ABB Network Partner

PYRAMID
Substation Automation
The total coordinated protection and control concept

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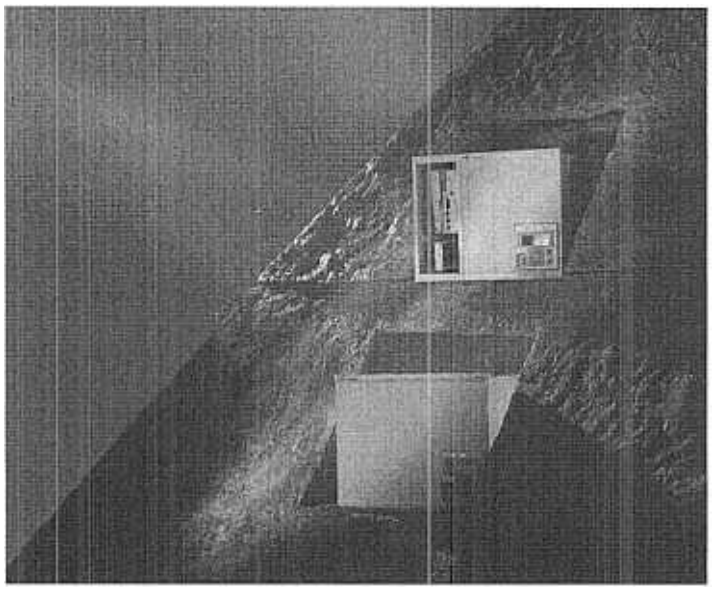

Features

- **Protection for all applications**
- **Control with flexible system functions**
- **Communication with fibre optics**
- **Self-supervision and diagnostic**
- **Support of hardware and software**
- **State of the art microprocessor technology**
- **Distributed intelligence**
- **User-friendly work places**
- **Improved performance and availability**
- **Step by step implementation**
- **A total substation automation concept**

Application

General
PYRAMID® Substation Automation includes, as a part of the Panorama Concept, a complete range of flexible object terminals, functional substation control and substation monitoring systems. All of the building blocks are based on state of the art numerical technology, compatible with conventional equipment. The new, improved technology can thus be implemented step by step from stand-alone protective relays to complete coordinated protection and control systems. The blocks included in PYRAMID® Substation Automation can be used as stand-alone protection units or be building blocks in a complete Substation Monitoring System (SMS), Substation Control System (SCS), and Relay Testing and Simulation System (RTS).

ABB can offer a comprehensive range of numerical protection terminals for generation, transmission, distribution and industry. These state of the art products offers many new possibilities. Communication of load and fault data gives a new dimension to protection and control. PYRAMID® Substation Automation even allows the connection of existing or new static/electromechanical relays. However the information from these relays is limited to data from signal contacts included in the relays.

Separate transducers of voltage and currents can however be added to conventional relays.
By this arrangement both existing relays and new numerical relays can communicate via a common fibre-optic bus. This makes PYRAMID® Substation Automation suitable for partial retrofit as well as completely new installations.

PYRAMID® Substation Automation has four corner stones:
- Protection
- Communication
- Control
- Self-supervision

One of the main advantages of PYRAMID® Substation Automation is that it may include building blocks from various product ranges and generations. High performance and total quality are the major requirements for each building block.

Continuity for old and new products including openess for the future such as for new sensors or intelligent switchgear.

PYRAMID® Substation Automation enables efficient power network management by providing modular solutions for protection, control, monitoring and communication for substations.

Application (cont'd)

Substation Monitoring and Control Systems
User-minded design and functional interface are the two main requirements for the man machine interface (MMI).

The information is structured for operation in the substation control system (SCS) and for evaluation in the substation monitoring system (SMS). SCS provides fast information/action such as event recording and switchgear control. The operator's workplace is adapted for safe and reliable communication between the operator and SCS.

The engineer's workplace, which can be a stationary or portable PC (local or remote) is a new tool to assure fast analysis of disturbances. Windows based evaluation software such as REVAL and RESDA save-time and produce user friendly reports. Other software packages, for example CT CURVES, a tool for making selectivity plans for distribution systems and RCALC simulation and setting calculation program for transmission, can be included.

A two-level communication structure
The entire substation is controlled and supervised from the higher station level, while individual lines, transformers, etc. are controlled and protected from the lower bay level. A number of dedicated control and protection terminals are provided for bay level control. This structure simplifies future expansion; i.e. the installation of additional bays.

The distributed structure increases the availability, because an internal fault will affect only a small part of the equipment. Since the most important functions are located at the bay level, the operation of a bay can be maintained even if an internal fault occurs at the substation level. The equipment for each bay is housed in one or more cubicles which can be assembled and tested at the factory. This reduces on-site erection and commissioning work. Information is transferred between the two levels via a serial station bus.

Station-oriented signal collection and the serial transmission of information between the two levels considerably reduces the amount of cabling required. Disturbance free transmission has been achieved by using a fibre-optic bus.

ABB has the experience
Over the years, ABB has designed and manufactured protective relays and control equipment for substations in power transmission and distribution systems. The experience thus gained has served as the basis for designing modern numerical protection and control equipment which can ensure more efficient and reliable operation.

The first commercial microprocessor-based control system was installed by ABB in 1983. Since then, ABB has delivered numerous systems throughout the world. This unique experience has been very valuable when designing the building blocks of PYRAMID® Substation Automation.

PYRAMID® Substation Automation functions: Overview

Man machine interface (MMI):
- Operation of power equipment (switchgear)
- Data presentation
- Engineer's support
- Supervision

Remote control interfacing:
- Adaption for serial communication with control centres via various protocols

Automatic functions and control sequences
- Interlocking of switching devices
- Synchrocheck function
- Tap-changer control for voltage regulation
- Load transfer for parallel transformers
- Switching sequences
- Local power restoration
- Autoreclosing
- Control of reactive power
- Application programs

Data acquisition and handling:
- Remote data acquisition
- Data evaluation
- Energy measurement
- Event list
- Alarm list
- Reports
- Printed output: event logs, reports
- Disturbance recording

Condition monitoring:
- Gas density monitoring (GIS)
- Supervision and self-diagnostics
- Circuit breaker monitoring
- Temperature monitoring

Protection functions:
- Generator protection
- Line protection
- Bus protection
- Transformer protection
- Feeder protection
- Motor protection

Protection Terminals
The PYRAMID® Substation Automation provides a full range of numerical protection terminals with communication to SMS or SCS.
Depending on the application each terminal with communication is named according to the following designation system, "REQ 000".

Transmission line and cable	REL 000
Bus and breaker	REB 000
Transformer and reactor	RET 000
Generator	REG 000
Distribution, line and cable	REF 000
Auxiliary and single function	RER 000
Multipurpose and special appl.	REX 000
Monitoring, reclosing and synchronizing	RES 000
Control and communication	REC 000
Test equipment	REY 000
Motor protection	REM 000

The last letter indicates the terminal type, e.g. L for Line and G for Generator. The three digits indicate hardware configuration and in what series the terminal is designed.

For distribution and industry the relays from the SPACOM range with communication are named "SPAQ 000".

Current	SPAJ 000
Voltage	SPAU 000
Protection and control	SPAC 000
Differential	SPAD 000
Generator	SPAG 000
Motor	SPAM 000
Signal	SACO 000

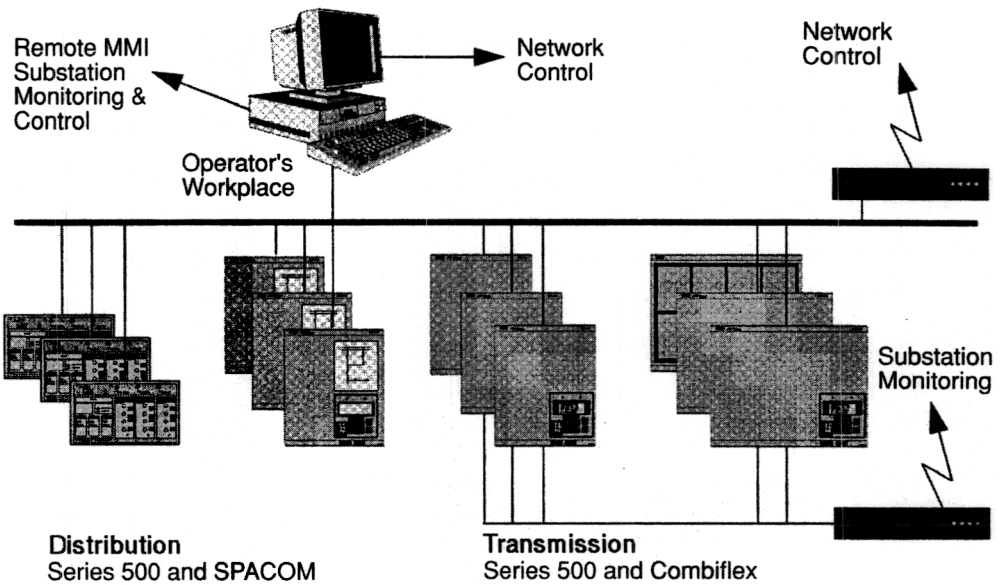

Fig. 1 PYRAMID® Substation Automation, total coordinated protection and control for a substation

Series 100
Modular Terminals
Each module is based on rack mounted printed board assemblies with dedicated microprocessors for each function. The modules can be reused and combined in different terminal configuration and divided in two subsystems. Analogue auxiliary functions can be added in a separate rack.

Series 100 is based on existing stand-lone RL relays for transmission and generation and existing SPACOM relays for distribution. These relays can be used both as stand-alone protections or as terminals with communication to SMS and/or SCS. The 100 number series is used to describe different hardware combinations of each terminal.

Series 200
Multi Terminals
The same terminal can be used for more than one object and various functions. The selection is made in the software and choice of CPU capacity.

Series 200 is dedicated to complex applications which require many functions included in one hardware module.

Series 300
Compact Terminals
Each terminal is mounted within one compact case which also has all interfaces. The function selection is made in software and internal hardware. Series 300 includes the previous MODURES 316, WRELCOM and SPACOM compact terminals.

These units can also be supplied stand-alone or together with an SMS or SCS system.

Series 400
One Object Terminals
Each terminal is based on modules configured in a complete terminal for protection and control of an object.

Series 500
Universal Terminals
The 500-series is the latest serie in state-of-art-technology terminals for protection, control and monitoring. A common hardware platform is used.

Application (cont'd)

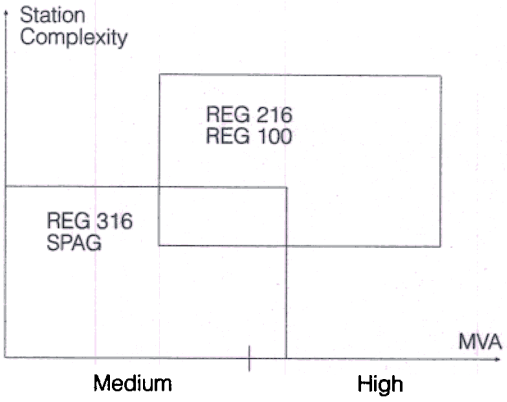

Fig. 2a Generator protection terminals

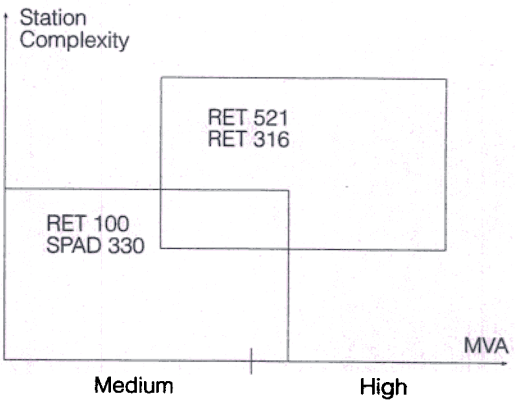

Fig. 2b Transformer protection terminals

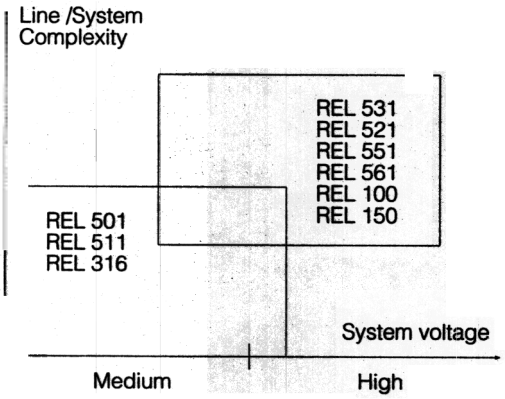

Fig. 2c Line protection terminals with micro-processor based distance functions

The REL 100-series includes high performance transmission line modular terminals for high voltage and extra-high voltage applications. The four-zone distance relay is provided with fault-location, system-supervision and earth overcurrent functions. Reclosing and disturbance recording can be implemented.

The following terminals are available with trip relay, test switch and communication.

REL 100	RELZ 100
REL 110	RELZ 100 + REXA 101/103
REL 120	RELZ 100 + RCRA
REL 130	RELZ 100 + REXA 101/103 + RCRA
REL 140	RELZ 100 special/order specific
REL 150	REZ 1
REL 160	REZ 1 + REXA 101/103
REL 170	REZ 1 + REOR 100
REL 180	REZ 1 + REXA 101/103 + REOR 100
REL 190	REZ 1 special/order specific

The third figure in the series is used to designate 1Ø or 3Ø, e.g. REL 111 is used for RELZ 100 + REXA 101.

The REG 100-series includes generator modular terminals. The generator protection units can be divided into sub 1 and sub 2 for maximum redundancy. Disturbance recording can be implemented.

REG 100	Generator protection terminal (basic)
REG 110	Generator back-up protection terminal (with underimpedance function)
REG 120	REG 110 + REOR 100
REG 150	Generator primary protection terminal (with high impedance differential)

The REB 100-series includes bus and breaker failure protection. REB 100 is based on the well known ultra-high speed differential measuring method used in RADSS. This allows CT-saturation as well as sharing of CT-cores with other protections. One 19" 6U rack can adapt 12 lines with test switch and 18 lines without. In an additional rack 11 breaker failure units can be included.

The REOR/RCRA 100-series includes disturbance recording modular terminals for high voltage and extra-high voltage applications. The object-oriented monitoring provides excellent, cost-effective event and disturbance recording for both local and remote post-fault analysis.

Communication to a local printer, local PC or remote PC is possible. With the communication program RECOM and evaluation program REVAL both data compression and data evaluation are available. Automatic disturbance evaluation is provided with the expert software RESDA.

The REY 100-series includes Relay Testing and Simulation System for HV and EHV applications

REY 100	FREJA basic unit
REY 110	FREJA with hard disc
REY 120	FREJA simulator with 15 A peak
REY 130	FREJA simulator with 75 A peak

Series 200 multi terminals
Each multi terminal consists of rack-mounted CPU's with auxiliaries. The terminals have unique flexibility - a large number of software modules are available for system adaption. The terminal can be used for more than one object by selecting pretested software modules and the appropriate CPU capacity.

REG 216/RET 216 is designed for generator and transformer applications. A complete generator transformer block protection unit, including disturbance recording, can be accommodated. It can be divided into sub 1 and sub 2 for maximum redundancy. A personal computer can be used for the on-site configuration and setting of the software library provided.

REG 216	MODURES 216 for generators

Series 300 compact terminals
Each compact terminal is housed in a compact case with all interfaces. The compact terminal is provided with pretested software modules, and hardware modules for system adaption. The compact terminal can be tailored on-site for dedicated application. The following relay protection units are available in the 300 series for high voltage applications.

REL 316	MODURES 316 LZ distance incl. options
RET 316	MODURES 316 TD differential incl. options

For distribution, the following compact terminals are available from the SPACOM range which can communicate with SCS and/or SMS

SPAC 300	Feeder protection and control
SPAG 300	Protection for small generators and motors.
SPAD 300	Transformer differential protection
SPAU 300	Voltage protection
SPAJ 300	Current protection

Series 400 one object terminals
These terminals consist of combinations of individual modules for protection and control of one object. The terminals are object oriented for maximum redundancy and reliability.

Combining different measuring principles in the same terminal for main 1 and main 2 does not interfere with the bay orientation. Analog measuring microprocessor relays can be easily accommodated together with numerical measuring relays and disturbance recorders for high-performance protective relaying.

PYRAMID® Substation Automation's fully coordinated protection and control thus constitutes a high-performance solution that can meet the user's most stringent redundancy and communication requirements. On request we can offer complete line bay, complete transformer bay and complete generator bay one object terminals.

Each bay can be designed for 1, $1^1/_2$ and 2 breaker arrangement with single or duplicated protection.

Series 500 Universal terminals

These IT based terminals are suited for generation, transmission and distribution applications. A built-in MMI and PC connection at the front gives fast access to terminal data at commissioning and service. In addition listed terminals below all have two independent communication ports for SCS and SMS.

REL 501	Line protection
REL 511	Line protection
REL 521	Line protection
REL 531	Line protection
REL 551	Line protection
REL 561	Line protection
REB 551	Breaker failure protection
REC 561	Bay terminal with a vast array of functions for one or several bays at transmission and subtransmission level.
RET 521	Transformer protection

Several options are available for all terminals such as e.g., disturbance recorder, event recorder, programmable logic and breaker related functions. All terminals can be configured with a large amount of binary inputs and outputs that are programmable. These can e.g. be used for control of switchgear equipment.

Application (cont'd)

Control and Monitoring

The traditional control system consists of a number of control panels with instruments, switches, alarm annunciators and other equipment. It also provides a number of subsystems such as interlocking, AVR for power transformers, sequence-of-event recorders, etc. Large space and cabling requirements, extensive maintenance and difficulties in modifying the system for future expansion are characteristics of traditional control systems.

PYRAMID® Substation Automation eliminates these disadvantages. In addition, the system provides statistics for the reporting of history, trends, etc.

Self-supervision minimizes maintenance and fault tracing. Once the system is programmed for a specific application, the user can, with little effort, modify and add functions himself.

The numerical control system is the key to safe and efficient substation operation. This system, which has been offered by ABB for several years, is thoroughly tried and tested.

PYRAMID® Substation Automation provides a total substation control concept.

Event recording and disturbance recording can be included in SCS.

The SMS system can collect disturbance data from a SPCR module in SPAC 530 and a 500 terminal, a RCRA module in REL 100 or directly from the terminal blocks, depending on the configuration. This information can then be transferred to the engineer's workplace. Separate event recording systems based on SACO are also available.

SMS can be used separately or coordinated with SCS.

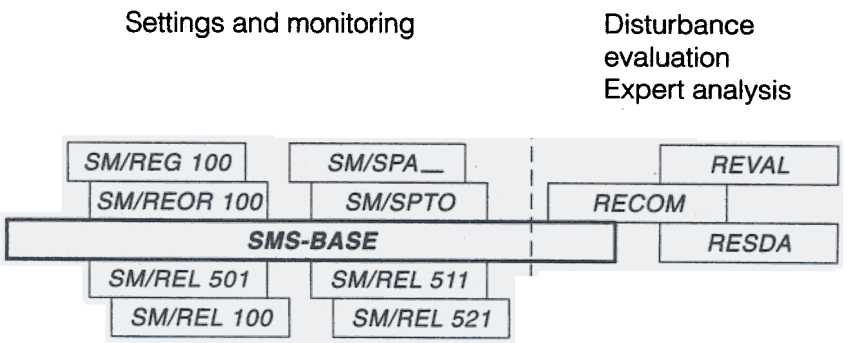

Fig. 3 SMS structure

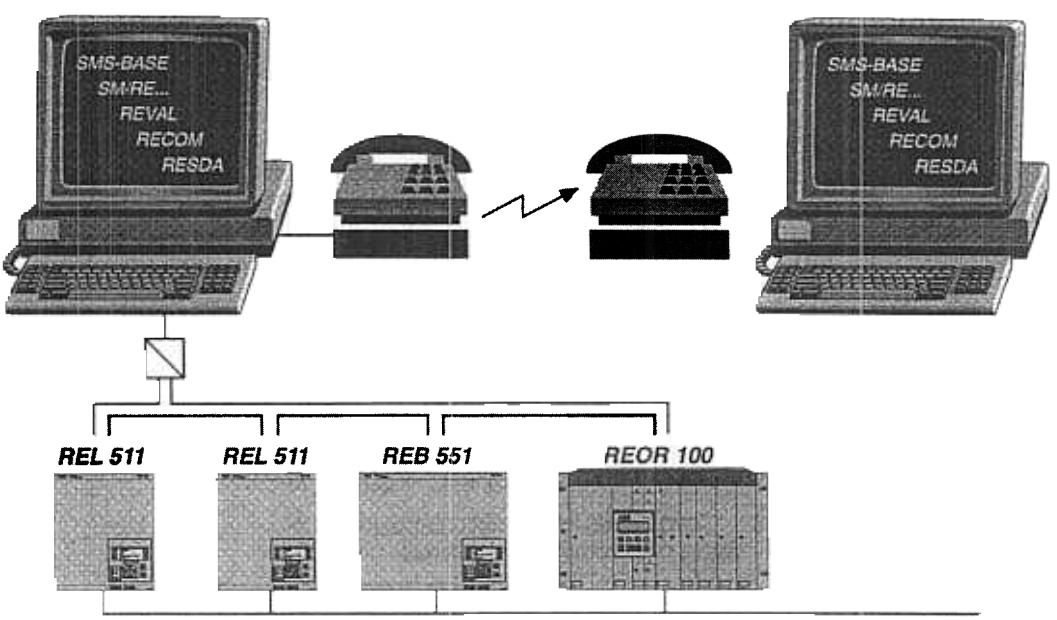

Fig. 4 SMS-communication for transmission and generation

Substation Control System
The system structure is divided into two levels; bay level and station level. The bay level consists of distributed terminals, whereas operator stations and gateways belong to the station level.

Together all units combine control, monitoring, recording and report generation in a hierarchy system that supervise it's own hard- and software.

The entire substation is controlled and supervised from the station level, while individual lines, transformers, etc., are protected, controlled and monitored from the terminals at bay level.

Man machine interface (MMI)
Using a "mouse", the operator can operate, control and supervise the substation by moving the cursor on a colour video display unit (VDU) to symbols or text. The necessary information is displayed in windows. Along with the windows and data, symbolic push-buttons of any size can be located anywhere on the VDU.

From the MMI, the operator can also read and change the settings of all numerical protective relays which are connected to the system via the fibre-optic bus. This MMI provides the operator with an excellent overview of the complete substation, and gives easy access to the various functions.

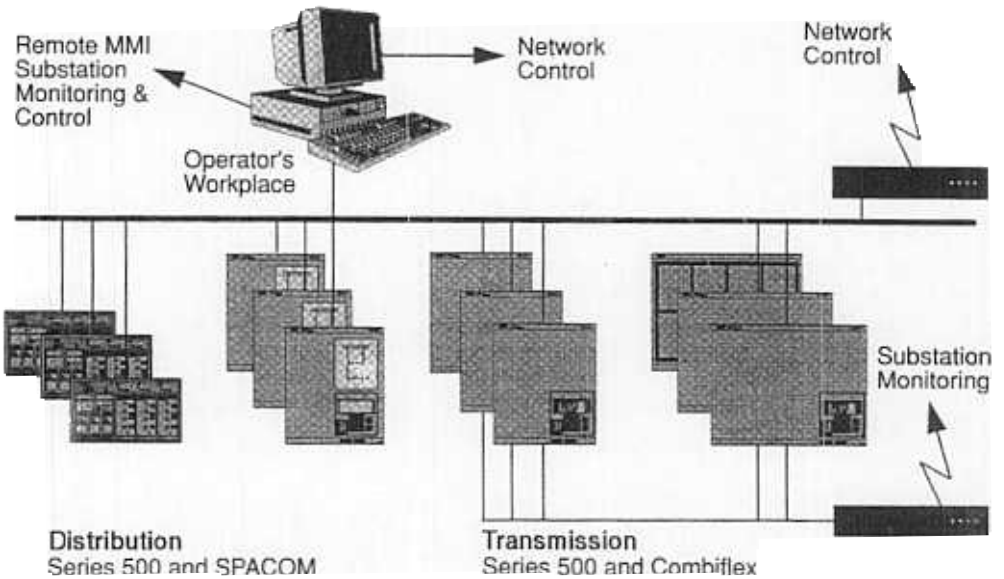

Fig. 5 SCS-structure for transmission, subtransmission and distribution

Station level
Three independent and autonomous units is the result of high requirements independently: the MMI system; the station computer (SC), for common station functions; and the gateway (GW), for communication with a remote control centre. Whenever the independent requirements are lower the function of all these units can be combined in the MMI.

Bay level
Functions related to a particular bay are located at the bay level. This is why the bay level computers are independent of each other, which increases the availability. Since the most important functions are located at the bay level, the operation of a bay can be maintained even if a fault occurs at the substation level. The equipment for each bay is housed in one or more cubicles which can be assembled and tested at the factory. This reduces on-site erection and commissioning work.

Serial data bus
Information is transferred between the two control levels via a serial data bus. The station level equipment is connected to the bay level computers via the station bus. Bay-oriented signal collection and the serial transmission of information between the two control levels considerably reduces the amount of cabling required.

Disturbance-free communication is achieved by using fibre-optic links.

Communication
PYRAMID® Substation Automation offers a very flexible and "open" system which can be designed to combine both the comprehensive PYRAMID® Substation Automation range of terminals, numerical relays from other manufacturers as well as existing and new conventional relays. Furthermore PYRAMID® Substation Automation can communicate to different types of Network Control Systems.

Application (cont'd)

One of the bigger differences between numerical technique and conventional technique is that numerical technique can store and memorize information, both digital, analogue and processed information. To structure and communicate the "right" information to the "right" person at the "right" time is essential for the overall performance of the system. How we arrange man machine interface is a task for both user and manufacturer. Furthermore, efficient and safe substation operation requires well-structured means of communication that meet the present and future needs of the user.

PYRAMID® Substation Automation provides communication facilities that can be adapted to the safety and efficiency requirements of operators and management, with capabilities for future expansion as needs increase and new technology is introduced.

The information is structured on three levels: operator's workplace, engineer's workplace and local man machine interface (MMI) or portable PC. The local MMI (which is a menu driven alpha-numerical display located on the front of the relay) or portable PC provides easy access and readability. The last three events are stored in the relay memory, and the information is automatically displayed at relay operation.

The setting of the relay is normally done from the local MMI or from a portable PC. Two different sets of values can be programmed. Remote setting can in principle be done, but this has to be carefully studied by the user to prevent outside persons from gaining access to this possibility.

The operator's workplace monitor can display all information relevant to the substation operation. The depth and the detail of information is selected by the operator, step by step, not to create information pollution.

The engineer's workplace monitor, part of SMS, presents the information stored in the terminal at trip operation. All terminal data and settings are accessible and are used for post-fault evaluation and disturbance recording. Once the data has been transferred to the data base, the terminal's event memory can be reset from the master station.

The important difference between SCS and SMS is that SCS is continuously on line via a dedicated communication path. The SMS is used on command, which means the engineer can call up the SMS system on a PC, via a modem and phone line. This also gives flexibility, as the workplace is portable (portable PC).

The communication between the different terminals and the operator's work place is performed via a fibre-optic object bus type LON. All numerical ABB PYRAMID® Substation Automation protection relays can be connected to this bus. Via a SPOC unit, digital information from any conventional relay can also be connected to the object bus.

As an option independent bus can be provided for the engineer's workplace. This bus is the well established SPA-bus.

The SPOC unit can also be supplied with transducers for real time values for voltage and current. Other types of numerical relays can be included via a SPOC unit terminal bay.

The unique structure in combination with a full range of versatile terminals provides outstanding flexibility with high availability and redundancy. It is an "open" system which can be tailored to the specific need of each user and each application. It offers a step by step implementation, including both new and existing protection relays.

For communication with an existing Network Control System a separate Gateway or the MicroSCADA can be used. Today more than 50 different Protocols have been implemented.

Protocol implementations for any other type of Network Control System, not yet included in our library, can be quoted on request.

Self-supervision

One of the major benefits of microprocessor technology is that no additional hardware is required for self-supervision; a function which increases the availability and reliability by ensuring that product and system faults can be identified without extensive fault-tracing, so the equipment can be returned to service quickly.

Self-supervision of the protection and control hardware and software thus reduces maintenance costs. The CT and VT circuits, the dc supply and trip circuits, and the communication links are also monitored continuously, which further increases the availability.

Messages from the self-supervision system are available both locally and remotely. This simplifies fault-tracing and cuts the time for repair. The resulting reduction in down time increases the dependability and security.

The main benefit of PYRAMID® Substation Automation self-supervision is that it covers the entire system. Moreover, back-up functions are included, for high reliability.

With a test interval of two years, the MTTR without supervision is approximately one year, since a fault will not be detected until the next test is performed. With supervision a fault can normally be repaired within 24 hours. This means the MTTR will be one day instead of 365 days - a significant improvement.

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The intelligent station

PYRAMID® Substation Automation offers a unique range of state of the art components which can be combined with conventional relays to give total coordinated protection and control.

As described in Fig. 2 ABB can offer two alternative performance levels in respect to such requirements as operating time, accuracy, resolution, etc. Both these alternatives can be included in PYRAMID® Substation Automation. The choice depends on the user.

These products can be used as stand-alone but can also be upgraded, step by step, to form the "Intelligent Substation". PYRAMID® Substation Automation offers workstations for the operator, relay engineer and service engineer. These workstations include software packages for statistics, setting calculation, disturbance evaluation, automatic testing and other expert programs.

PYRAMID® Substation Automation also offers great flexibility and can give technical and economical optimum solutions for different requirements on performance and availability.

For a technical proposal please contact your nearest ABB representative. The following information is required:

- One line diagram of the high voltage system
- Protection, control and monitoring functions included per terminal
- Performance level required for main functions
- Functions included per workstation
- Existing equipment to be interfaced with
- Remote communication required

Detailed description of each building block in PYRAMID® Substation Automation is found under sections 1-11.

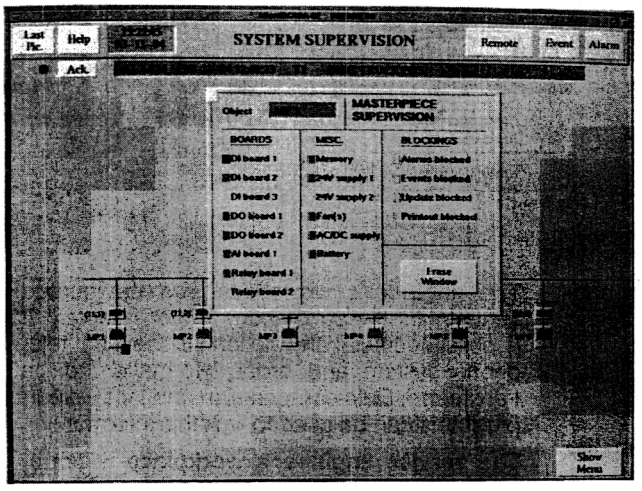


Fig. 6 SCS System supervision

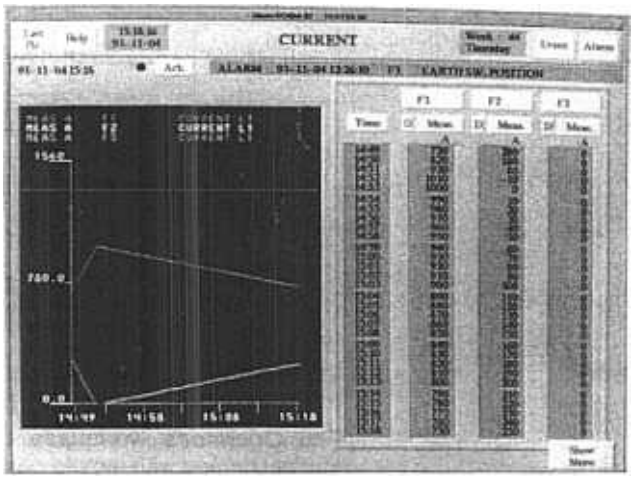


Fig. 7 SCS statistics

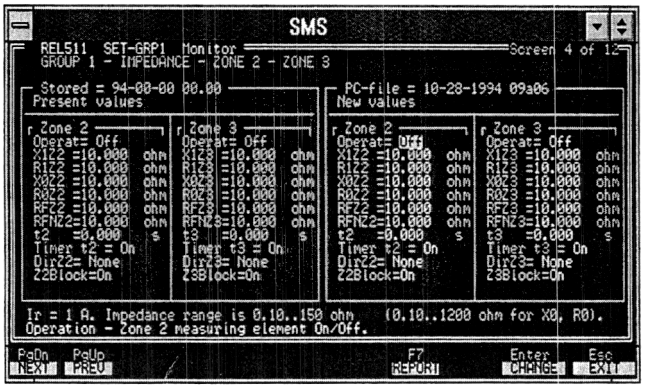


Fig. 8 Programming of REL 511 from SMS

The selection of suitable terminals is based on customer requirements on performance and the functions to be included.

For the 220 kV system the line terminals REL 521 and REL 561 are normally used. This provides duplicated microprocessor based full scheme distance relays. The two terminals have different measuring algorithms in order to avoid common failures. For the transformers and 132 kV lines, RET 521 and REL 511 can be used. If higher performance is required REL 521 can be implemented instead. For the distribution level SPAD 345 and SPAC 530 are normally used.

REL 501 and REL 511 with overcurrent starting is also an alternative for distribution feeders with double end infeed.

Application (cont'd)

One of the bigger differences between numerical technique and conventional technique is that numerical technique can store and memorize information, both digital, analogue and processed information. To structure and communicate the "right" information to the "right" person at the "right" time is essential for the overall performance of the system. How we arrange man machine interface is a task for both user and manufacturer. Furthermore, efficient and safe substation operation requires well-structured means of communication that meet the present and future needs of the user.

PYRAMID® Substation Automation provides communication facilities that can be adapted to the safety and efficiency requirements of operators and management, with capabilities for future expansion as needs increase and new technology is introduced.

The information is structured on three levels: operator's workplace, engineer's workplace and local man machine interface (MMI) or portable PC. The local MMI (which is a menu driven alpha-numerical display located on the front of the relay) or portable PC provides easy access and readability. The last three events are stored in the relay memory, and the information is automatically displayed at relay operation.

The setting of the relay is normally done from the local MMI or from a portable PC. Two different sets of values can be programmed. Remote setting can in principle be done, but this has to be carefully studied by the user to prevent outside persons from gaining access to this possibility.

The operator's workplace monitor can display all information relevant to the substation operation. The depth and the detail of information is selected by the operator, step by step, not to create information pollution.

The engineer's workplace monitor, part of SMS, presents the information stored in the terminal at trip operation. All terminal data and settings are accessible and are used for post-fault evaluation and disturbance recording. Once the data has been transferred to the data base, the terminal's event memory can be reset from the master station.

The important difference between SCS and SMS is that SCS is continuously on line via a dedicated communication path. The SMS is used on command, which means the engineer can call up the SMS system on a PC, via a modem and phone line. This also gives flexibility, as the workplace is portable (portable PC).

The communication between the different terminals and the operator's work place is performed via a fibre-optic object bus type LON. All numerical ABB PYRAMID® Substation Automation protection relays can be connected to this bus. Via a SPOC unit, digital information from any conventional relay can also be connected to the object bus.

As an option independent bus can be provided for the engineer's workplace. This bus is the well established SPA-bus.

The SPOC unit can also be supplied with transducers for real time values for voltage and current. Other types of numerical relays can be included via a SPOC unit terminal bay.

The unique structure in combination with a full range of versatile terminals provides outstanding flexibility with high availability and redundancy. It is an "open" system which can be tailored to the specific need of each user and each application. It offers a step by step implementation, including both new and existing protection relays.

For communication with an existing Network Control System a separate Gateway or the MicroSCADA can be used. Today more than 50 different Protocols have been implemented.

Protocol implementations for any other type of Network Control System, not yet included in our library, can be quoted on request.

Self-supervision

One of the major benefits of microprocessor technology is that no additional hardware is required for self-supervision; a function which increases the availability and reliability by ensuring that product and system faults can be identified without extensive fault-tracing, so the equipment can be returned to service quickly.

Self-supervision of the protection and control hardware and software thus reduces maintenance costs. The CT and VT circuits, the dc supply and trip circuits, and the communication links are also monitored continuously, which further increases the availability.

Messages from the self-supervision system are available both locally and remotely. This simplifies fault-tracing and cuts the time for repair. The resulting reduction in down time increases the dependability and security.

The main benefit of PYRAMID® Substation Automation self-supervision is that it covers the entire system. Moreover, back-up functions are included, for high reliability.

With a test interval of two years, the MTTR without supervision is approximately one year, since a fault will not be detected until the next test is performed. With supervision a fault can normally be repaired within 24 hours. This means the MTTR will be one day instead of 365 days - a significant improvement.

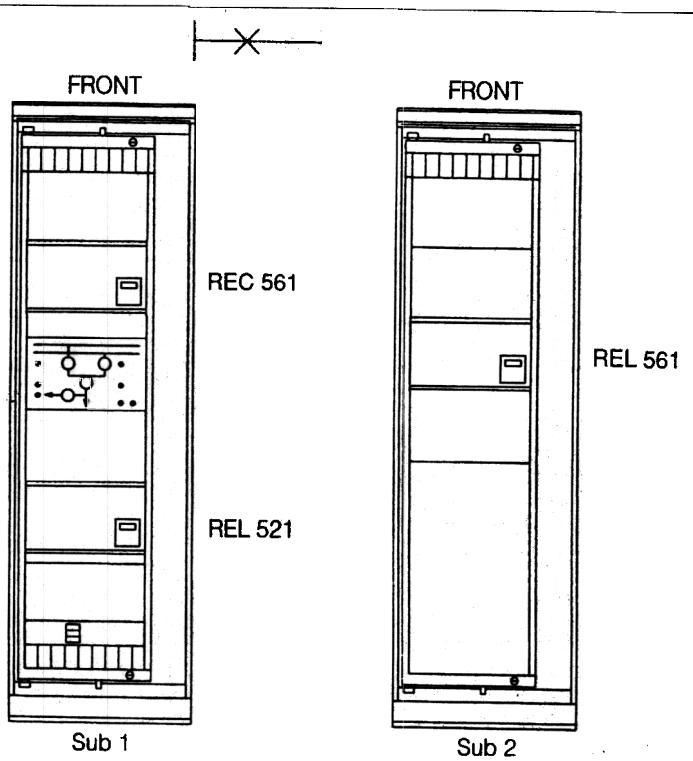


Fig. 10 Single breaker arrangement, one transmission line and duplicate protection.

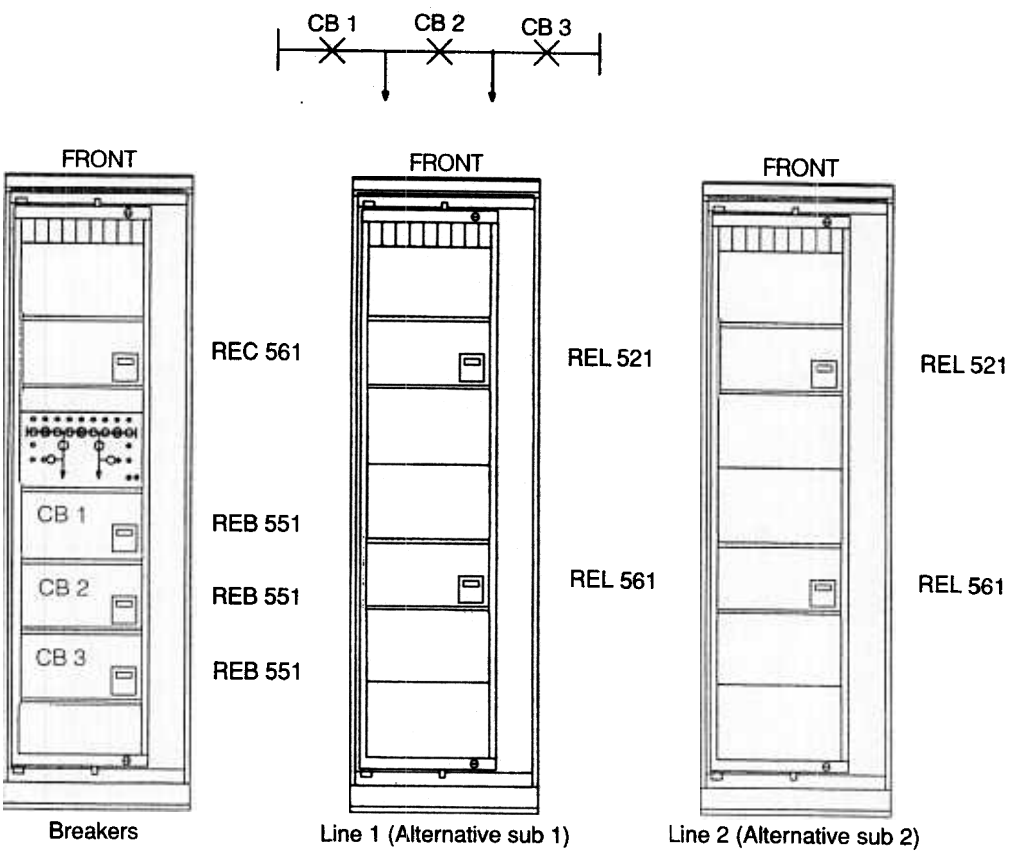


Fig. 11 Breaker and a half arrangement with three breakers two transmission line and duplicate protection per bay.

Application (cont'd)

The above terminals can communicate with both SCS and SMS. In addition to this, local printout from event recorder and disturbance recorders can be included separately or as back-up.

When designing the PYRAMID® Substation Automation it is important not only to define the hardware to be used but also the tasks to be performed by the personnel. It is also important to specify when and where those tasks are to be performed.

On-line functions and off-line functions should be separated. Off-line functions can be statistical follow-up or setting of relay protection.

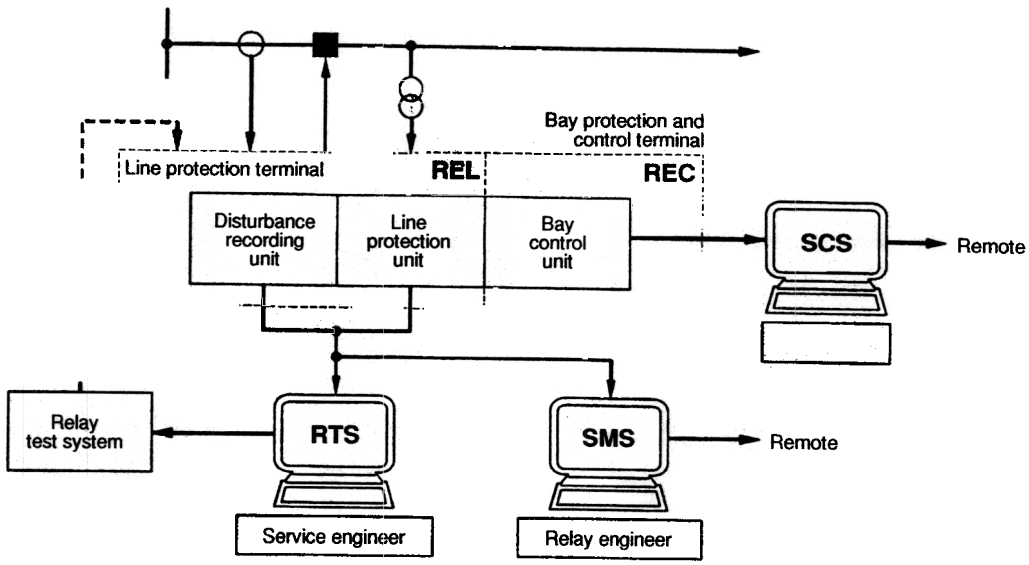


Fig. 9 Workstation for PYRAMID® Substation Automation

In the PYRAMID® Substation Automation concept the man machine interface is structured in four work levels.

The Technician's local workplace on bay/terminal level using local MMI or portable PC.

The Operator's workplace centrally in the substation and with remote gateway

The Relay engineer's workplace with central or remote PC.

The Service engineer's workplace with mobile Relay Testing and Simulation unit.

These four workplaces can be used separately or combined. The important thing is that the PYRAMID® Substation Automation offers this very comprehensive and flexible way of working.

The technician's workplace is based on simple setting and indication directly on the terminal. This is based on LED's, user friendly keyboard and display with background light. From this station each terminal can be totally controlled locally, even if the communication is down. Normally, the setting and testing of relays is done locally.

The operator's workplace is continuously connected to each terminal. Via fibre-optic cables all information is immediately transferred to the operator. This information is selected to give a clear and fast view about what is happening. Printout from the disturbance recorder modules can be obtained.

The engineer's workplace can be located centrally (in the substation) and/or remotely. It is possible to call any station via the local telephone system and order information to be transferred. Data compression and local expert programs can be used to limit this information.

The service engineer's workplace is portable and can be used during commissioning, testing and/or maintenance. Recorded disturbances can be played back through REY 100 to reproduce disturbances and test the performance of the relay.

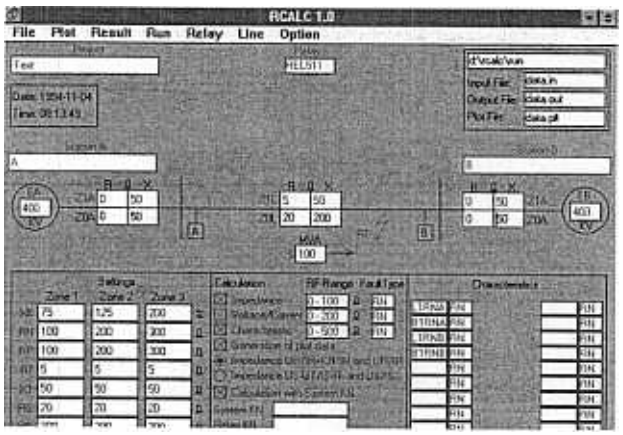
The intelligent terminal

PYRAMID® Substation Automation can be adapted to various degrees of requirements and complexity. Fig. 10 shows an example of a terminal which is appropriate for a 220 kV line. Main 1 protection is REL 521 and main 2 protection is REL 531 which means the disturbance recorder module is included in REL 521. For a substation with one and a half breaker arrangement the panel layout is shown in Fig. 11. The equipment related to the breakers are installed in panel 1. In panel 2 the line 2 equipment can be placed and in panel 3 the line 3 equipment can be placed. As an alternative, the subsystem 1 equipment, with main 1 protection for both lines, can be placed in cubicle 2 and subsystem 2 equipment in panel 3.

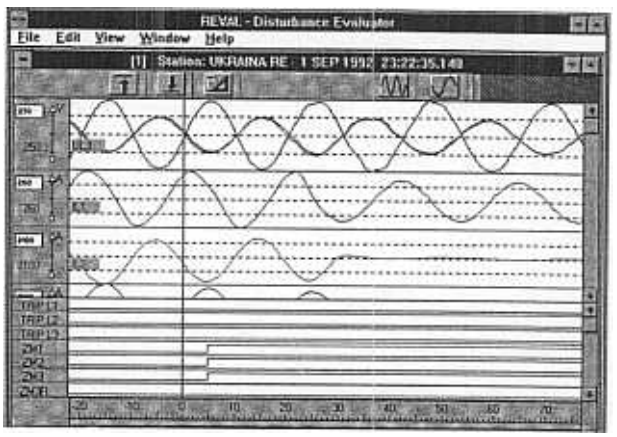
These line bays are operated through the three workstations in Fig. 9.

The relay engineer's workstation

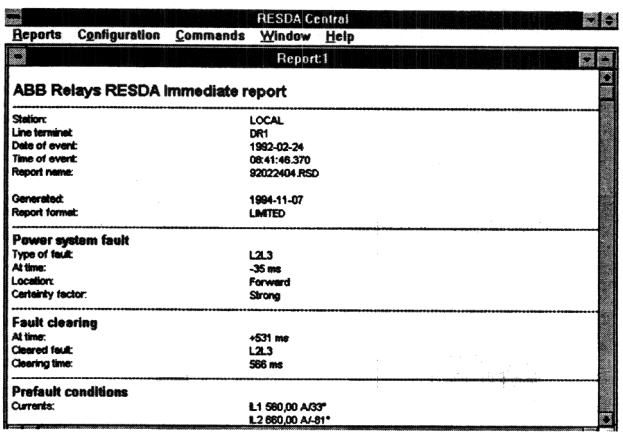
Fig. 13 shows the engineer's workstation. Normally the engineer does not need to follow the day to day operation. This is done by the operator. If a fault occurs for which the engineer rapidly needs to analyse the disturbance, he can, from any telephone via a modem, call up the substation. In his PC he can have RCALC stored for this particular line. With RCALC he can simulate the line and rapidly see the effect of load transfer, source to line ratio or mutual coupling on his settings as shown in Fig. 13a and b. From the terminal he can now also collect the disturbance information from both ends of the line as shown in Fig. 13c. With REVAL, evaluation program, he can easily study currents and voltages in detail. In this case the terminals shows start and trip and the analog information shows that heavy CT-saturation occurs. With the expert program, RESDA, the engineer will for a majority of the fault get an automatic analysis.



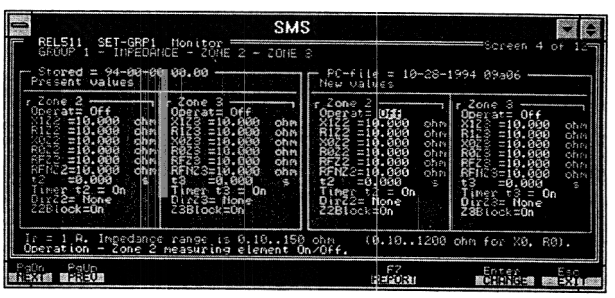
a Simulated system - RCALC



b Disturbance evaluation - REVAL



c Automatic evaluation - RESDA



d Programming of a protection - SM/REL 511

Fig. 13 SMS, engineers workstation

The Intelligent substation

PYRAMID® Substation Automation is a step by step approach with unique possibilities to apply modern microprocessor based technology both in new and old stations. It offers many new concepts to simplify both engineering, operation and maintenance. Reduced cost due to less wiring and space, no need for separate transducers, etc. are some examples. Most savings in time and cost are of long term nature which means that substantial cost savings are realized throughout the lifetime of the substation.

In addition to the savings PYRAMID® Substation Automation offers added value in capacity and availability and a complete coordinated solution with system responsibility by one manufacturer. This guarantees future support of hard- and software included in the PYRAMID® Substation Automation concept. The flexible nature step-by-step philosophy, and user friendly workstations is an excellent base for the intelligent substation.

References

PYRAMID Substation Automation		1MRB 520 007-SEN
REG 100	Generator protection terminal	1MDS02004-EN
REG 216	Generator protection terminal	1MDS02005-EN
Transformer	Protection, Monitoring and Control	1MRK 500 401-SEN
RET 316	Transformer protection terminal	1MDS04004-EN
Breaker	Protection, Monitoring and Control	1MRK 500 501-SEN
REB 100	Busbar protection terminals	1MRK 505 002-SEN
REL 316	Line protection terminal	1MDS06003-EN
REL 100/RELZ 100	Numerical line protection terminal	1MDS06004-EN
REL 100	Line protection terminals	1MDS06019-EN
Line	Protection, Monitoring and Control	1MRK 500 600-SEN
Bay	Protection, Monitoring and Control	1MRK 501 001-SEN
RES 100	Disturbance recording systems	1MDS10004-EN
SCS 200	References	1MDR11004-EN
REY 100	Relay testing and simulation system	1MDA12007-EN