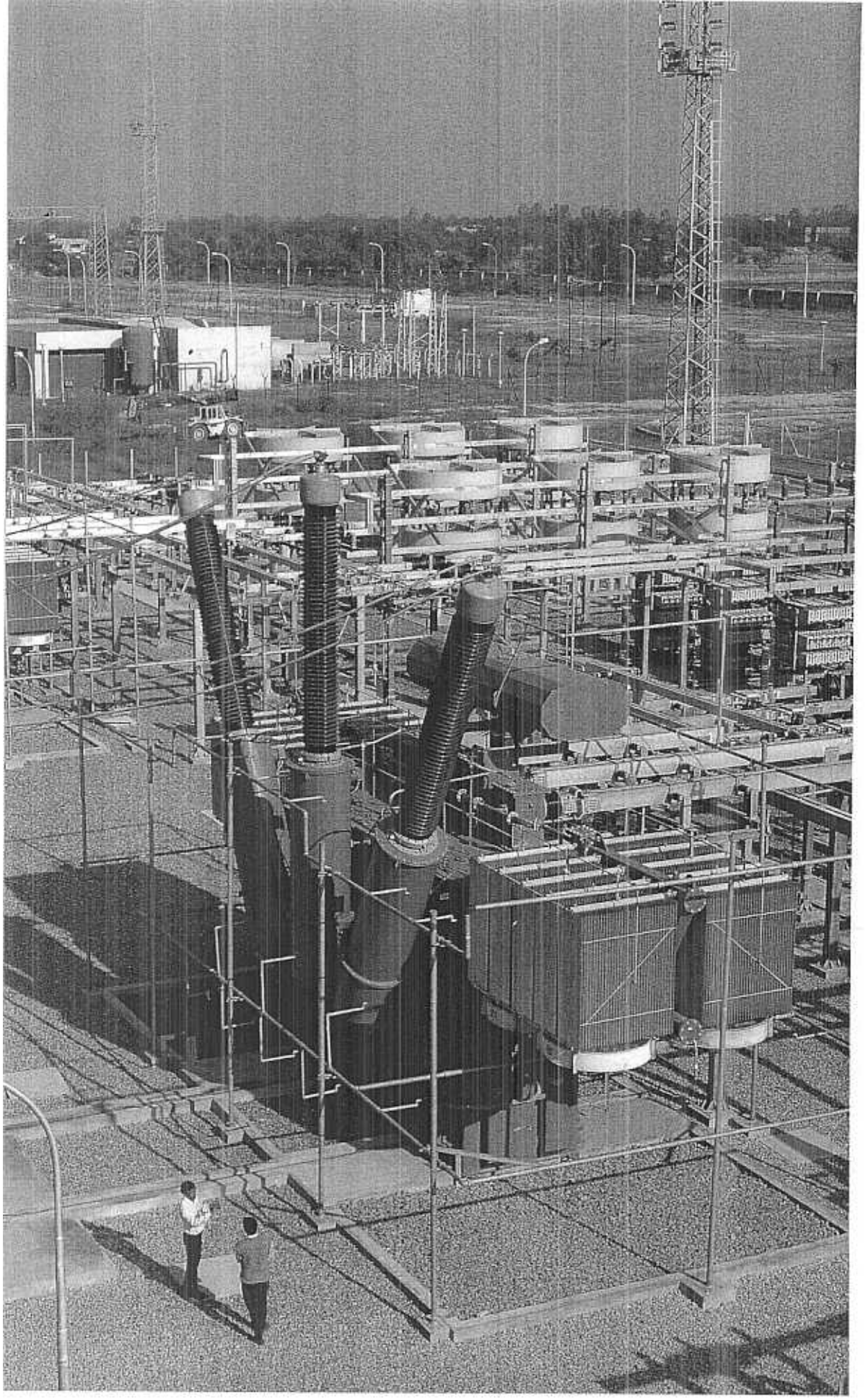
Transformer

Protection, Monitoring and Control

Panorama

ABB Network Partner

ABB



Power transformers are expensive and important components in a power system. It is necessary to provide first-class protection to limit damage in case of severe faults and to prevent abnormal conditions which can shorten component lifecycles and cause subsequent failures.

Power transformers are made in a wide range of sizes and with a variety of connections, from medium-sized distribution transformers to huge power station step-up transformers and EHV system transformers. Big units are also made as auto-transformers with two voltage levels sharing a part of the winding. Transformer windings can be arranged for different vector group connections and quite often there is also a tap-changer with a facility for voltage regulation.

A shunt reactor is in some ways similar to a power transformer, but there are also differences which are significant to the protection arrangement. An oil-immersed shunt reactor is often equipped with protection similar to that of a transformer.

Transformer protection based on long experience

Power transformer protection should ensure fast and dependable tripping for a fault in the transformer or transformer switchbay. In addition, it should not cause non-selective tripping in the event of external faults , but it is usually set up to offer time-graded back-up protection for external short-circuits and earth-faults.

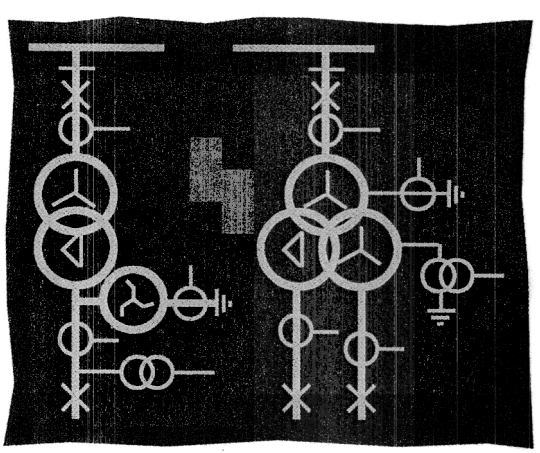
To cope with the wide spectrum of application aspects for transformer protection, a number of functions have come into use. There are various kinds of electrical protection functions supplemented with other protection and monitoring devices built onto the transformer, such as oil and winding temperature devices, Buchholz gas and sudden pressure relays and others.

The characteristics of power transformers and certain phenomena in switching and other service conditions are of importance to the design and structure of power transformer protection. When switching-in the transformer or its parallel unit, or in the event of a sudden return of voltage after disconnection, a considerable inrush of current results, which must not be interpreted as a fault condition.
At voltage rise, the transformer may go into saturation and draw a considerable magnetising current, which is also an abnormal condition but not a fault requiring instantaneous tripping.

A transformer differential protection device is a widely used form of protection for instantaneous detection of internal faults in transformers larger than a few MVA . The requirements concerning transformer differential function differ somewhat from generator or busbar differential protection, to take two examples. In addition to the conditions mentioned above, phase shift, inrush current etc., the current transformer ratios usually need a balancing correction, and the effect of the tap-changer will further contribute by a varying rate of imbalance.

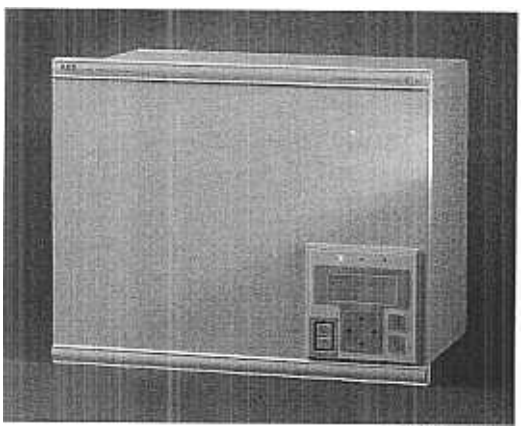
The effect of an internal or external earth-fault depends very much on the system neutral earthing at the points of power infeed and other neutrals. The method of system earthing varies with system voltage and depends also on the practice of the user. System neutrals may be earthed directly, through low impedance resistors, reactors, high impedance arc suppression reactors or high impedance resistors, or they may be left connected through just a surge arrester.
A high earth-fault current should be cleared quickly by the differential or other current relaying function. A low earth-fault current can be cleared by time-graded current and neutral voltage functions.

Long experience allied to knowledge of modern numerical design and simulation technology form the basis for the design of the numerical transformer protection relay.



The most common types of power transformers are of the two-winding and three-winding type.
In some cases an earthing transformer is used to create a neutral for earthing.

Multifunctional protection terminal RET 521



Several useful functions which have been traditionally provided by individual relays are here combined into one multi-functional protection terminal, RET 521.

In the relay basic and optional protection and associated functions are available, such as:

- Transformer differential
- Time-overcurrent
- Restricted earth-fault
- Earth current
- Neutral voltage or overvoltage
- Collection of binary signals from external devices for overtemperature etc.
- Trip logic
- Logic elements for free use
- Service value indication
- Event logging

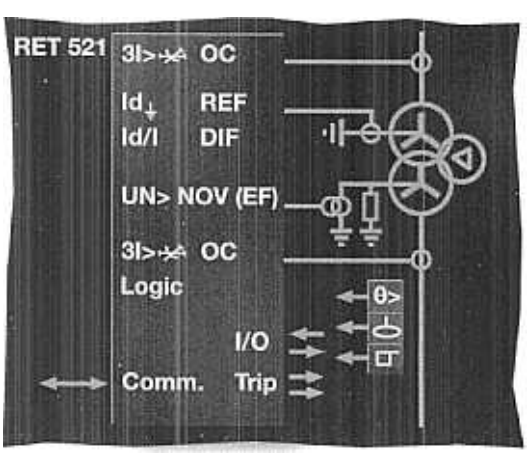
Transformer differential protection (DIF)

The transformer differential protection device is the major protection in the transformer and shunt reactor protection terminal and it is designed for two and three-winding transformers. It is stabilised against external faults, inrush current and over-excitation via a selectable current bias characteristic and harmonic restraint.

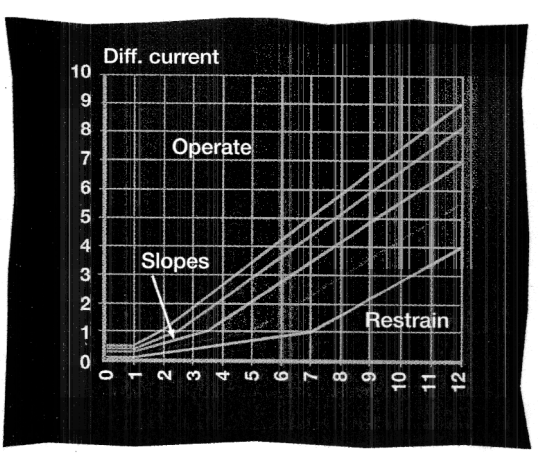
The protection device includes an internal current amplitude and vector group compensation for various transformer connection groups, which means that no interposing CTs are needed.

There is a generous range of setting possibilities including individual setting of basic sensitivity, current bias slope and high set non-restrained differential function for high current faults.

Applications such as transformers with on-load tap-changers or shunt reactors can be covered.



Example of functionality in one application.



Current bias characteristics.

Three-phase time overcurrent function (OC)

The three-phase time overcurrent function has two current levels with a wide setting range:

- Level 1: A choice of inverse and definite time-overcurrent characteristics
- Level 2: Instantaneous or definite time setting

Overcurrent protection can be individually applied to the HV side and to the LV side.

Restricted earth-fault function (REF)

The restricted earth-fault function offers instantaneous protection for internal earth-faults in low impedance earthed systems. It uses current measurement in the phase conductors and in the connection from neutral to earth. It can be made more sensitive than the transformer differential and still be stable in the event of external faults and inrush current.

Earth-fault current protection

For low impedance or directly earthed systems (option). The earth current protection function has the same features as for the three-phase OC protection, but it is a single-phase function and can be set for greater sensitivity.

Single-phase or neutral overvoltage function (NOV)

The neutral or single-phase overvoltage function has one voltage level and two definite time steps.

Inputs for external protection devices

The transformer and shunt reactor protection terminal are also equipped with collection and logic facilities for external protection devices. Indication, event logging and trip logic can thus be arranged for transformer oil, winding temperature devices and Buchholz gas detection, to name a few examples.

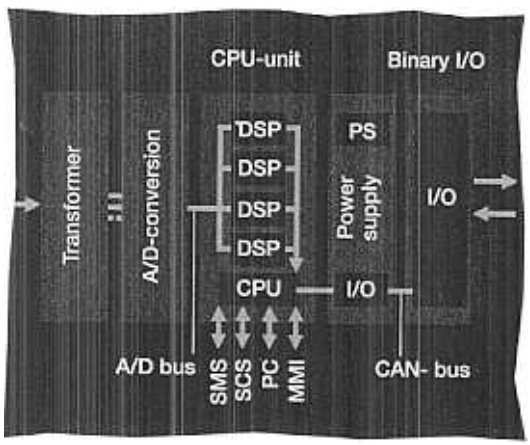
Indications and event recording

RET 521 has a facility for indications and event recording. It includes spontaneous frontal MMI indication of operations, reading of service values such as phase currents and differential currents, plus time-tagged logging of protection operations and other events.

Technical particulars.

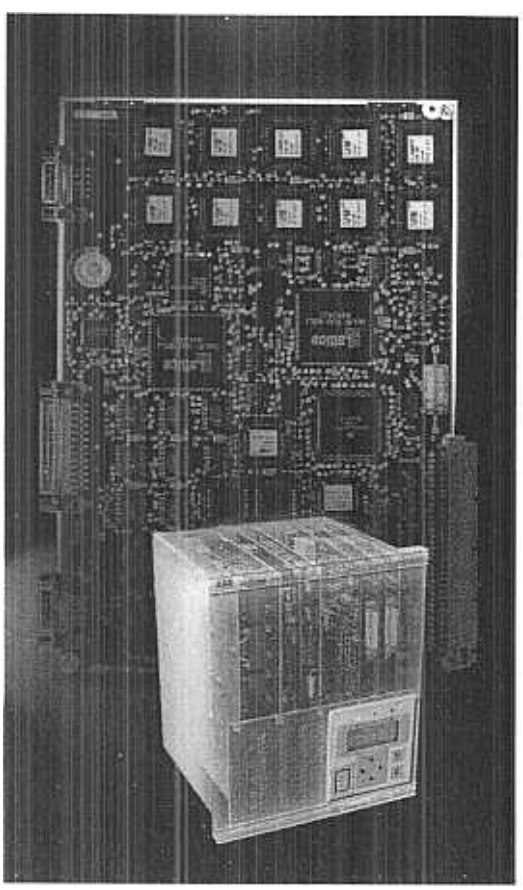
General data:	
Rated frequency, fr	50 Hz, 60 Hz
Rated current, Ir	1A , 5 A
Rated voltage when used, Ur	100, 110, 115 V, 100/√3, 110/√3, 115/√3
Auxiliary power	48-60, 110-125, 220-250 V DC
Binary inputs	48-60, 110-125, 220-250 V DC
Transformer differential	
Basic operate level Id1	settable
Bias slope, intermediate region,	selectable
High set unrestraint level, IHigh	settable
Transformer vector group compensation:	Yy, Yd1, Dy11 etc.
Current amplitude correction	
Overcurrent	
Operate level 1, Is1	0.5 - 5 p.u.
Time-lag characteristics acc. to IEC 255-3	Independent; 0.1-5 s Dependent (inverse): selectable
High set level 2, Is2	settable
Time-lag , t2	0.025 - 1 s
Restricted earth-fault	
Operate current, Is	settable

The 500 Series platform design



The Binary In/Out modules are optional. The number of input transformers and A/D conversion modules depends on actual demand for the variant.
Data communication with Substation Control and Substation Monitoring is optional.

The RET 521 transformer protection relay conforms to the 500 Series design, with a housing made of sheet steel, height 6U.



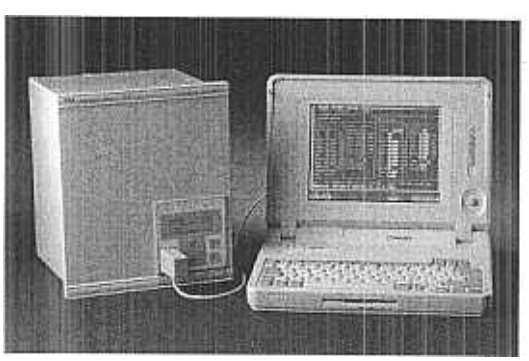
The 500 Series uses the same hardware and software platform for protection and control applications. This results in a user-friendly product which is programmable through the built-in MMI, the PC connection at the front, the Station Monitoring System or Substation Control System. The compact, safe and user-friendly 500 Series allows you to configure your own intelligent terminal to ensure optimum performance. This can reduce both installation and maintenance costs and also provide a more efficient "power system management", reducing operational and disturbance costs and permitting better utilisation of high-voltage equipment.

Electrical connections are made by screw terminals at the rear. The relay can be mounted in a 19" rack, or it can be flush or semi-flush mounted in a panel.

A Combitest test switch for injection testing is available on request.
Behind the front there is an interconnection board into which circuit boards are plugged from the rear. There are modules with input transformers, A/D conversion, modules for processing, power supply and binary input and output signals.

The basic unit has four binary input circuits and five output relays. Additional I/O modules with binary inputs and output contacts are available as an option.
Processing is carried out in a central microprocessor and digital signal processors. All binary inputs and relay outputs are configurable for different functions.

The relays in the 500 Series can be equipped with two communication ports operating independently of each other, permitting simultaneous communication with two different masters. This gives the user the possibility of having both a monitoring and a control system in the same station.

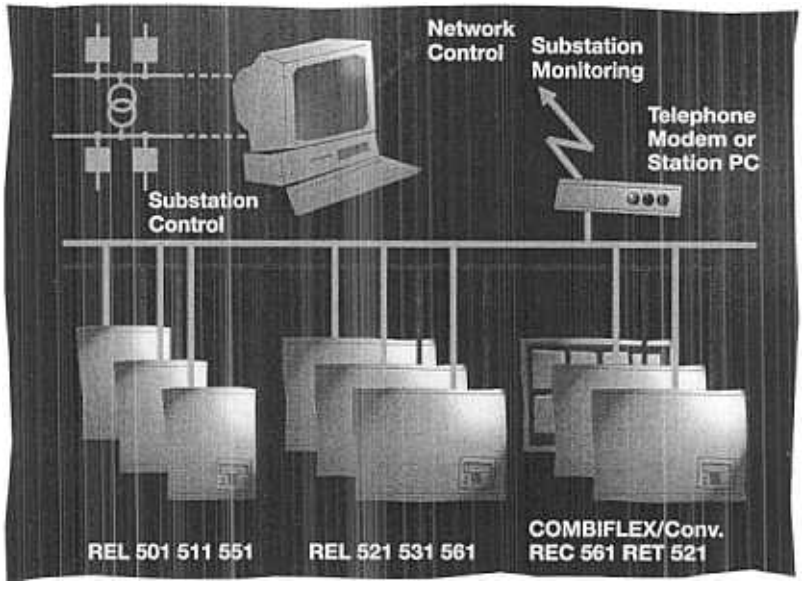


Each protection terminal is always equipped with a built-in local MMI, but a PC can also be connected to the front as a complement, for maintenance and fast commissioning.

The intelligent path to reliable communication

The 500 Series is a part of the PYRAMID® concept for Substation Automation and the Panorama concept for Power Network Management: the intelligent terminal in the intelligent substation for the intelligent power network, from generation to consumption.

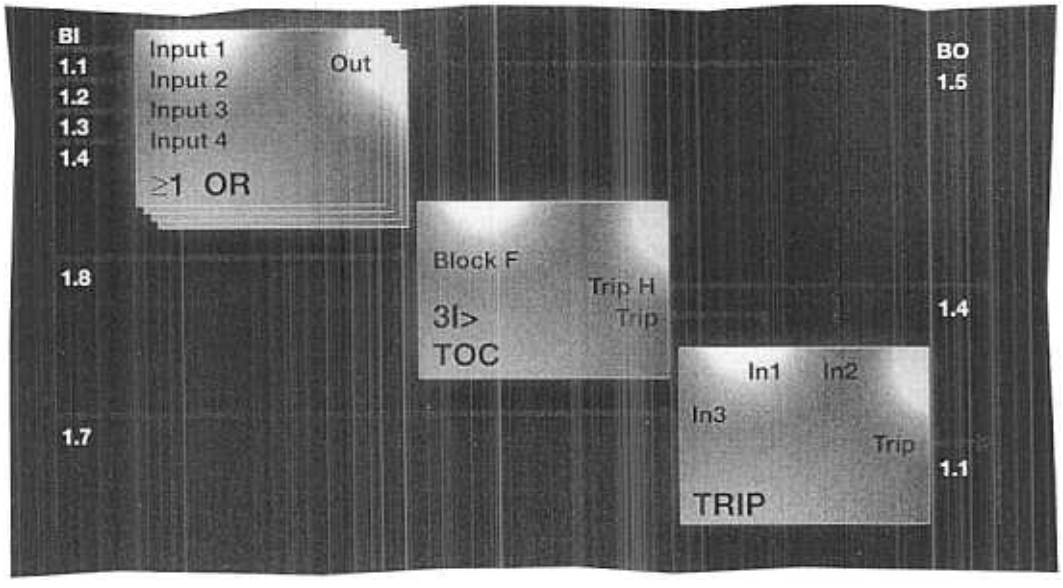
In the intelligent substation, the communication philosophy is of the utmost importance in order to provide the right information to the right person at the right time, and in a reliable way. For this reason, the numerical protection terminals in the 500 Series can be equipped with two remote communication ports operating independently of each other, permitting simultaneous communication with the Station Control and Station Monitoring System.



Communication gives possibilities of intelligent sharing of information.

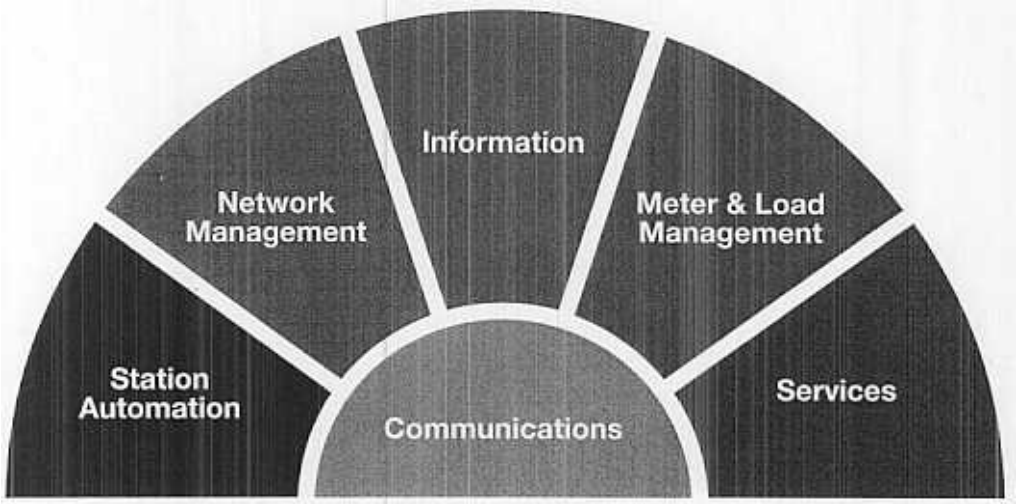
The intelligent way of engineering

Application flexibility is achieved by selection of basic and optional functions and I/O-modules. Through the MMI, functions and free logical elements can be interconnected and configured to inputs and outputs to adapt to a particular need. External auxiliary relays and test switch may supplement the unit.



Transformer

Protection, Monitoring and Control



Panorama is the ABB solution for efficient and reliable management of power networks.

Panorama stands for an open view in all directions, utilizing innovative information technology.

Panorama enables the user to always be in perfect control of the power process, from generation to consumption.

Panorama is the complete concept for today and for the future, from ABB Network Partner.

1MRK 500 401-SEN Printed in Sweden 1995 Västra Aros

Panorama

ABB Network Partner AB
S-721 71 Västerås
Sweden
Tel +46 21 32 13 00
Fax +46 21 14 69 18

ABB Network Partner

ABB