ECONOMICAL AND TECHNICAL ADVANTAGES OF A MODULAR PLUG-IN RELAY SYSTEM CONSIDERING THE NEEDS FOR RETROFIT IN MODERN POWER SYSTEMS

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SYNOPSIS

The mechanical packaging of auxiliary and protective relays significantly affect the initial and annual costs of the control system and the relay terminals. A cost effective modular, flexible relay packaging concept that is applicable to microprocessor, static and electromechanical relays as well as combinations of technologies is desirable both from the manufacturers and customers perspectives. A mix of properly sized plug in modules that can house new advanced microprocessors as well as traditional electronic and electromechanical technology then makes possible the adaptation of the resulting products and systems to a host of physical and operating requirements. The COMBIFLEX modular system has lived up to those demands since the introduction in 1969. Very good operating experience has been recorded over the years in a wide variety of installations in many countries all over the world. Over 5 million modular relays have been delivered. Retrofit and extensions to existing installations is a good portion of the present business. The products have been included in ABB projects and also sold for separate use by other projects and directly to the final customers.

1. INTRODUCTION

The packaging details of a modular plug-in relay system having a broad line of auxiliary components can significantly affect costs in the following areas;.

A. Initial costs.

Engineering costs
Housing costs
Installation costs
Factory & panel builder's costs
Field installation cost
Start-up testing and commissioning costs

B. Costs after installation

Maintenance and replacements costs
Spare parts inventory
Retrofit and field modifications and expansion costs
Upgrading costs
Service costs (Energy costs)

2. THE BASIC REQUIREMENTS

A. A Broad Product Line

Transmission and generation and control terminals need to contain many relay functions. Some of these functions such as the primary protection measuring function in the past led to the use of varying electronic relay designs and today the use of modern microprocessors. Other requirements such as electrical interfaces and needs for physical separation led to optical or electromechanical designs. The method of packaging the various components needed must therefor be compatible with both microprocessor, static and electromechanical designs. Most relay terminals must also interface with other control and alarm functions. The relay packaging should preferably provide many of those functions and other required features. Ancillary modules are therefore designed as integral parts of the system. In order to meet all the needs of a modern power system a broad product line is required.

B. Compactness

The economy of standard designs of substations and auxiliary control panels requires that the assigned space for relaying be minimal, yet adequate for a variety of relay and control schemes. Similar needs exist in non-standard designs when relaying space must be allocated before the full relaying needs are identified. The relay packaging technique should provide for the needed compactness.

C. Flexibility

Upgrading an existing relay terminal frequently poses the need to fit new relaying gear into a minimum space or space not originally planned for relaying use. The relay packaging should be flexible so as to provide a means to replace an existing relay package completely or in part with a space efficient design capable of handling the current and future relaying needs.

D. Rational Design

To provide the desired flexibility, the functions within a given plug-in module should be at some rational minimum, but not so few as to result in excessive inter-module wiring. Considering the very wide range of functions needed for modern power system relay and control schemes, the packaging should physically consist of more than one module and one size. I.e. the building block system should be modularised with all sizes being compatible and capable of being intermixed (such as the 2 x 4's and 2 x 6's, etc., in the building construction business).

E. Reliable Connections

The number of screw terminals should be minimized since they are time-consuming to make especially in the field and are a potential hazard if not made correctly and tightened properly. This requirement is emphasized in a modular design with a large number of available interconnections. Also the personnel hazards should be minimized when working behind panels that may be wholly or partially energized.

F. High Quality and Workmanship

The reliability of the products in the relay and control system to perform its intended function demands high quality of the workmanship and the internal design as well as the quality of packaging of the modules. Quality of material selection is also of importance to secure the best longevity of service.

G. Factory Assembly

Factory labor costs are generally less than field labor costs. Thus the packaging should lend itself to sub-assembly of groups of modules as well as complete pre-assembly and wiring by the original ABB factory or other panel building shops or other OEM's.

H. Local assembly

Local assembly is desirable in many countries. Local assembly at various ABB Customer Centres and at independent OEM´s improve service and make sure wide spread competence is available closer to the customer location. This also improves the service degree. The possibility of providing local added value is also desirable. High volume low cost mass-produced modules can then combine with locally produced items and the necessary engineering meeting to meet the local customer requirements. Increased local assembly and value added is thereby encouraged by a modular building block concept. Local assembly and also production of COMBIFLEX is desirable. New IT tools disseminate information required for the proper engineering and to provide data for applications.

I. User Assembly

Many relay users are staffed and organized to build their own relay and control systems, especially those which require a one of a kind solution. The packaging system should be designed in such a way that no special skills are needed to assemble a system on site.

J. Test Features

Another critical factor in upgrading an existing system installation, is the needed outage time for testing and verifying the installed equipment. The testing features provided in the relay package should permit safe testing even when other crews are still on the job site, thus minimizing the total installation time.

K. Maintenance

The techniques required for trouble shooting and replacements of relays and other components should preferably be simplified as much as possible. Time required to remove a defective or outdated device and receive a modern replacement should be minimized. The modules should be sized so it is cost effective to replace a faulty module rather than repair and especially repair electronics in the field.

3. THE SOLUTION – THE COMBIFLEX MODULAR MOUNTING SYSTEM

COMBIFLEX is a modular system for rational mounting and wiring of relay modules, components, and terminal connections. The plug-in modules mount into the terminal bases. The system is adapted for mounting into international standard 19” racks and into swing rack doors in standard 19” cubicles. Complete relay terminals can thus be built up from modular COMBIFLEX components. Redundancy is achieved through the individually operating functional modules and DC supply units that may be divided into two separate groups. The different available cases may mount to switchboards or 19” racks. Many possible combinations of the standardized parts available and the assemblies mount into conventional switchboards or 19” racks. It is also possible to projection-mount relays directly onto panels. New types of panel mounting cases allow small individual relays to be economically mounted in panel cut-outs.

Fig. 1 The standardized modularity permits easy combinations of products into the same cubicle and allows any relay design to be included.

Some cases, the RHGS 6 and 12, can also be bolted together with the 500-series terminals allowing COMBIFLEX relays and accessories to be physically included with the larger terminals. E.g. test switches are typically housed in RHGS 6 adjacent to a 500 series relay terminal. It can also be separately mounted in a separate equipment frame in the same 19” panel (Fig. 1). The RHGX 30 permits mounting of COMBIFLEX relays over the full 19” panel width (Fig. 2). The RHGS series cases may also be mounted in panel cut-outs or directly onto a flat surface, e.g. a concrete wall.

A front connected RXZ 41 base is shown in Fig. 3. There is also the two-seat version type RXZ 21 which provides a means to utilize COMBIFLEX relays if a 19” rack assembly or a panel cut-out is impractical. The RXZ base is available in two versions. One has screw terminals and the other use COMBIFLEX connections.

The RXZ1, 2, 2H and 4 bases are mainly intended for DIN-rail mounting. This type of base can also be mounted flat on a steel panel. This base is suitable for tight locations where only a few auxiliary functions are needed e.g. in a small metal-clad switchgear compartment. Standard screw terminals can be used for connection to external wiring or the external connections can be made directly to the rear of the bases using COMBIFLEX crimped on sockets to the leads. The external lead is physically retained with the terminal base. The terminal socket has a retaining collar. The terminal base has a retaining clip. When once mated they cannot be separated without the use of a clip-spreading tool, extractor RTXD. This detail is shown in Fig. 4.

Fig. 2. The RHGS 6, 12 and 30 are 6U tall to match the 500-series terminals in height.

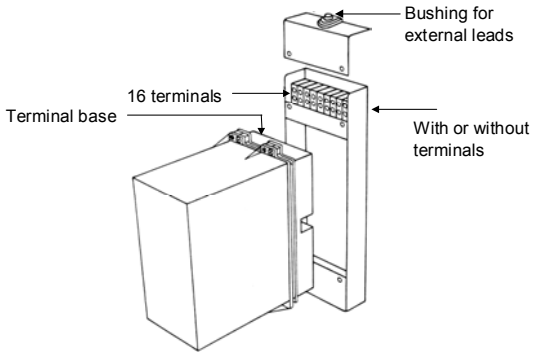

Fig. 3. Front accessible surface mounting with screw connections

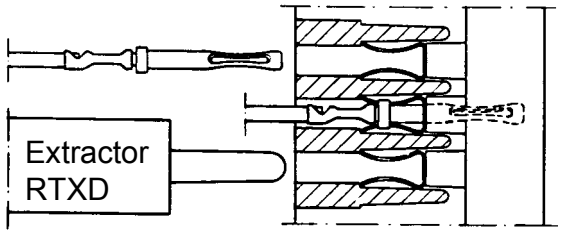

Fig. 4. The terminal socket locks in place by a retaining clip inside the relay terminal base. To extract the wire a simple plastic tool type RTXD is used

4. COMBIFLEX ACCESSORIES

Many accessories are available for COMBIFLEX product assemblies. Some accessories mount in a rear recess in the terminal base. Fig. 5 shows the location of this recess between two vertical double-rows of connection holes.

The type RTXK accessory is a current short circuiting device, in practise “a make before break switch”, which provides two input terminals for up to 20A rated AC current connections. All COMBIFLEX relay modules that have AC current inputs are provided with this device. During removal of an installed relay module, the RTXK provides a short circuit between the two current leads. This makes it possible to safely remove and insert a relay during service. The details of the RTXK are shown in Fig. 6. Safety for personnel is ensured via the shorting bar that makes a short circuit before the current circuit to the coil is opened via the relay connection pins upon withdrawal. Upon insertion of a relay the coil circuit is made before the shorting bar is opened.

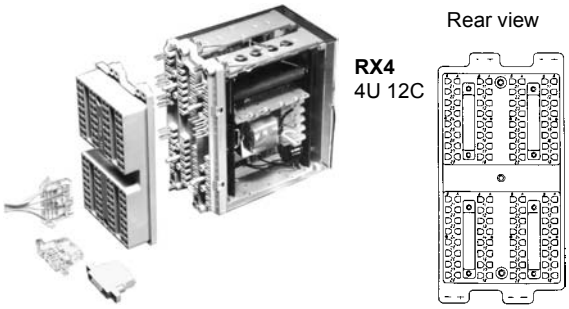

Fig. 5. The terminal base accepts accessories. The RX 4 has four spaces for accessories.

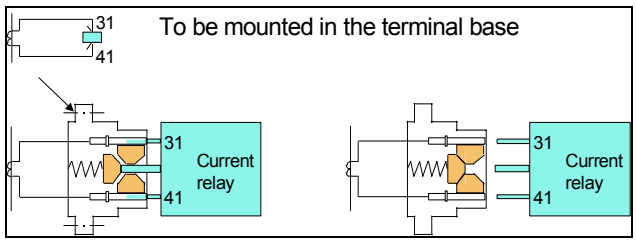

Fig. 6. The short-circuiting device RTXK mounts in the base and is operated by current relay insertion.

The RTXE component block (one block is shown in Fig. 5) mounts also in the recess of the base when it is not used for current connections. This is a convenient way of mounting diodes, resistors or thermistors. The components are sealed within the plastic encapsulation and terminated with 250 mm (10”) leads provided with 10A terminal sockets. These accessory components are used for rectification, pickup and dropout delays, discharge resistors and voltage adaptations etc. A device called RTXV also mounts in the mentioned recess like RTXE. It is used to control that the level of the pick up voltage is above a safe value. This is used for auxiliary relays or optocoupled inputs that are not allowed to operate when the voltage is low or e.g. during transient voltage discharge due to DC battery ground faults or through installed capacitive surge-suppression devices.

A variety of connectors are included in the COMBIFLEX system. The RTXG connector is used for rapid and simple connection and disconnection of leads and multi-core cables for example those between apparatus groups and individual cubicles. Mechanical assemblies of up to six RTXG are available. The RTXC branch connector shown in Fig. 7 is used or making branch connections with leads. With a number of branch connectors assembled together, a number of incoming leads can be joined to a greater number of outgoing leads.

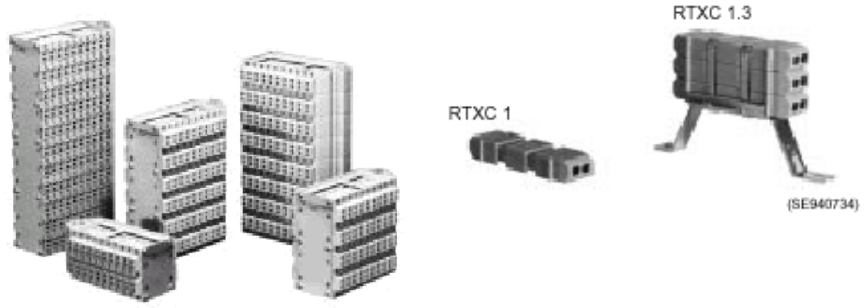

Fig. 7. The RTXC connectors are built up from individual branch connectors RTXC 1.

The branch connector has contact clips and silver-plated terminal pins built into a plastic holder. It is available with 10 A or 20 A terminals. The 10 A connector is beige and the 20 A connector is transparent. Up to four socket leads, for example one incoming and three outgoing, can be connected to the RTXC 1 branch connector. Blocks of 20, 40, 60, 80 and 100 RTXC 1 are also available. The RTXC offers following advantages compared to conventional screw terminals;

a. Electrical isolation – Internal wiring is connected to one side of the block and all the field connections are made to the other side without any exposed electrical parts.
b. Rapid and reliable connection – This is accomplished by the quick socket connection securely held in place by the retaining clip.
c. Space saving – About 8 times as many connection points can be made in the space usually occupied by a typical screw terminal block.
d. Multiple connection points. Any number of connection points can be accommodated via jumpers between the individual RTXC connectors in a RTXC 100 connector block assembly.
e. A branch connector type RTXCB can be used to provide access to two 10A terminals from one point.
f. The RTXD extractor is used to release wiring from RTXC in the same way as for the relay terminal bases.

5. COMBITEST

The test switch allows testing of functions related to the total relay package in a user-oriented manner. There are versions for 8,18 or 24 contacts with associated test plug handles. Accessory plugs provide means for temporary blocking and also for in service current and voltage measurements. Only one test handle of each size is required for all existing versions of test switches used for testing any protective relay. The design is fail safe in that no wiring is needed to ensure proper shorting of current circuits when the handle is inserted into the test switch. This is a designed safety feature. Flexibility of this system provides means for testing complete relay system or subsystems in addition to the individual modules. The make before break contacts (normally used in the current shorting function) can also be used as an SPDT switch. This permits programming a change in the relay scheme automatically when the test handle is inserted. For example, the time delay of a backup function could be modified when testing the primary protective relays.

6. CUBICLES AND PROJECT DESIGNS

The COMBIFLEX system components are applicable for mounting into any type of panel or cubicle. The described identification and terminal designation system can be utilized in any installation. When the equipment is installed in a panel with relays of other manufacture, the designation of the location of the COMBIFLEX equipment can easily follow the existing designation system used by a client. Within the COMBIFLEX assembly, the COMBIFLEX notations and standard wiring tables used in the manufacturing can normally also be included in the client system. Standardized CAD drawings of protection schemes and individual relays are available on the Internet for downloading and use in these designs by OEM´s and customers directly at; www.abb.com/SubstationAutomation

Fig. 8. Interior of the relay room at the Ibiuna substation in Brasil.

The modular system is compatible with equipment of other manufacturers. It is recognized that the flexibility of the COMBIFLEX system becomes increasingly advantageous with the scale of use. A good example of a large installation with many relay cubicles containing COMBIFLEX protection, control and signaling functions is the substation at Ibiuna. The same COMBIFLEX relaying arrangement is also used at the Itaipu substation. Both stations are owned by Furnas in Brasil.

7. AUXILIARY RELAYS AND TIMERS / REPLACEMENTS

The COMBIFLEX modular sizes and shapes have been selected to maximize the values in three areas:

a. User's applications in respect to standardization with flexibility, high functional density, and low installation and maintenance costs.
b. Designers' flexibility to provide large enough components to minimize interfacing points with other modules, yet small enough to facilitate the introduction of new techniques on continuing basis.
c. Manufacturer's quality control and efficiency.

A new range of low cost auxiliary relays is now available for light to medium contact duty applications. The relays are designated RXMB1, RXMB2, RXMC1, RXMD1 and RXMD2 (Fig.8). The two relays within RXMB1 may be used separately to provide 2 or 3 contacts per coil or with the coils paralleled to provide more contacts when needed. RXMB 2 doubles this capability. Some RXMB versions are pin compatible with earlier RXMA and RXMM relays. One example of an application for a special RXMB 1 relay is for trip circuit supervision as shown in Fig. 9. The RXMD1 and RXMD 2 are bi-stable relays with light duty contacts. RXMD2 is providing more contacts and can be used to replace RXMVB 2 pin-compatibly when lighter contacts are acceptable.

The timers available in COMBIFLEX cover the setting range from 10 milliseconds to 99 hours (i.e. days). Microprocessors or programmable custom integrated circuits are used. Auxiliary output relays with contact are used. Very good accuracy is achieved and the new relays replaces over 50 older timer models and versions with

pin-compatible connection arrangements. This permits older installations to find new replacement relays for all timing purposes. Spares can then be reduced to a few models covering the entire operating voltage range and timing ranges of the earlier models.

Fig. 8. The RXMB 1 and RXMB 2 relays

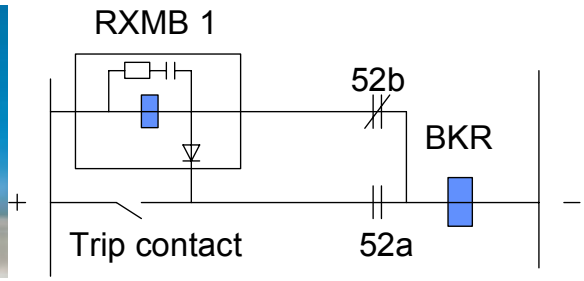

Fig. 9. Trip circuit supervision using a version of the auxiliary relay type RXMB 1

The following user advantages are provided;

a. A nameplate containing not only the type designation, catalogue number, rating information but also a schematic showing the coil connections and the contact arrangement and connections. This is shown, for example, in Figs. 8. The new auxiliary relay line provides this information directly on the cover.
b. All relay modules and accessories use captive screws on covers.
c. Relay modules are provided with a dust-proof polycarbonate cover.
d. Relays that need visual inspection have transparent covers.
e. A sealing plug is used on relays equipped for maintenance operation of the relay armature and also for settings. This enables the user to manually test the relays without removing the cover during commissioning.
f. Targets are optionally available for many of the auxiliary types. There are both manually or electrically reset targets. The targets are protected and visible through the clear cover.
g. Standard plug-in accessory blocks are available for convenient modification of relay characteristics.
h. COMBIFLEX auxiliary relays are designed for low power consumption minimizing station battery requirements.
i. Contacts are designed to minimize contact bounce, which is necessary for a long contact life.
j. A broad range offering standard contact configurations is available.

8. PROTECTIVE RELAYS / RETROFIT

Protective relays, to fit practically any need, are provided in the COMBIFLEX design. New relay terminals, e.g. the 500-series protection and control terminals fit into the same mounting arrangements and combine easily with the COMBIFLEX auxiliaries and protective functions in racks and cubicles. New housing arrangements are available to combine COMBIFLEX modules into the 6U height of the 500 series terminals (not described in this paper). It is expected that the physical size needed to do the job will continue to shrink as the electronic components shrink at the same time the capability increases.

The COMBIFLEX modular building block system is used to provide complete Protection Schemes. One example is the modular generator protection scheme type RAGCX. In the RAGCX, the standard relay components combine to make custom generator protection schemes. At the same time space is reduced and higher functionality achieved compared to previously used relays. The earlier protection assemblies are practically speaking shrunk into individual plug-in units in the RAGCX. The new measuring elements offer a wider range. For example, the over current relay RXIDK 2H (RAIDK) has a setting range 75mA to 40A for the 1A version and 375mA to 200A for the 5A version. This makes the relay universally applicable and only two models are needed compared to the earlier RXIDF relay that was offered in 21 version.

Current and voltage measuring relays filter the input signal to suit different applications. The standard relay frequency response for 50-60Hz relays (without the optional filter) provides a moderately increasing operating value for higher frequencies. The optional filter, which is built in to the relay, can be selected to provide a flat frequency response from 20Hz to 2000Hz or a sharp 50-60Hz characteristic or 150-180Hz characteristics. The new single-phase based measuring microprocessor relays in the star 2H series and their replaced earlier relay types are found in Table 1.

Table 1. The Star-2H series relays.

Relay type	Function and earlier relay replacement possibilities
RXIDK 2H	RXIDF 2H replacement. Also RXIDE 4 can be functionally replaced
RXIDG21 H/RAIDG	Replacing RXIDG2H special logarithmic characteristic Time-Over-Current relay for selective sensitive ground fault relaying.
RXVK2H/RAVK	Replaces RXVE thermal over-current protection.
RXEDK 2H/RAEDK	Two-stage selectable over or under voltage relay with inverse of fixed time delay, offering replacements to many earlier products. RXEL, RXEF, RXEG etc
RXFK 2H/RAFK	New two-stage frequency relay module replaces single stage RXFE 4 and provides an alternate dF/dt function to the second stage in addition. The relay is suitable for different applications e.g. load shedding with 10mHz or 25mHz setting resolution
RXLK 2H/RALK	V/Hz relay for over excitation protection of transformers and generators. Replaces RATUB and provides new inverse functions suitable for different protected objects.
RXPDK 2H/ RAPDK*	Three versions of directional overcurrent and ground relays replacing RXPE/RXIDF combinations and RXPF 4, RAEPA etc.
RXISK 2H/RAISK	Voltage restraint overcurrent relay. Replaces combinations of overcurrent and undervoltage relays e.g. RXIDF 2H or RXIDK 2H with RXIG 2 or RXEDK 2H.
RXZK 2H/RAZK*	New multi-purpose single zone and dual zone and out of step impedance relays. These relays may substitute RXZF 2 and RXZK 4 and many special assemblies
RXPPK 2H/RAPPK	Reverse power relays replacing RXPE 40 etc

In order to improve the operation of directional overcurrent and impedance relays for close in faults when the polarizing voltage disappears a controlled voltage memory function is provided for the RXPDK 21H and the RXZK 21H and RXZK22H.

The dc burden of the new relays is substantially lower than earlier types. The burden is typically 1,3 W per module before operation and 3W maximum during operation. This favorably affects service costs and also reduces heat build up in the panel thereby reducing ambient operating temperatures. This is favorable affecting life expectancy of the relay installation and the total life-cycle costs.

8.1. THREE-PHASE MULTIFUNCTION PROTECTIVE RELAYS

During the late 1990´s the COMBIFLEX developments have been focused on multi-phase relays and also new mounting arrangements and production improvements. New multi-phase relays have been introduced in order to enable more efficient packaging and substitution of some earlier relay types where component supplies are dwindling and production difficulties exist.

RXEDA 1 three-phase overvoltage relay with definite time delay setting. The relay does not require a separate auxiliary DC battery voltage supply for operation and can therefor replace earlier electromechanical relays such as single phase or three-phase assemblies of the RXEC 1 and RXED 1 and also the RXEL 2. The relay is suitable for AC and DC operation. RXEDA 1 can also be used as an undervoltage relay but then a separate timer is needed when time-delayed function is required. E.g. the RXKL 1 or RXKA 1 can be used. The star one platform allows functions to be programmed into a very small amount of space. The RXETB 1 (Fig. 10) is a three-phase fuse failure relay replacing the earlier RXETA 1 type that contained a mercury wetted contact which now is not permissible in some countries for environmental reasons. The star four platform allows compact solutions to be programmed into a unit having 4 analog inputs for current or voltage. A number of relays are being created by using this platform.

The dc burden of the star four platform itself without the dc/dc converter power supply is below 3W prior to operation with the back-light text-window lit up and less than 5,5W after operation. This favorably affects service costs and also reduces heat build up in the panel thereby reducing ambient operating temperatures. This favorably affects the life expectancy of the relay installation and the total life-cycle costs.

Fig. 11. The star four platform allows compact solutions to be programmed into a unit having 4 analog inputs for current or voltage.

Fig. 10. The compact RXETB 1 three-phase fuse failure relay

- RXHL 401 three-phase and ground overcurrent relay replacing the RXIDE 43 and RXIDK 4 and some versions of RACID, RACIC.
- RXHL 411 three-phase and ground overcurrent multifunction relay. This relay offers a replacement for the three-phase and ground overcurrent RACIB, RACIC and three-phase thermal overload relay RXVE 43 and the RXIDK 4 and some versions of the RAICA breaker failure relay. In addition the reclosing relay function of RACIB is optional.
- RXHL 421 - same as RXHL 411 but two-phase overcurrent and a directional ground relay function for high impedance grounded systems. Can replace e.g. RACIB and combinations of discrete relays e.g. RXIDE 43 with RXPE 4. The relay has a ground directional unit with a unique “synchronous” memory. This permits operation under very special conditions.
- RXHL 422 - same as RXHL 411 but two-phase overcurrent and a directional ground relay function for low impedance or solidly grounded systems. Can replace e.g. RACIB and combinations of discrete relays e.g. RXIDE 43 with RXPE 4. The relay has a directional unit with a unique “synchronous” memory. This permits operation under very special fault conditions.
- RXIIK 4 – a negative sequence overcurrent relay. This is a replacement for the RARIB and RARID relays.
- RXHB 411 – a compact breaker failure relay for transmission networks. The relay has current based back-up functions in addition to the breaker failure functions that may be used also for single pole trip applications with separately set breaker failure back up trip timers for different fault types. The relay permits setting current detectors below load in order to secure operation even when low level fault currents are present.

The wide setting range offered for phase overcurrent and the separate settings and elements for groundfaults makes its possible to adapt to most system applications including the needs for high voltage transmission. Versions allow different rating of the ground current input transformer to enable applications for all types of system grounding methods, i.e. solid, medium and high impedance, resistor or reactor grounded systems.

The breaker failure function included in the overcurrent relays RXHL 411, 421 and 422 is complete with separately set current detector levels for the phase and ground currents. The phase current settings are permitted to be below rated current as initiation of the BFR function only takes place after a trip command has been given.

All the IEC standard curves NI, VI, EI are available as well as the RI (ASEA-curve) and the Long time inverse curve. The logarithmic RXIDG curve is also available as a setting for the ground element. This curve is mainly used for clearing of ground faults in the solidly earthed 400kV systems in Scandinavia.

There are two opto-coupled inputs and five programmable output relays in the basic star four platform that can be tied to any of the included relay functions. One output can be used for the processor internal supervision and the processor watch-dog. There is also an optional I/O expansion board available having 4 optocoupled inputs

and 4 extra output relays. DC supply is taken from a standard RXTUG 22H, suitable for all battery voltages from 24V to 250V. (The unit has an 18-300V operating range.)

9. ECONOMIC ADVANTAGES

The economics of standard designs are well recognized. Utility standards are frequently limited to a required non-modular moulded case auxiliary relay and timer design. Very often those relays are specified to have screw terminals. The required space is often large due to the specified need for ring lug terminals. With the modular COMBIFLEX design, up to 80 relay functions or 150 contact outputs can be provided in a 4U standard 19" equipment frame. This compact and modular design impacts favourably on the total cost.

COMBIFLEX scores favourably in installed component labor cost. Rack mounted devices are easier and less costly to mount as compared to mounting individual moulded case or industrial grade equivalents. Rack mounting does not require the expensive and time consuming process of punching individual cut-outs in steel panels and the broad line of COMBIFLEX components to select from greatly the need for mounting individual devices. Physical mounting effort has been conservatively estimated at about 25% of the other methods. COMBIFLEX wiring costs is estimated at about 20% of the traditional screw connections. The inherent and costly problems of intermittent connections and the exposed electrical hot points representing physical and potential hazards to personnel are eliminated by the safety features of the locked COMBIFLEX pin and socket connection.

COMBIFLEX is faster, easier and less costly to modify or expand. Steel-panel changes are not normally required and the associated drafting, engineering, steel and labor costs are therefore greatly reduced. The modular plug-in design of relays, other component devices and all the connections provides additional cost savings in field labor. COMBIFLEX also offers a flexible and convenient shelf storing feature. Spare or future relays can be mounted and stored in either unfilled or spare rack mounted equipment frames. Such relays and bases can be utilized for future expansion or replacement purposes. Other cost savings are realized with the low continuous power consumption of the COMBIFLEX auxiliary relays. E.G RXMA 2 with 15 contacts and only 2W consumption. This reduces requirements on the station battery and ancillary equipment.

Economical custom solutions can be created by the user without need for special programming or design skills. COMBIFLEX relays are in service world-wide with extensive installation in the tropics and desert areas, as well as the northern latitudes of U.S. and Europe. The system meets ANSI and IEC standards. Seismic vibration testing according to ANSI standard C37.98 have been performed and the evaluated fragility levels for COMBIFLEX relays and components are available upon request. Many of the relays have been tested and approved for nuclear applications in the US as well as in Sweden and other countries.

Modern relays have a designed life-expectancy of about 25 years. Many of the earliest installations of COMBIFLEX relays and components are therefor due to be replaced within the foreseeable future. It is the intention of ABB to enable ease of replacement with the presently available modern and coming new models of the COMBIFLEX design.

10. CONCLUSION

The continuous introduction of modern technology into the COMBIFLEX system ensures it´s place in future protection and control in the OEM market and also for the power system customers that build their own relay and control panels. Retrofit of existing installations will become more important as the continued deregulation process increase profitability demands. Cost efficiency is therefore emphasized in the new product developments and also in the refinements of existing products. A complete new series of microprocessor based single phase measuring protective relays now exist to fill the needs of maintaining existing COMBIFLEX installations in service many more years to come. Numerical multi-phase and -function COMBIFLEX relays, that are easy to use, meet the latest customer specification requirements and allow very compact and space saving installations.

REFERENCES

[1] For more detailed information (Buyer´s Guide, Brochures, Diagrams, etc.) refers to Website: www.abb.com/SubstationAutomation