Getting it right the first time

Innovative development of low-end intelligent relays for distribution applications

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As the demand for low-end intelligent electronic devices (IEDs) grows, ABB is responding by developing its own portfolio of low-end relays. In this context, the company initiated its RE_60_ program in late 2005. The immediate focus of this program was to address the development of the REJ601, REF601 and REJ603 relay types.

REJ601 and REF601 are auxiliary-powered, three-phase over-current and earth-fault relays with Rogowski-sensor interfaces. REJ603 is a self-powered, three-phase over-current and earth-fault relay with customized CT interface. REJ603 was the first of these products to come onto the market. The launch of REF601 will follow shortly.

For a product to be competitive in the low-end segment, a number of important factors must be considered: The total cost of the device, including design and development, should be minimal; increased functionality should be incorporated; and the time to market should be short. To meet these criteria, ABB adopted a "first-time-right" development approach. The principle behind this approach is that only one prototype is created, and redesigns and modifications are avoided.

Consequently, the requirements had to be very clear from the beginning. Additionally, it was important to embark on an intensive and comprehensive review of the mechanical and electrical designs in terms of functional, environmental (EMC[1]), temperature, vibration) and cost aspects. The initial designs were distributed within ABB for scrutiny. The target was to identify as many deficiencies as possible ahead of the prototype design phase. For some details, smaller pre-studies were initiated to fully verify the functionalities and requirements.

The accompaniment of the design process by strict application of the stage gate model Factbox 1 and the intensive type-testing of the first ultra-low-end relay, recently enabled the relay to progress beyond the design center into production. The new REJ603 device is the first of a completely new low-end series.

The principle behind the "first-time-right" approach is that only one prototype is created, and redesigns and modifications are avoided.

Factbox 1 The ABB gate model

A gate model is a decision-support tool for project and business management. Its name derives from the so-called gates marking the completion of important project milestones. When such a gate is reached, progress is reviewed and future actions decided.

Requirement planning

For a "first-time-right" development to succeed, the requirements need to be crystal clear.

A sophisticated requirements management tool was used to handle these requirements. The tool helped define initial market requirements using input from different end users obtained through active participation of product managers across the globe. These requirements were refined in a time of three months. Specific pre-studies were also embarked upon to define the best approach to the more critical aspects of the project. Once the market requirements were frozen, product specifications were drawn up to capture their respective implementation approaches. Active dialogue between the product management and research and development teams in this phase helped in the creation of the very stable requirements.

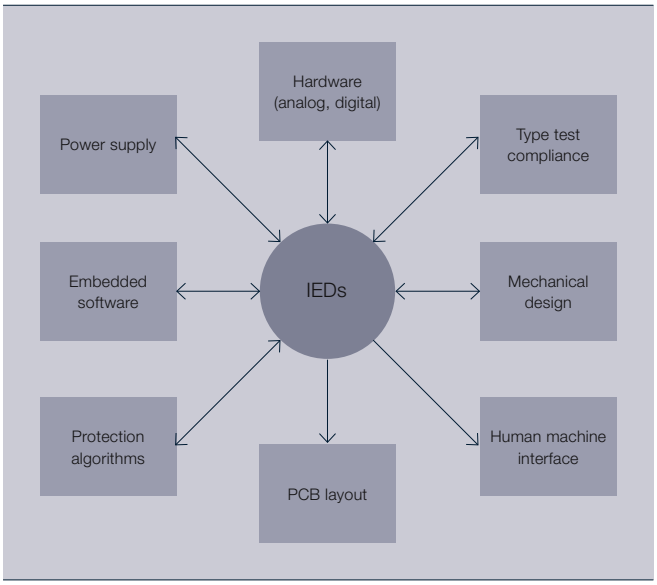
Product design

The efficient development of products requires integration and coordination among multiple functional areas 1.

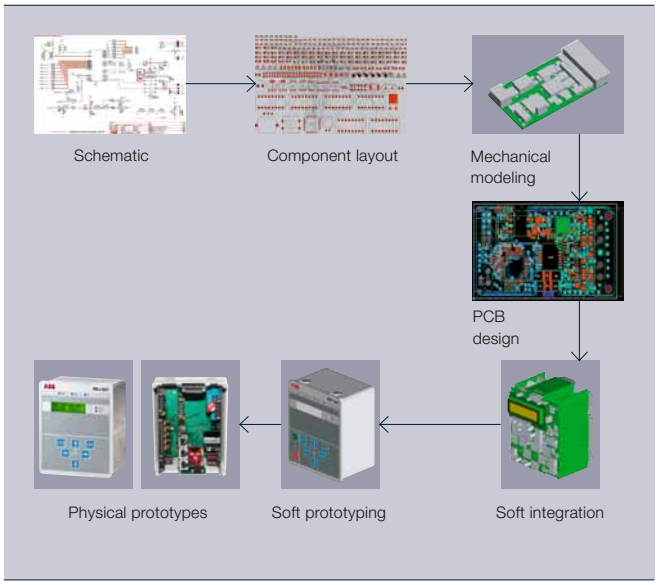
To accurately hit the "right the first time" approach, special attention was given to extensive simulation in all aspects of the development of the prototype. The electrical designs were extensively reviewed from a functional, environmental and cost point of view 2.

After the component's specifications were screened by ABB's component engineers, schematics for the functional part of the design were created. The component standardization process used also helps ensure that most component types selected can equally be sourced from alternative manufacturers. It also ensures that the component types selected conform to ABB's

1 The efficient development of products requires integration and coordination among multiple functional areas.



2 The creation of an intelligent electronic device (IED) design – from schematic to prototype



broader requirements. This facilitates economies of scale for components used in common with other products of ABB's Distribution Automation division.

Special attention was given to extensive simulation in all aspects of the development of the prototype.

The selection of the digital core (microcontroller) took into account the flexibility required of the architecture so that it could meet the product's short- and long-term development requirements (with scalable features and reusability of code).

The schematics were subsequently translated for PCB[2] layouts with the standard footprint/PCB decal libraries. The process followed common guidelines for PCBA[3] specifications so as to ensure reduction in the cycle time in PCBA manufacturing. PCB layouts were also reviewed for optimal immunity to electromagnetic interference.

Embedded code that was to become an integral part of the product was also handled in a high-level language (HLL) environment. The code is structured so as to support maximum reusability of modules. The profiling of the code in a simulated environment also facilitated in the estimation of the real-time performance of critical modules, reducing the post-integration effort.

Specialized hardware test code was also developed for the boards to be able to test basic hardware readiness immediately on the receipt of the PCBA.

The mechanical side was designed in parallel. This process also captured the 3-D models of the PCBA. Soft modeling of the complete product helped optimize the internal product layout with efficient use of available volume. It also helped eliminate physical issues related with inter-PCBA or PCBA-mechanics mismatches. This approach minimized iterative aspects and related conflicts that must typically be dealt with in a traditional development cycle.

Following this soft modeling of the products, design for assembly (DFA) and design for manufacturing (DFM) analyses were performed on the integrated soft prototypes. This way, the critical aspects of the review were covered, while shorter cycles were achieved in the manufacturing line.

An automated test system enabling reduced product test cycles on the shop floor during production was also designed. This system helps to perform the high quality functional check for each sample and ensures a common product-test platform for the IEDs of ABB's Distribution Automation Product Group.

The profiling of the code in a simulated environment facilitated in the estimation of the real-time performance of critical modules, reducing the post-integration effort.

REJ603 technical highlights

REJ603 is a self-powered three-phase non-directional overcurrent and earth-fault protection device with DMT[4] and IDMT[5] characteristics.

The relay offers two-stage, short-circuit and time-over-current protection against phase-to-phase and earth-faults, being immune to magnetizing transformer inrush. It has extensive

3 Self-powered feeder protection relay REJ603 for secondary distribution protection

Factbox 2 Additional highlights of the REJ603 relay

- Dual mode of earth-fault measurement: internal calculation and external CBCT[*] input
- Integrated IDMT curves (IEC and special) in a single product to cover time coordination needs of secondary distribution protection
- Capacitor discharge impulse output for low-energy trip coil
- Built-in manual-reset electromechanical flag for trip indication
- Easy setting by DIP switches, protected by a transparent cover
- Compact design and mounting arrangement suitable for ring main unit (RMU) applications
- Test facility for testing entire scheme, including primary CT, relay, and trip coil
- External binary input, activated by an external voltage input, which can be utilized for remote tripping of the circuit breaker

Footnote

[*] CBCT: core balance current transformer

Footnotes

[1] EMC: electro-magnetic compatibility

[2] PCB: printed circuit board.

[3] PCBA: PCB assembly

[4] DMT: definite minimum time (a DMT relay is designed so that the time needed for the relay to release is approximately constant over the working current range of the relay)

[5] IDMT: inverse definite minimum time (an IDMT relay is designed so that the time needed for the relay to release is inverse to the current over part of its working range)

self-diagnosis capabilities and a fail-safe feature that causes the circuit breaker to trip when the phase current exceeds 20 times the Is_{max} current of interface CT and there is a critical failure of the internal relay.

Some of the additional highlights of the REJ603 3 are shown in Factbox 2.

Area of application

REJ603 is designed for the selective short-circuit and earth-fault protection of feeders in secondary distribution networks and for protection of transformers in utilities and industries. The device is a self-powered numerical relay, requiring no external supply voltage, making it an ideal choice for installation even in remote locations where auxiliary supplies are not available. The relay is primarily used in ring-main units within distribution networks and it derives power from the primary current transformers 5.

The REJ603 has been commercially released.

REJ601 / REF601

The REJ601 / REF601[6] is an auxiliary-powered relay providing three-phase non-directional overcurrent and earth-fault protection with DMT and IDMT characteristics. It uses Rogowsky current sensors for phase-current measurement.

With its compact size and unique technical features, the RE_ 601 series is an ideal solution for retrofits and implementations in restricted spaces.

The relay offers three-stage, short-circuit and time overcurrent protection against phase-to-phase faults and two-stage protection against earth-faults, and is immune to magnetizing transformer inrush. It has extensive self-supervision capabilities. The integrated protection of the RE_ 601 devices, along with the benefits of modern current sensors, provide the improved availability, compactness and safety of medium-voltage switchgears.
The RE_ 601 relay has a user-friendly design. The pre-adapted inputs/outputs and universal power supply allow the relay to suit to user needs easily. In addition, the LCD display and five dedicated LEDs clearly display online measurement data and faults, events / fault records allowing them to be rapidly analyzed and dealt with.

Optional communication allows the relay to connect to control and monitoring systems through serial communication for remote control and monitoring.

Some of the additional features of the RE_ 601 4 are listed in Factbox 3.

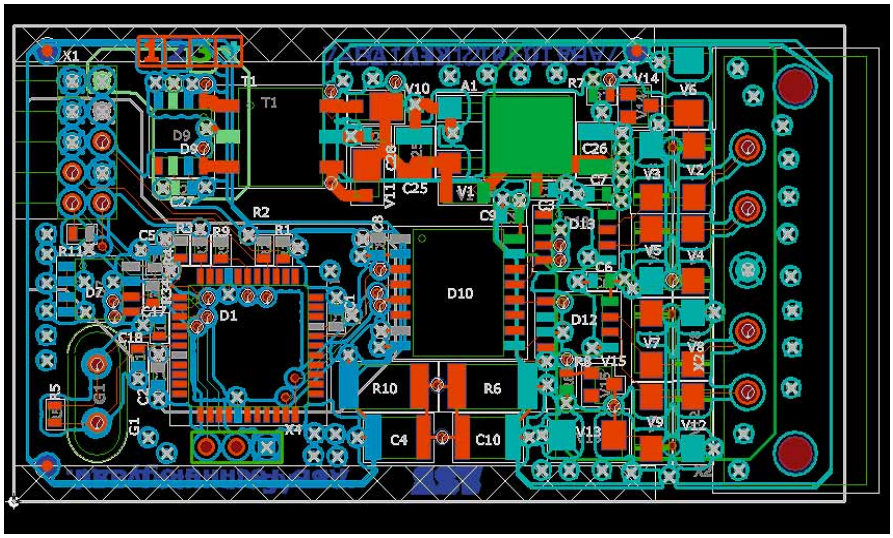
Area of application

RE_ 601 is a numerical feeder protection relay, designed for the protection and control of utility and industrial

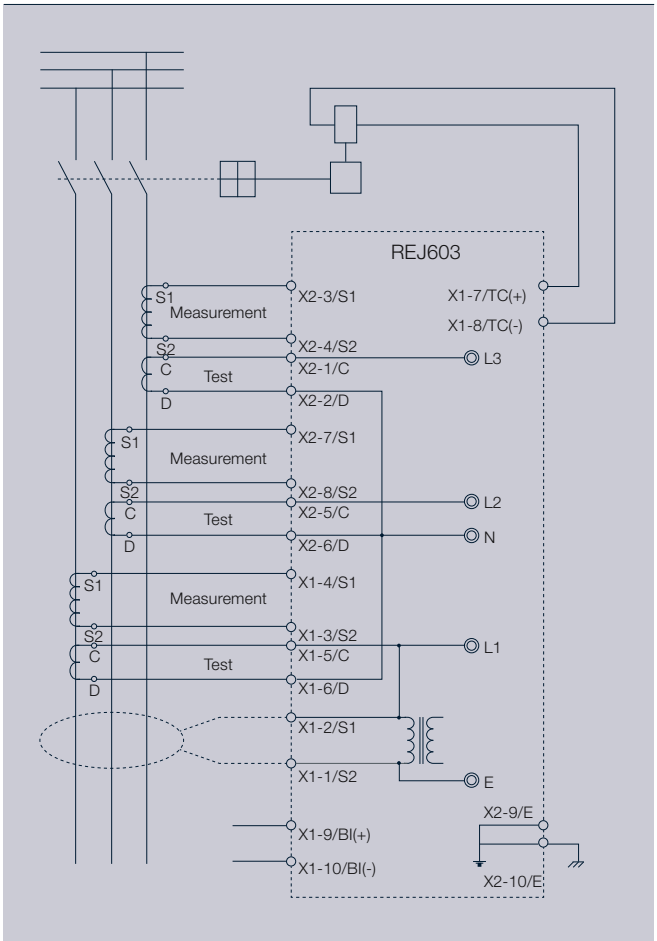
Factbox 3 Additional highlights of the RE_ 601 relay

- Integrated IDMT curves (IEC and special) in a single product
- Sensor interface eliminates need for current transformers with different nominal values
- Availability of four selectable current ranges
- Unit-ready/internal-relay failure, protection start and trip indications via LEDs
- Phase overcurrent and earth-fault indication through separate LEDs
- Universal-range power supply providing compatibility to different conditions of the installation's supply-voltage
- External input for remote trip and remote reset
- Local as well as remote breaker control (only on REF601)
- Optional remote serial communication feature over MODBUS-RTU protocol
- Test facility for relay hardware

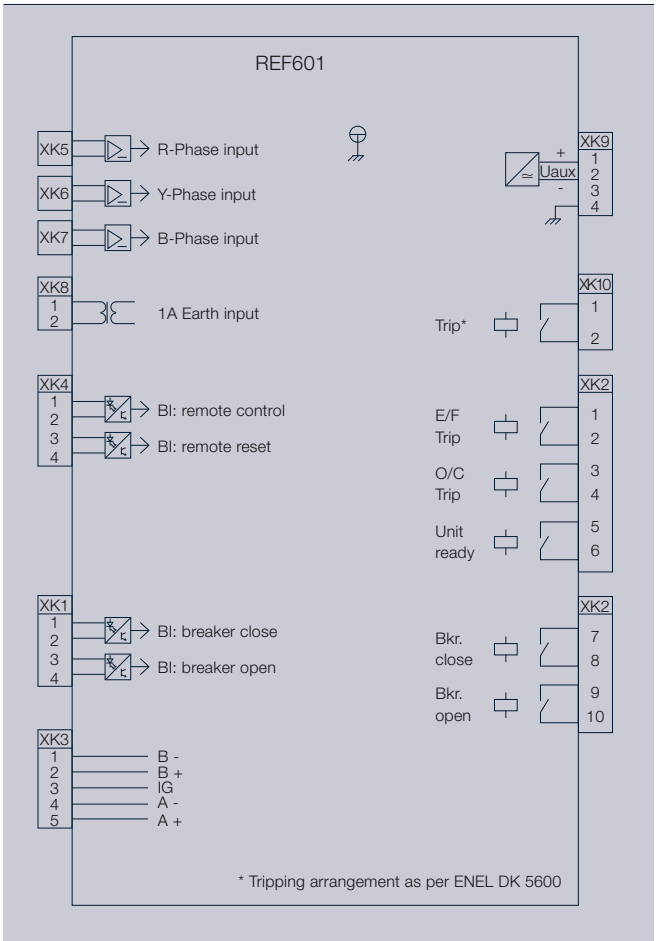
4 ABB's REF601 a and REJ601 b relays



5 Connection diagram of self-powered feeder protection relay REJ603

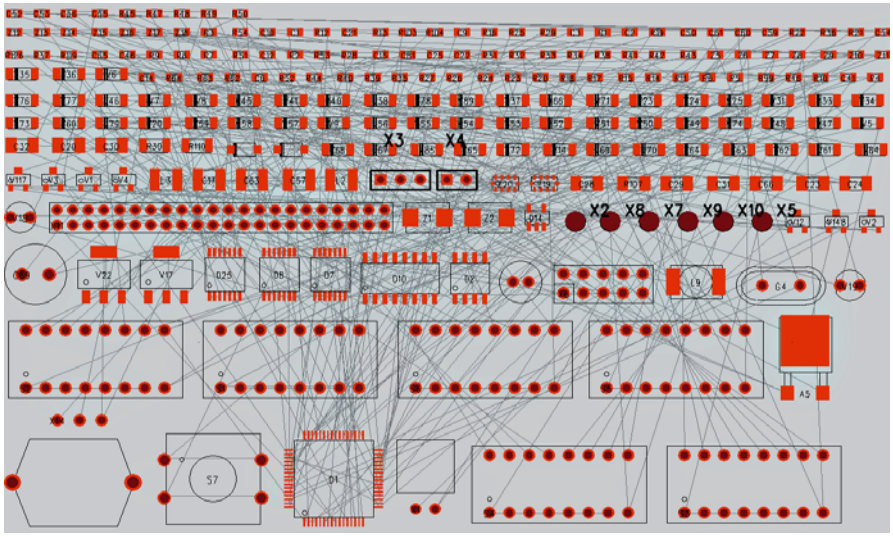


6 Connection diagram of REF601 overcurrent and earth-fault relay



power systems in primary and secondary distribution networks 6. The relay is primarily used along with ABB VD4 / HD4 – R series circuit breakers. With its compact size and unique technical features, the RE_ 601 series is an ideal solution for retrofits and implementations in restricted spaces. It has a shallow mounting depth and no loose parts, and is quick and easy to install on breakers such as the ABB VD4 / HD4-R types.

The market release of RE_ 601 is scheduled for the fourth quarter of 2008.



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Footnote

[6] A REF relay is a feeder protection and control device, whereas a REJ relay is a protection device only.