
   This fault recording system is the best way to test the functioning of the electromechanical protection system.

■ *Conclusion*

Lightning-fast detection and correction of faults has not only increased end user satisfaction but has also saved N-ERGIE money. Unique product features such as automatic data transmission and system management, the advantages of a high sampling rate and resolution, and the high-quality, user-friendly software for fault records have all contributed to the complete success of SIMEAS R. The extensive expertise of the Siemens project managers was decisive in achieving the high degree of customer satisfaction.

Quality in the Power System

The fault and power quality recording system at CFE

■ The company

The Comisión Federal de Electricidad (CFE) is a state-owned utility in Mexico. It is responsible for generating, transmitting, and distributing electrical energy for over 21 million customers. CFE also allocates energy to regional power distribution companies such as Luz y Fuerza in the Mexican Federal District.

Because of undefined power system disturbances and limit violations, CFE operates an extensive power quality system. This system stretches from the northern Baja California Peninsula region to the southern Yucatan Peninsula region.

■ The starting situation

Currently, CFE has an equipment pool of 173 digital fault and power quality recorders (SIMEAS R), 40 fault recorder systems (OSCILLOSTORE P531), and 4 data concentrators (DAKON). To date CFE has operated the installed fault recorders in off-line mode.

Operating the fault recorders in isolation requires each CFE agent to have a laptop with its own OSCOP P license, resulting in many single-user licenses and thus higher costs. Data transfer takes place manually and remote data transmission is not available.

Fig. 1 CFE at a glance

Fig. 2 Overview of the CFE regions with an installed SIMEAS R digital fault and power quality recorder

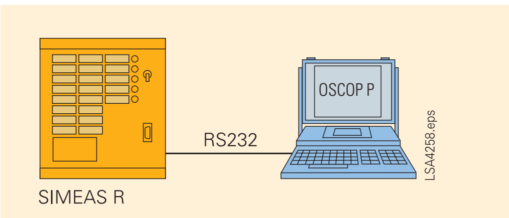

Fig. 3 Fault recorder in off-line mode operation

The concept

CFE and Siemens Mexico collaborated to develop a concept that met the following requirements by the customer:

- Quickest possible fault analysis
- Central data management
- Central parameterization
- Integration into the existing communications infrastructure

The challenge was to install 16 analog channels (8U/8I) in one central unit – a special requirement influenced by the American competition.

Automatic data collection and processing

The fault records of the analog and binary channels are recorded in the individual systems by the fault recorders (SIMEAS R) and automatically collected and processed in a data concentrator (DAKON).

Flexible access

The DAKON is an industrial PC to which several SIMEAS R and numerical protection relays can be connected. The fault recorders can connect to DAKON using either fiber-optic cable or a LAN. The DAKON also provides the option of remote access from regional evaluation stations. Normally this access relies on the communications structure the customer provides, which in most cases consists of an analog telephone network (see Fig. 4).

Real-time synchronization via GPS

In the DAKON, parameters (OSCOP P software) define which information from the fault recorders should be automatically transmitted. Real-time synchronization is necessary so that the data recorded at the various points can be allocated clearly to each fault event. CFE decided to install synchronization using GPS (global positioning system) receivers. High-precision real-time synchronization allows users to compare the logs of the connected fault recorders with those of the protection relays from different locations.

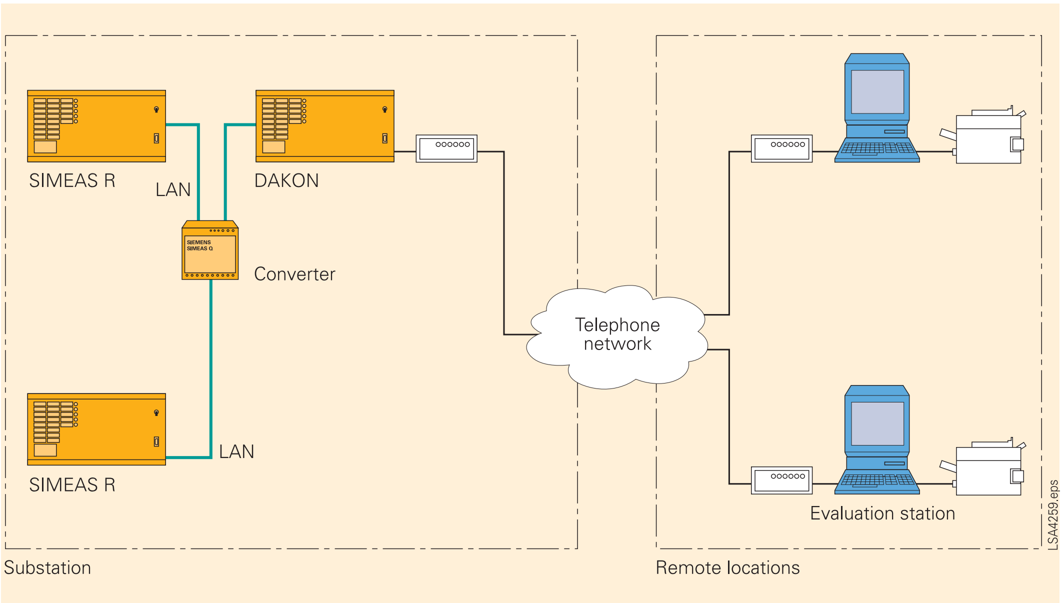

Fig. 4 System concept

The special advantages

Always flexible

The SIMEAS R is a multifunctional recorder with the following basic functionalities:

- Fault recorder
- Power/frequency recorder
- Round-the-clock (digital or mean value) recorder
- Message printer
- Voltage dip recorder

Of these five functionalities, CFE primarily uses the fault recorder.

Optional add-on package

In addition, CFE acquired the optional add-on package for OSCOP P. This software module (DIAGNOSE) enables automatic calculation and reporting of the fault location on a line.

Conclusion

The comprehensiveness of the SIMEAS R and OSCOP P fault recording system provides CFE with a uniform system with no limits to further extensions. The profound know-how and expertise of the local Siemens project managers was decisive in achieving the high degree of customer satisfaction.

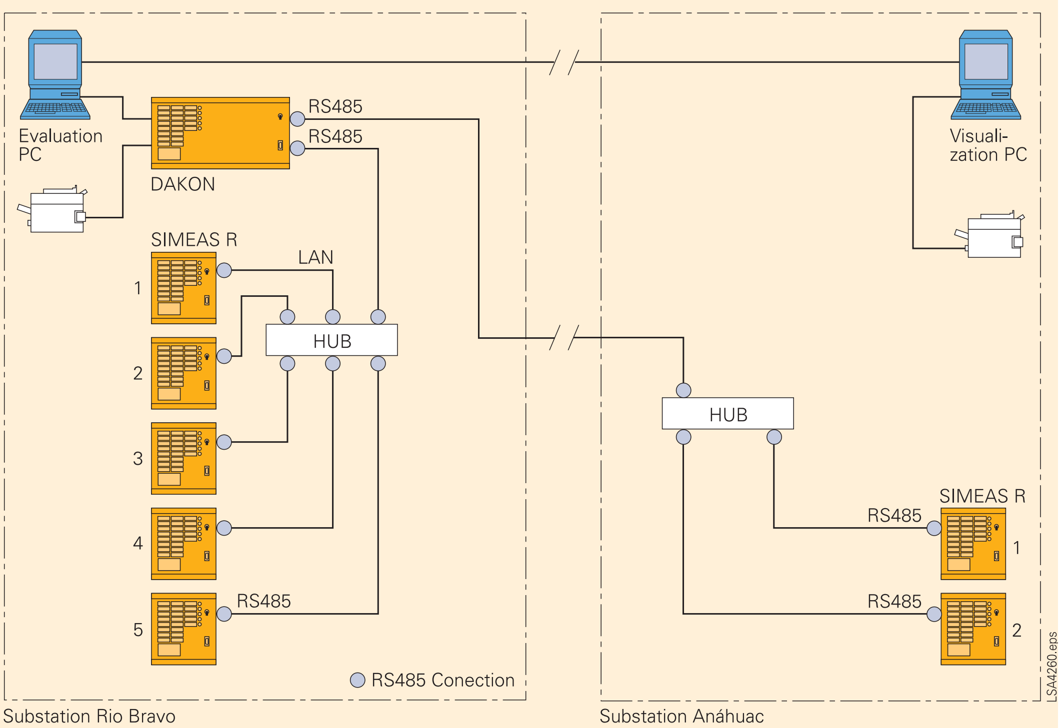

Fig. 5 Example of a system configuration for the substations in Rio Bravo and Anáhuac

Workflow Efficiency from Start to Finish

The energy business with electronic processes (e-procure)

The company

E.ON is the world's largest private energy services company with sales of over EUR 46 billion and about 66,000 employees. The company is clearly focused on its core businesses of electric power and gas. E.ON Energie is one of Europe's largest energy services companies and is active in nine European countries. Its 16 million customers rely on E.ON Energie for their daily supply of electricity and gas in the Netherlands, Hungary, Czech Republic, Switzerland, Italy, Poland and other countries.

The starting situation

Deregulation and related unbundling activities in the energy industry have led to changes in purchasing processes (smaller units, network breakups, etc.) As a result, there is a growing demand for increased availability of electric power systems (along with reductions in personnel and inventories), which means that replacement parts must be made available faster.

The concept

These developments inevitably require the optimization of procurement processes in the energy industry. The rapid development of Internet technology in combination with economical networking - even of widely different IT systems as well as corporate ERP standards (Enterprise Resource Planning) - now make this possible. Customary procurement channels for goods and services can therefore be drastically shortened and order handling costs can be reduced.

Such integrated B2B solutions are designed mainly to optimize order handling both for the customer and the supplier. The entire purchasing process, from planning to procurement and from order approval to invoicing, is performed automatically on the Internet or Intranet.

A decision regarding the use of Internet-based procurement solutions depends principally on the ordering process costs, the ordering frequency and the number of suppliers involved. E.ON had already integrated the electronic procurement process for so-called "C items" (not directly required for production) into the SAP system and used it successfully in electronic ordering. This resulted

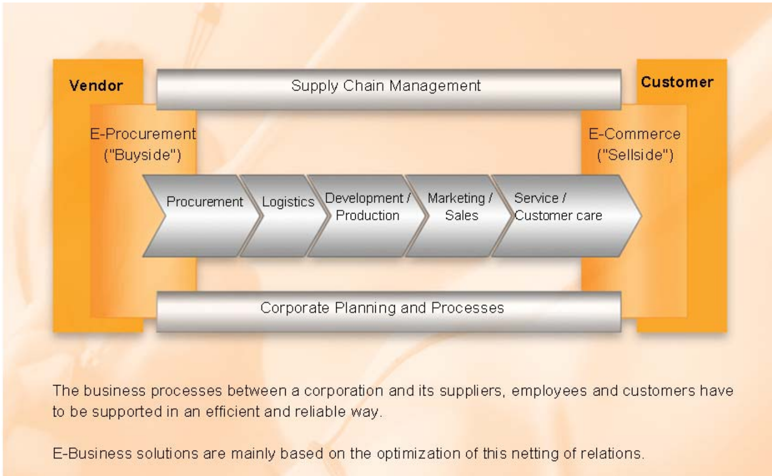

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Fig. 1 Procurement process chain

in a significant decrease in the high administrative and purchasing costs, which often exceed the actual value of such items.

Of course this approach doesn't need to be limited to typical "C items. " So it made sense to apply this solution to other areas as well, to make ordering easier for the "end user" in purchasing and in the services area.

One requirement for expanding the use of this solution is the generation and integration of electronic product catalogs. The challenge in electronic integration is in the details.

Because the energy industry in particular tends to need complex products that are tailored to particular requirements and specified or configured for various applications by an engineer. In the past, needed products were selected from a catalog by the engineering department and recorded in special Excel lists. Only then was a request conveyed to the appropriate purchasing function.

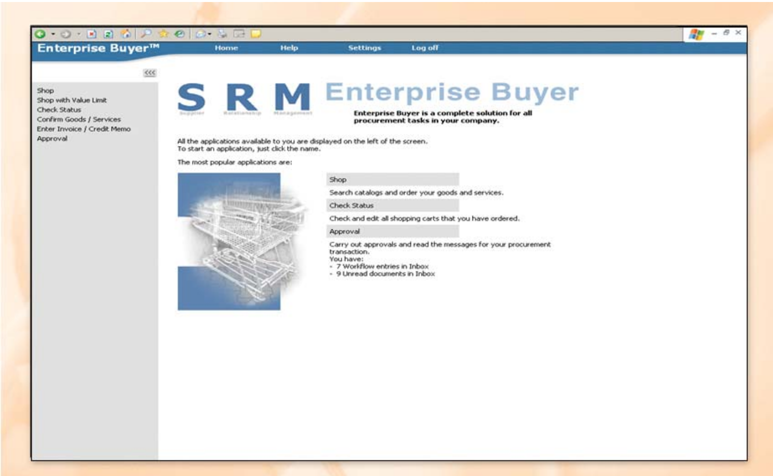


Fig. 2
SAP purchasing portal

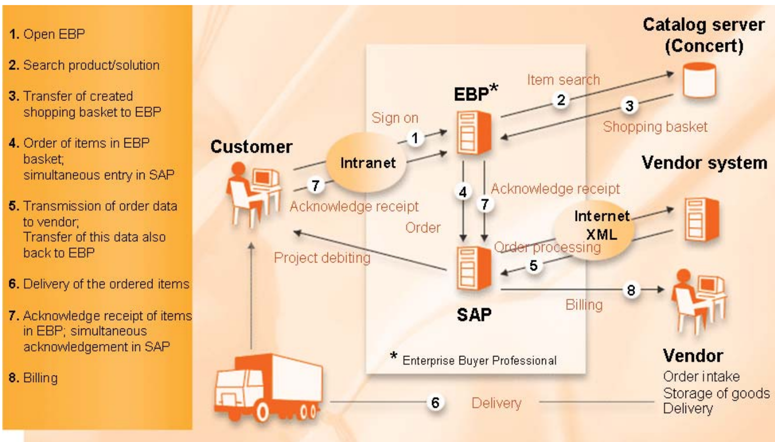
The creation of a configurable electronic product catalog by Siemens PTD PA enabled E.ON to expand the already successfully implemented electronic solution for "C items" to these more complex products. E.ON's objective in integrating the catalog into its SAP system was to electronically integrate all steps in the purchasing process into this SAP System and to eliminate any media discontinuities (product catalog, notepads, Excel lists etc.) as well as manual interactions.

■ *The special advantages*

E-collaboration: The ordering party (buy side) and supplier (sell side) always collaborate electronically.

E.ON has succeeded, in conjunction with Siemens PTD, to establish an e-collaboration system between the two partners. To achieve this, two teams were created (buy and sell side) that worked together closely to define and implement this customer's requirements. The link between the two systems was then established swiftly, and the implementation of the solution was completed with a four-week trial run in January 2004.

Fig. 3
Integrated ordering process description, B2B solution



The integration of the product catalog by Siemens PTD has reduced the workload for participants on both sides and substantially shortened the turn-around times of orders. All processes related to procurement are now handled electronically. E.ON employees can configure and buy products they need directly from their desk now - without leaving the internal SAP system!

What's more, E.ON engineers can electronically access any information for the entire Power Automation product line. They can for instance select and order combinations of customer-specific products online. The required approval and release functions are integrated into the system and performed online in order to assure the necessary transparency of the ordering processes. Time-consuming request procedures in other systems or application changes are no longer needed. An encrypted link ensures maximum data security.

Unique in this solution is the exchange of current information directly over a cost-effective Internet link between the master product data stored at PTD PA and the installed SAP Enterprise Buyer System. As the Buyer in this system, E.ON has access to the very latest PA product information, configuration schemes, drawings, technical descriptions, customer-specific prices and agreed-upon commercial conditions via its purchasing system. Consequently, the Buyer has around-the-clock access to all relevant information.

Due to the electronic interface between the SAP system at E.ON and the certified SAP interface in the Siemens system, the order entry at this end is also performed in electronic form directly in the SAP system and can be processed immediately: Another advantage, which not only helps cut costs but also minimizes keying errors during order entry, speeding up the ordering process.

The entire ordering process chain now runs electronically and interface-free. As a result, product selection is simplified and the process takes much less time.

■ *Credit process replaces invoicing*

To further simplify the process, E.ON uses a credit method in payments for B2B orders. A defined budget is agreed upon with the supplier as a framework for orders to be placed by the customer side. What sets this approach apart is that Siemens, rather than the customer, monitors the budget limit and informs E.ON when the agreed-upon budget is reached. So it is the supplier who keeps track of the budget. Siemens benefits by the transparency of the order volume that can be expected over a given period of time.

■ *Conclusion*

A key argument for the integration of the PTD product catalog was the opportunity to not merely integrate static product data but to also interactively configure the desired products specifically for the intended application. The resulting product selection with the agreed-upon pricing is immediately displayed to the buyer in the SAP System and directly processed online. As a result, the project manager obtains a precise view of the required budget early, i.e. at the time of the product selection. A key advantage, since tracking the budget is important, in addition to tracking the availability of electrical equipment.

With this system, E.ON can now order online, through its own SAP system, any SIPROTEC relays it needs - always with the very latest data at hand. The company predicts significant cost savings due to the simplified ordering process. During the introductory phase, E.ON still pegged the internal order release limit in its SAP system at an order value of EURO 10,000.00. This limit is individually adjustable and will soon be increased. The objective is to process all E.ON orders to Siemens Power Automation Division by this electronic method.

Since this approach is so new here, potential savings can only be put in perspective by referring to other B2B processes: Typical savings in the required transactions are in the range of 15 % to 20 %.

The advantages on both the customer side and the supplier side relate to the simplified ordering process.

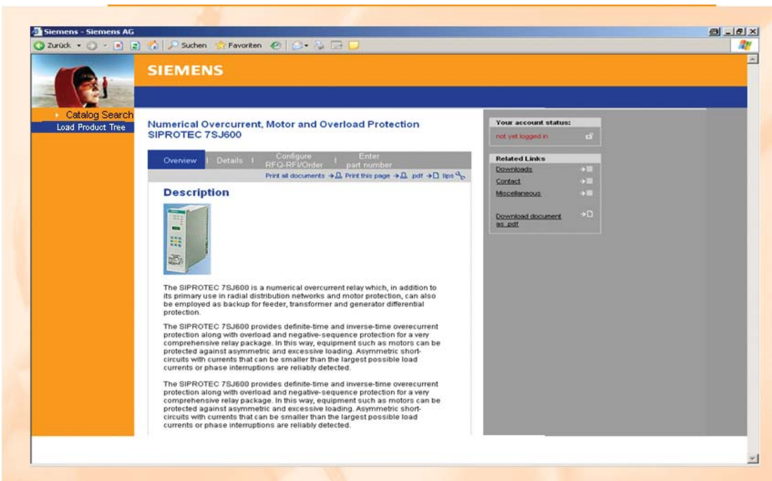


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Fig. 4 PTD PA product information

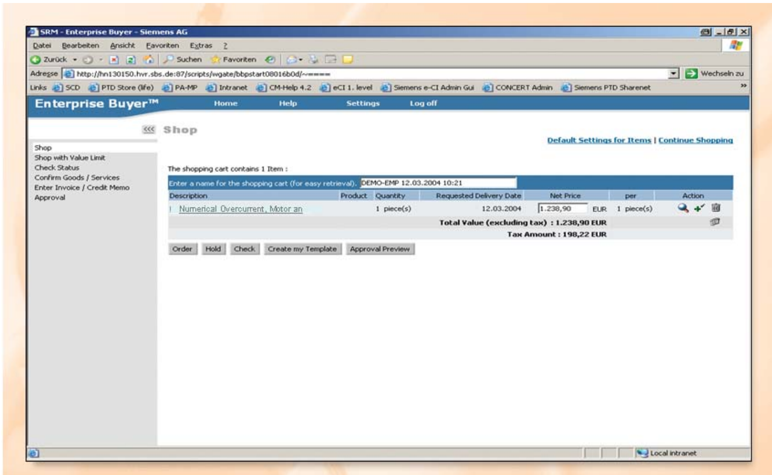

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Fig. 5 SAP purchasing portal, shopping basket function

Specifically as a result of:

- Measurable process improvements
- Always up-to-date product data
- Supplier-side data maintenance
- No waiting for product information, selection or pricing
- Visibility of the complete product line

With this approach, E.ON receives all the required information to configure currently needed products within its own purchasing System - without leaving this System or having to change to other applications - and to place the entire order directly online in its SAP System in accordance with agreed-upon conditions.

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