

An Improved Ring Main Unit

Field of the Invention

- 5 The invention relates to fault protection apparatus for electrical distribution systems. The invention particularly relates to ring main units for electrical distribution systems.

Background to the Invention

- 10 A ring main unit (RMU) is a fault protection apparatus for use with electrical distribution systems. A typical RMU comprises multiple moving contact switching devices, each incorporated into a respective circuit branch of the RMU. In some RMUs, including a type commonly referred to as a smart RMU (SRMU), each switching device is operable by one or more respective protection device coupled to the respective circuit branch. Each protection device may comprise one or more current
15 transformer and a relay.

It is desirable to minimize the number of current transformers that are required by the RMU, since this reduces its cost and complexity, and increases its reliability.

20 Summary of the Invention

- A first aspect of the present invention provides a fault protection apparatus comprising: a plurality of feeders, each feeder being connectable between a common feeder connection point and a respective feeder terminal; a respective switching device provided in each feeder between said
25 common feeder connection point and said respective feeder terminal; and a respective feeder protection device associated with each feeder, each feeder protection device comprising a sensor and a feeder protection relay, the sensor being coupled to the respective feeder and connected to the feeder protection relay, the feeder protection relay being coupled to the respective switching device and being operable by said sensor to operate said respective switching device, wherein each
30 sensor has first and second connection terminals, and each feeder protection relay has first and second connection terminals, the first terminal of each feeder protection relay being connected to the first terminal of the respective sensor, the respective second terminal of at least two feeder protection relays being connected to a common relay connection point, and the respective second terminal of the respective sensors of said at least two feeder protection relays being connected to a
35 common sensor connection point, and wherein the apparatus further comprises an internal protection relay having first and second terminals being connected respectively to the common relay protection point and the common sensor protection point.

- A second aspect of the invention provides a ring main unit (RMU) comprising the fault protection
40 apparatus of the first aspect of the invention.

Preferred features are recited in the dependent claims appended hereto.

Further advantageous aspects of the invention will be apparent to those ordinarily skilled in the art upon review of the following description of a specific embodiment and with reference to the
5 accompanying drawings.

Brief Description of the Drawings

An embodiment of the invention is now described by way of example and with reference to the
10 accompanying drawings in which like numerals are used to denote like parts and in which:

Figure 1 is a schematic view of one phase of a typical ring main unit (RMU);

Figure 2 is a schematic view of one phase of an RMU of the type shown in Figure 1 illustrating a
15 conventional arrangement of protection devices implementing a first protection scheme;

Figure 3 is a schematic view of one phase of an RMU of the type shown in Figure 1 illustrating a conventional arrangement of protection devices implementing a second protection scheme;

20 Figure 4 is a schematic view of one phase of an RMU of the type shown in Figure 1 illustrating a preferred arrangement of protection devices implementing a first protection scheme and embodying one aspect of the present invention;

Figure 5 is a schematic view of one phase of an RMU of the type shown in Figure 1 illustrating a
25 preferred arrangement of protection devices implementing a second protection scheme and embodying one aspect of the invention; and

Figure 6 is a schematic view of a 3-phase RMU of the type shown in Figure 1 illustrating a preferred arrangement of protection devices implementing a first protection scheme and embodying one
30 aspect of the present invention.

Detailed Description of the Drawings

Referring now to Figure 1 of the drawings there is shown generally indicated as 10 a fault protection
35 apparatus suitable for use with embodiments of the present invention. The fault protection apparatus 10 may be connected to an electrical distribution system (not shown) in order to protect parts of the system (e.g. a transformer) from the effects of a fault in another part of the system. The apparatus 10 comprises multiple circuit branches 12 (typically referred to as feeders), each feeder 12 having a terminal 14 for connection to another part (not shown) of the system, for example a transformer or a
40 network line (e.g. electrical cable). Each feeder 12 typically comprises a bus bar. In the illustrated

embodiment, the apparatus 10 has three feeders 12. In alternative embodiments, the apparatus 10 may have two or more feeders 12.

The apparatus 10 includes a common connection point 15 to which each feeder 12 is connected.

- 5 Between the common connection point 15 and the respective terminal 14, each feeder 12 includes a switching device 16 that includes a movable contact switch 18 operable between an open state and a closed state. In the closed state, the movable contact switch 18 makes an electrical connection within the switching device 16, and in the open state the movable contact switch 18 breaks the electrical connection within the switching device 16. In one mode of operation when the movable
- 10 contact 18 in its closed state, the switching device 16 allows electrical current to flow through itself, thereby connecting the respective terminal 14 to the common point 15. In another mode of operation when the movable contact is in its open state, the switching device 16 prevents the flow of electrical current between the respective terminal 14 and the common point 15. The precise configuration and operation of the switching device 16 may vary from embodiment to embodiment. For example, in
- 15 some embodiments, the switching device 16 may be operable between an engaged (or closed) mode, an earthing mode and an isolating mode, and may include components in addition to the movable contact switch 18 to effect these modes.

- Each feeder 12 further includes at least one protection device 20 that coupled to the feeder 12 to
- 20 detect faults. The protection device 20 is also coupled to the respective switching device 16 to operate the switching device 16 in the event that a fault is detected. In particular, the protection device 20 causes the movable contact switch 18 to open upon detection of a fault. The protection device 20 typically comprises at least sensor 22 coupled to the feeder 12 to monitor current and/or voltage, and at least one relay 24 (typically comprising a relay (electromagnetic) coil or a digital
- 25 relay) coupled to the switching device 16 for operating the movable contact switch 18 in the event that a fault is detected. The sensor 22 may for example comprise a current transformer (typically comprising a primary winding coupled to the feeder 12 and a secondary winding connected to the relay 24).

- 30 Typically the apparatus 10 is used with multi-phase electrical distribution systems in which case a respective instance of the apparatus 10 is provided for each phase (although the relays 24 may be used in common by each phase as is illustrated by way of example in Figure 6).

- The movable contact switch 18 is typically part of a circuit breaker (not shown), i.e. the switching
- 35 device 16 comprises a circuit breaker (typically together with one or more other components to enable the switching device to operate as required for the application). For example, the switching device 16 may comprise a vacuum circuit breaker (VCB), in which case the movable contact switch 18 may be vacuum interrupter.

- 40 An apparatus of the type shown in Figure 1 may be referred to a ring main unit (RMU), or more specifically as a smart ring main unit (SRMU) in the case where it includes relay-operated circuit

breakers or the like. Generally, a RMU or SMRU is connected to two (cable) lines and one or two transformers via its terminals 14.

The apparatus 10 may be configured to provide more than one protection scheme, for example differential line protection, exact or rough balance bus bar protection, or transformer overcurrent or thermal protection. Each type of protection may require the detection of one or more respective fault conditions that may depend on the current and/or voltage detected in one or more of the feeders 12.

Figure 2 shows a single phase of an SMRU 110 (in which the switching devices are not shown)

having a respective feeder protection device 120 for each feeder 112, each protection device comprising a current transformer 122 and a relay 124. The protection devices 120 may support one or more protection schemes for protecting for the respective feeder 112 (and therefore for the respective line or transformer to which the feeder may be connected). In addition to this feeder protection, the SRMU 110 is configured to support protection against internal (bus bar) faults. One method to implement this protection is to have a respective additional current transformer 222 in each feeder 112, the additional current transformers 222 being connected to an additional bus bar protection relay 224. The additional current transformers 222 are connected in parallel and the additional relay 224 is connected to the common points A, B of these connections as shown in Figure 2. For typical multi-phase applications, the architecture of Figure 2 is repeated for each phase (although the relays 124, 224 may be used in common by each phase as is illustrated by way of example in Figure 6). Typically, the bus bar protection relay (BP) trips the circuit breakers in all feeders upon detection of an internal fault.

In use, the relay 224 is responsive to an unbalance of the phase currents in all incoming and

outgoing feeders 112 to provide what is known as exact bus bar balance protection (against internal faults).

Figure 3 shows an alternative configuration of the SRMU 110 in which a protection scheme known as rough balance bus bar protection is supported. In this case, the additional current transformer for

at least one of the feeders 112 is omitted (typically the, or each, feeder connected to a transformer).

The additional current transformers 222 for the other feeders 112 are connected in parallel and the additional relay 224 is connected to the common points A, B of these connections as shown in

Figure 3. As a result the bus bar protection relay 224 is responsive to the difference of the phase currents in the incoming and outgoing lines connected to the respective feeders 112 associated with

current transformers 222. An internal fault can be identified in this case providing the bus bar protection relay 224 has a longer trip time than the transformer protection relay(s). This disadvantage (i.e. the necessity to delay tripping in case of an internal fault) is partly compensated by the advantage of providing back up protection for the failure of transformer protection.

However, a general disadvantage of the approach illustration in Figures 2 and 3 is the need for a relatively large number of current transformers (e.g. twice as many as are required just for feeder

protection in the case where exact bus bar balance protection is supported), and the associated requirement for connection facilities (e.g. plugs, harnesses), all of which increase the complexity and cost while reducing the reliability of the SRMU.

5 Referring now to Figures 4 and 5, there are shown respective examples of a protection apparatus 310, 410 embodying one aspect of the present invention. The apparatus 310, 410 are of the general type shown in Figure 1, like numerals being used to denote like parts and the same description applying as would be apparent to a skilled person. The switching devices 16 have been omitted from Figures 4 and 5 since their presence in the drawings is not necessary for an understanding of
10 the invention.

Referring first to the apparatus 310 of Figure 4, a respective feeder protection device 320 is provided for each feeder 312, each feeder protection device 320 comprising a sensor, preferably a current transformer 322, and a feeder protection relay 324. A bus bar protection relay 424 is also provided.
15 Each sensor 322 has first and second connection terminals st1, st2 (e.g. corresponding to first and second ends of the secondary winding of a current transformer). Each relay 324, 424 has first and second connection terminals rt1, rt2 (e.g. corresponding to first and second ends of a relay coil). Each feeder protection relay 324 has its first terminal rt1 connected to the respective first terminal st1 of the respective sensor 322 for the respective feeder 312. The respective second terminal rt2 of
20 each feeder protection relay 324 is connected to a first common connection point A. The respective second terminal st2 of each sensor 322 is connected to a second common connection point B. The first and second terminals rt1, rt2 of the bus bar protection relay 424 are connected respectively to the common connection points A, B. The arrangement of Figure 4 is provided for each phase (although the relays 324, 424 may be used in common by each phase as is illustrated by way of
25 example in Figure 6). The arrangement of Figure 4 allows not only individual feeder protection scheme(s) to be supported but also exact bus bar protection, while requiring relatively few sensors 322, e.g. half the number required for the arrangement of Figure 2.

The apparatus 410 of Figure 5 is similar to that of Figure 4 and the same description applies except
30 that the feeder protection device 320' for one of the feeders 312' (the central feeder 312 as shown in Figure 4) is not connected to the bus bar protection relay 424. Instead, the respective first and second terminals rt1, rt2 of the relay 324' of the feeder protection device 320' are connected to the respective first and second terminals st1, st2 of the sensor 322' of the feeder protection device 320'. The other feeder protection devices 320 and bus bar protection relay 424 are interconnected as
35 described for Figure 4. In typical embodiments, the feeder 312' is connected to an external transformer (not shown). The other feeders 312 are typically connected to an external network line (e.g. cable). The arrangement of Figure 5 is provided for each phase (although the relays 324, 424 may be used in common by each phase as is illustrated by way of example in Figure 6). The arrangement of Figure 5 allows not only individual feeder protection scheme(s) to be supported but
40 also rough bus bar protection, while requiring relatively few sensors 322.

In typical embodiments, the or each protection device 20, 120, 320, 320' associated with a feeder 12, 112, 312, 312' connected to a transformer is configured to implement overcurrent and/or thermal transformer protection. Typically, overcurrent protection operates in the following way: if measured current exceeds a preset pickup current a protection timer starts timing with a predefined speed.

- 5 When the timer reaches a threshold, the relevant protection element issues a trip request signal. If in the course of the timer incrementing, the measured current drops below pickup current, the timer resets to zero. Thermal protection generally involves an integration measurement that is activated when current exceeds certain value and continues until integrated function exceeds selected limit. In this regard it simulates physical heating of the protected device (transformer or line) and is often
10 applied for transformer and line protection at low overcurrents.

In typical embodiments, the or each protection device 20, 120, 320, associated with a feeder 12, 112, 312 connected to a network line are configured to implement differential and/or overcurrent line protection. Differential protection typically operates on the basis of comparison of the feeder current
15 with the current flowing through the feeder of a neighborhood substation. For example, the value of the current of the neighborhood substation is delivered via pilot wire or another communication channel (not shown). The relay compares two currents and in case their substantial difference trips the breaker. In this way the relay responds to the fault between substations.

- 20 Figure 6 shows a three phase fault protection apparatus 510, or RMU / SRMU, embodying one aspect of the invention and being a three phase equivalent of the apparatus 310 of Figure 4. The three phases are indicated as A, B, C, with corresponding terminals for the feeder protection relays 324 and bus bar protection relay 424 being also being labelled A, B and C.

- 25 It will be seen from the foregoing that, in preferred embodiments, one sensor, e.g. current transformer, is provided per phase per feeder (i.e. there is no dedicated sensor for bus bar protection). By connecting these sensors as described (i.e. creating two star points for each phase between which the bus bar protection relay is connected), the same functionality is provided as described in relation to Figures 2 and 3 but with a reduced number of sensors and associated
30 connection facilities. As a result of this reduction, reliability is increased while cost and complexity is reduced.

The invention is illustrated herein in the context of an apparatus comprising three feeders 12, 112, 312, in particular a three-feeder RMU. It will be understood that the invention may be used with any
35 number of feeders, and may not necessary be an RMU.

The invention is not limited to the embodiment(s) described herein but can be amended or modified without departing from the scope of the present invention.

CLAIMS

1. A fault protection apparatus comprising:

5 a plurality of feeders, each feeder being connectable between a common feeder connection point and a respective feeder terminal;

a respective switching device provided in each feeder between said common feeder connection point and said respective feeder terminal; and

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a respective feeder protection device associated with each feeder, each feeder protection device comprising a sensor and a feeder protection relay, the sensor being coupled to the respective feeder and connected to the feeder protection relay, the feeder protection relay being coupled to the respective switching device and being operable by said sensor to operate said respective switching

15 device;

wherein each sensor has first and second connection terminals, and each feeder protection relay has first and second connection terminals, the first terminal of each feeder protection relay being connected to the first terminal of the respective sensor, the respective second terminal of at least two
20 feeder protection relays being connected to a common relay connection point, and the respective second terminal of the respective sensors of said at least two feeder protection relays being connected to a common sensor connection point,

and wherein the apparatus further comprises an internal protection relay having first and second
25 terminals being connected respectively to the common relay protection point and the common sensor protection point.

2. A fault protection apparatus as claimed in claim 1, wherein the respective second terminal of each of said feeder protection relays is connected to said common relay connection point, and the
30 respective second terminal of each of said sensors is connected to said common sensor connection point.

3. A fault protection apparatus as claimed in claim 1, wherein the respective second terminal of at least one of said sensors is connected to the respective second terminal of the respective feeder
35 protection relay.

4. A fault protection apparatus as claimed in claim 3, wherein the respective terminal of the respective feeder to which said at least one of said sensors is coupled is connected in use to a transformer.

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5. A fault protection apparatus as claimed in any preceding claim, wherein the respective terminal of the respective feeder of said at least two feeder protection relays is connected in use to a network line.
- 5 6. A fault protection apparatus as claimed in any preceding claim, wherein at least one and preferably all of said sensors comprise a current transformer.
7. A fault protection apparatus as claimed in any preceding claim, wherein said feeder protection relay and/or said internal protection relay comprise an electromagnetic coil relay.
- 10 8. A fault protection apparatus as claimed in any preceding claim, wherein said feeder protection relay and/or said internal protection relay comprise a digital coil relay.
9. A fault protection apparatus as claimed in any preceding claim, wherein a respective set of said
15 feeders is provided for each phase of a multi-phase electrical distribution system, each feeder of each set comprising a respective one of said switching devices and a respective one of said sensors, and wherein the first terminal of each feeder protection relay is connected to the first terminal of the respective sensor of each respective feeder of each phase, the respective second terminal of said at least two feeder protection relays being connected to said common relay
20 connection point, and the respective second terminal of the respective sensors of said at least two feeder protection relays of each phase being connected to a respective common sensor connection point per phase.
10. A fault protection apparatus as claimed in any preceding claim, wherein each switching device
25 comprises a movable contact switch.
11. A fault protection apparatus as claimed in claim 10, wherein said movable contact switch comprises a circuit breaker.
- 30 12. A ring main unit comprising a fault protection device as claimed in any preceding claim.