SMART RING MAIN UNIT REDUCES OUTAGES TO A MINIMUM

Lars HJORT
HM Power AB - Sweden
lars.hjort@hmpower.se

Torbjörn KARLSSON
Protrol AB - Sweden
torbjorn.karlsson@protrol.se

ABSTRACT

In the 1960's, the load switch disconnector for Distribution Networks was launched for the first time. Before then, electric utilities had access only to circuit breakers large in size and requiring a lot of maintenance, or simple disconnectors and exchangeable fuses. Therefore the load switch disconnector and the fuse load switch disconnector represented a substantial break through. It opened up for smaller, cheaper substations and switchgears, and made it possible to introduce the open loop system, which reduced outage times when a fault occurred in a cable section.
Today the size and price of full range circuit breakers are such that it is possible to use them in Ring Main Units. In combination with modern fault indicators as presented in CIRED in Turin 2005, remarkable improvements in availability can be achieved. The cost for such a Ring Main Unit with circuit breakers is not higher than existing ones with load switch disconnectors.

INTRODUCTION

This report describes how technical improvements and cost reduction in the industry makes it possible to use Ring Main Units, with full range circuit breakers combined with reliable fault detectors and inexpensive communication, to achieve the long term goal to isolate cable faults in medium voltage networks to no or minimum impact for the end clients.

MAIN PRINCIPLES

When designing a new network or when refurbishing an old one, the medium voltage switchgears in all secondary substations in the loop should be equipped with full range circuit breakers in all feeders. They can be manually operated and installed with an isolator in series with the circuit breaker. The operational mechanism is designed such that the breakers can always be tripped remotely by pre-charged springs; both for opening and closing (one is always open in an open loop system). This requires a reliable fault detector mentioned below. If you cannot fully rely on the fault detectors you need to use the trial and error method requiring motor drives.
In either the incoming our outgoing line feeder a fault detector is installed. It is preferable to use the pass-through type of fault detectors described in CIRED Turin 2005 [1]. They are now well proven and found very reliable and provide accurate detection not only for short circuit currents, but also very small (1A) earth fault currents in high impedance earthed systems. The sensitivity is comparable to directional earth fault relays. The fault detectors communicate to their adjacent neighbors by fiber cables or signal wires. Detectors for complete open loop systems are connected in a ring configuration.
Let us imagine that circuit breaker number 8 (Fig. 1) is open in the loop, and that the fault occurs in the cable section between breaker 5 and 6. The detector in Substation B, indicates that the fault has "passed me". The detector in Substation C indicates that the fault "did not pass me." The control algorithm decides that the fault is between circuit breaker 5 and 6 and that those two breakers should be tripped.

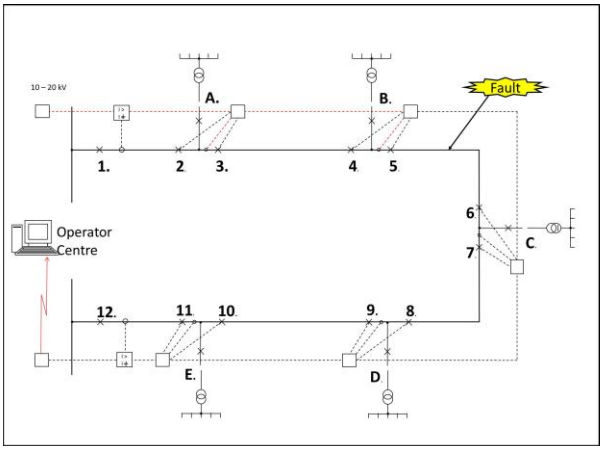

Fig.1

This can be achieved in no longer time than the tripping time of circuit breaker 1 in the primary substation, about 100ms. (Including time to catch the fault, evaluate and make decisions, communicate, time for tripping coil to react, time for the circuit breaker to open and arc quenching time.)
The overcurrent relay for breaker 1 is blocked during the time the detectors try to isolate the fault, but not if the fault occurs on the cable between breaker 1 or 2. In this case breaker 1 participates to isolate the cable.

If for some reason the system does not manage to isolate the fault, breaker 1 will trip after about 150ms. Same principle is used for earth faults but it is possible to give the system more time for action before breaker 1 comes in as a second step.

After tripping the circuit breakers 5 and 6 the open breaker number 8 is commanded to close. This will take another 50ms. Consequently total fault clearance is done within around 150ms.
Clients connected to transformers between the primary substation and breaker number 5 will not be affected at all nor will the clients connected to transformers between breaker number 8 and the primary substation. Clients connected to the transformer between breaker 6 and 8 will be affected for a period of around 150ms.

DECENTRALIZED COMMUNICATION

Present solutions of Distribution Automation often use load switch disconnectors with motor drives, together with an extension of the SCADA system to the secondary substations. Short circuits and directional earth fault relays together with CT´s and PT´s indicate the faults. This still causes outages of some minutes and is a quite complicated and expensive solution, which also requires substantial future maintenance.

Instead, the smart ring solution uses fast communication between adjacent substations and does not involve the SCADA system, and the tripping logic is distributed to the fault detector itself. The communication to the operational center must not occur within a few milliseconds, but since everything is accomplished locally it results in a very cost effective and less complicated solution compared to a more centralized solution as an extended SCADA. After the faulty cable is isolated it reports back to the operational center.

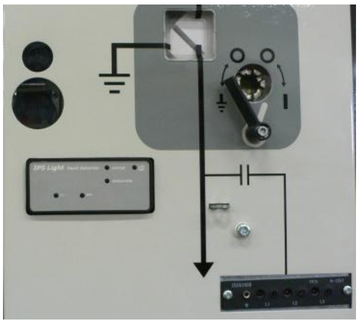

Fig 2. *Pass-through type of fault detector*

STEP-WISE INSTALLATIONS

In some countries with a very high speed of development and green field installations it is possible to design and build a distribution loop this way from the beginning. In most cases however, it is not that easy. There are existing investments to consider. Some of the existing secondary substations in the loop may be 30 – 40 years old; at the same time some could be very young. Therefore the investment must be done step-wise and the utility may work out an investment strategy for every distribution loop. Most important areas come first, and important or old secondary substations are replaced first, others later. Sometimes perhaps the best strategy is to replace switchgears in just some of the secondary substations in the loop and provide them with fault detectors and benefit from the installation from day one although it is not 100% perfect.
Another strategy could be to install fault detectors in all substations, whether the switchgears are replaced or not.
We all understand it could take up to 10-20 years to reach the end goal, a distribution loop that isolate faults without or with minimum outage time. We also recognize that if the electric utility just wait to make decisions and keep investing in traditional equipment they push the possibility to reach the goal in front of them perhaps another 40 years.

DISTRIBUTION TRANSFORMERS TO BE ISOLATED FOR EARTH FAULTS

Above describes a solution with full range circuit breakers in the line feeders. However, there are a lot of advantages also to use circuit breakers for the transformer feeder instead of fuse switch disconnectors. One is that it is possible to install an earth fault relay and trip the circuit breaker if an earth fault occurs in the distribution transformer. In communication with the fault detectors mentioned earlier the single transformer could be isolated without influence on other parts of the loop. CIRED report WG 03 Fault management describes some statistics over earth faults in distribution transformers [2].

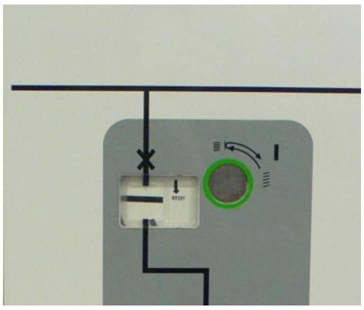

Fig 3. *Full range circuit breakers*

BENEFITS FOR THE POWER DISTRIBUTOR

The main benefit with the smart ring solution is that the electric utility can reach even higher availability than existing double cable systems, at about half of the investment costs. The savings are mainly reduced costs for cables and medium voltage switchgears. Main driving forces in society require higher performance of availability than is achieved today.

Just consider one aspect, communication and the cost for lack of communication. Will future requirements accept outages at all?

At the same time, cables, cable terminations and other equipment is getting older, which makes it even more difficult to obtain high availability. Using a smart ring solution described in this paper, such cables etc. can be utilized longer since the consequences of cable faults is reduced substantially.

REFERENCES

1.CIRED Turin 2005, Novel method for selective detection of earth faults in high impedance grounded distribution networks. Jan Berggren ProTrol, Sweden, Lars Hammarsten Göteborgs Energi Elnät, Sweden.

2.CIRED Working Group WG3, Fault management, Final report 1995.