TELECOMMUNICATION INDEPENDENT “SELF-HEALING” M.T. CABLE DISTRIBUTION NETWORK

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ABSTRACT

The “Self-healing” protection feature of a medium voltage cable distribution grid is an integral part of a well-functioning DMS/SCADA system applied in the grid.
Reliable telecommunications are indispensable for the operation of the DMS/SCADA system.
Through the application in the grid of the “Smarter RMU’s instead of conventional RMU’s, a “Self-healing” protection concept will be provided which can be used as a backup in the case of a telecommunication breakdown or a DMS/SCADA malfunction.
The same “Self-healing” protection concept can be provided as well in any grid in the absence of a SCADA system, provided a number of “Smarter RMU”s is installed in the Grid.
The “Smarter RMU”, is a Single Breaker, Auto-Loop-Sectionalizing, Fuse-less Smart RMU. Using its local intelligence (microprocessor), the following can be achieved:

- *Automatic fault location and fault isolation.*
- *Automatic network reconfiguration to minimise the number of electricity consumers affected.*

INTRODUCTION

Figure 1 shows the single line diagram of the “Smarter RMU”. The vacuum breaker which is located in the main loop is bi-directional and can handle any type and amplitude of short circuit. The 3-position switch always provides the connection with the transformer with the load side of the Breaker thus assuring its protection in the rare case of a high amperage fault.
The performance requirement of the 3-position Switch is to interrupt the Transformer load current.
This “Smarter RMU” concept was primarily designed to meet the high requirements of the “Smart Grid” and DMS/SCADA application, and to provide a maintenance free operational life of at least 50 years. The availability of the intelligence and sensing devices, as shown in Figure 1, combined with the breaker positioned in the main loop provide the tools to deliver a decentralised “self-healing” alternative to DMS/SCADA systems.

FAULTS IN THE TRANSFORMER OF THE “SMARTER RMU”

In isolated and Petersen grounded systems the transformer zero sequence currents are extremely low. Through its sensors the “Smarter RMU” microprocessor is able to identify them and open the 3-position switch, isolating the damaged transformer in less than 300 msec.

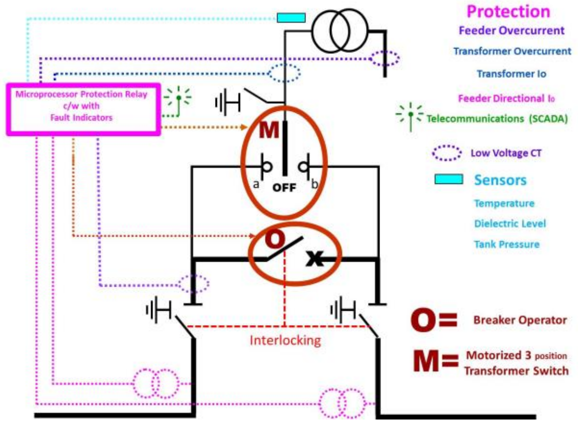

Figure 1. Schematic of the “Smarter RMU”

In the rare case of a phase to phase fault (only 0.018% of the total network failures) or a high amplitude earth-fault (if the grid is earthed), the microprocessor will trip the breaker, then open the 3-position switch and afterwards reclose the breaker and restore power downstream and isolate the damaged transformer within 500 msec.

ZERO SEQUENCE FAULTS IN ISOLATED AND PETERSEN COIL GROUNDED SYSTEMS.

Voltage and current sensing is required in order to identify zero sequence faults in isolated or Petersen grounded systems. The “Smarter RMU” sensors (Rogowsky coil and Capacitive Voltage Sensors), combined with the microprocessor control/protection relay can easily identify the zero sequence faults. As they are extremely low, co-ordination is simple. Figures 2 to 5 illustrate the sequence of events.

In Figure 2 the coordination between all breakers is set to a dead time interval of 300 msec resulting in a tripping time of 1800 msec in the Power Substation Breaker "1A" and 300 msec in the last Breaker in the string ("6A"). In this example, the zero sequence fault occurs between distribution substations "3A" and "4A".

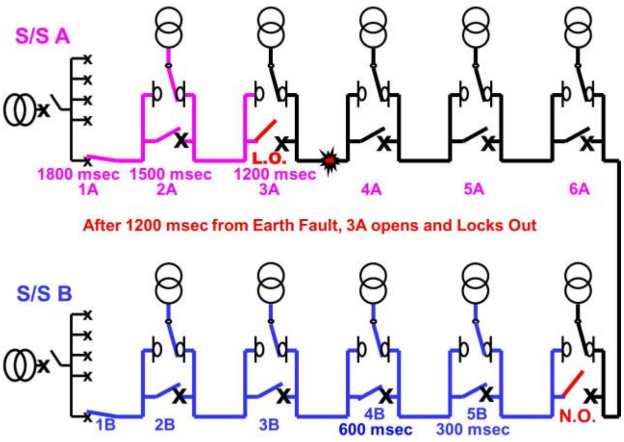

Figure 2.

The Breaker 4A with a time delay of 1200 msec, will trip and lockout (see figure 3).

After a time interval of 300 msec from voltage loss, the breakers "4A", "5A" and "6A" will open. After 2100 msec from loss of voltage the N.O. breaker ("6B") will close. After 300 msec of voltage appearance caused by the closing of the N.O. breaker "3A" will temporarily set the trip time in 100 msec and close. After successful closing, it will change its trip time to 300 msec.

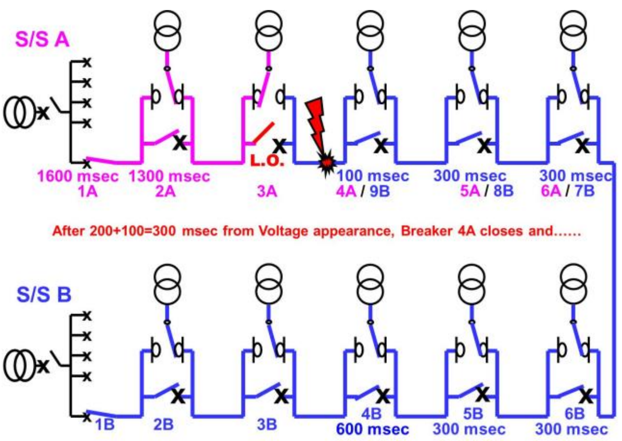

Figure 3.

Like the breaker "6A", breakers "5A" and "4A" will operate in a similar way, and breaker "4A" will trip and lock out.

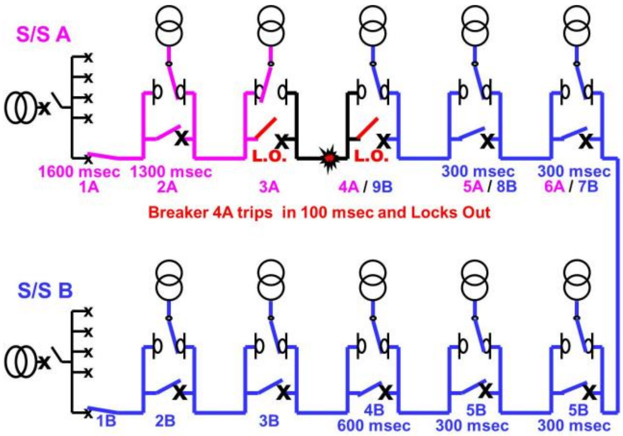

Figure 4.

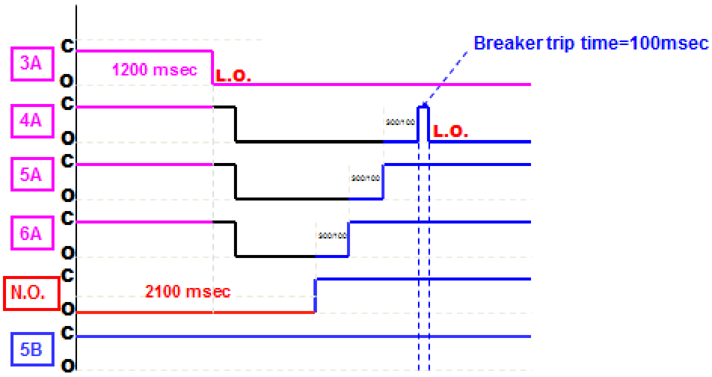

Figure 5. Within 3000 msec the fault was located, isolated and service restored.

OVER CURRENT FAULTS

In the following example shown in figures 6 to 9, there are 8 breakers in series in the same string. Breakers “8A” and “7A” will be programmed with a trip time of 100 msec, Breakers “6A”, “5A” and “4A” with 300msec and “3A”, “2A” and “1A” with 500msec. The fault is in this example between “5A” and “6A” (figure 9).

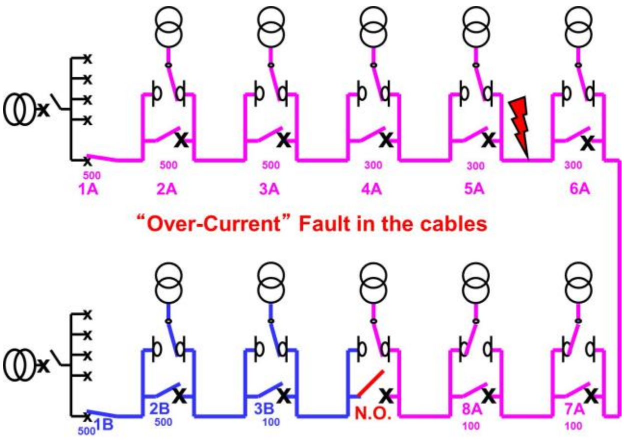

Figure 6.

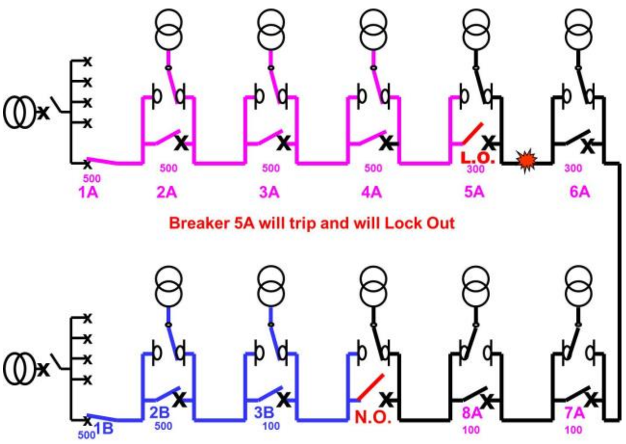

Figure 7.

The Breakers “4A” and “5A” will trip in 300 msec and after a time delay of safety buffer of 800 msec, the breaker “4A” will reclose and set the trip time in 500 msec. Similarly after 800 msec breaker “5A” will reclose, trip and lock out (figure 10). After an additional 800 msec from the lock out of breaker “5A”, breaker “6A” will trip and lock out being programmed to do so after the appearance and disappearance of the voltage during the trip and reclosing operation of “5A” as shown in figure 9.

After a further 800 msec from the lockout of “6A” the normally open point will close and restore power to the rest of the grid as shown in figure 8. The contact position of all breakers over time is shown in figure 9.

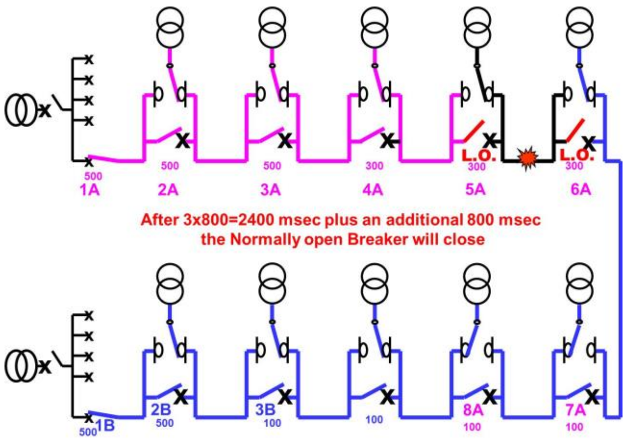

Figure 8.

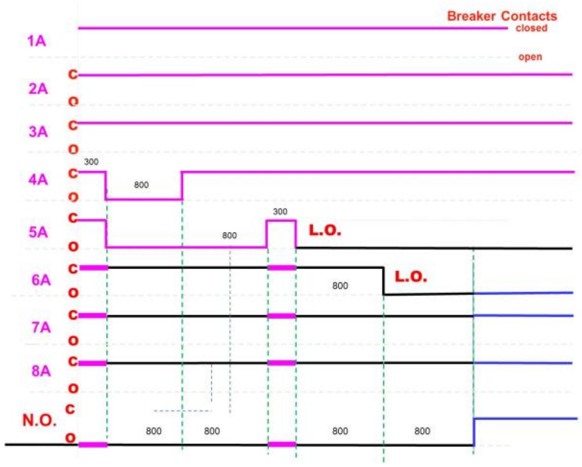

Figure 9. Within 3500 msec the fault was located, isolated and service restored.

PRACTICAL APPLICATION

In an existing grid, five "Smarter RMUs" are installed including the normally open point (N.O.) as shown in figures 10 to 11. The trip times for a zero sequence fault in an isolated or Petersen grounded system are as shown.
Using the same programming as in the example illustrated in figures 2 to 5, effectively treating conventional RMUs between "Smarter RMUs" as cable the resulting automated configuration will be as shown in figure 11.

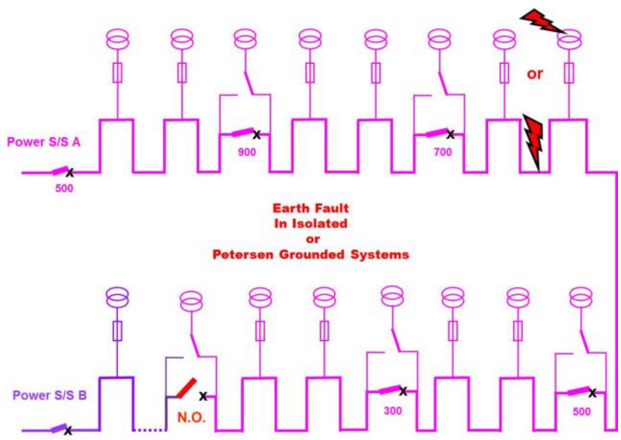

Figure 10. A Grid-string with 5 Smarter RMU's being integrated including the N.O. unit.

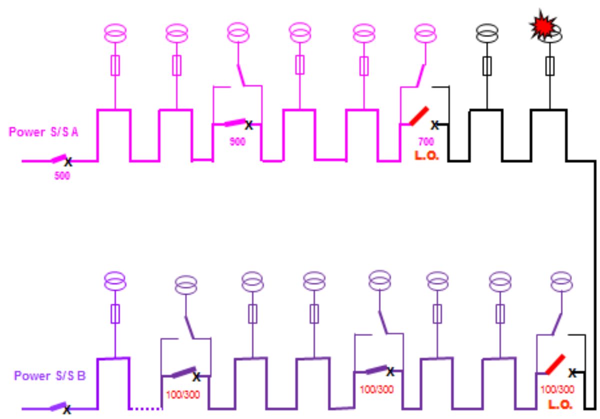

Figure 11. The Fault was located and isolated and the network reconfigured.

By installing a small number of "Smarter RMUs" in an existing ring system with no remotely controlled sensors, motorization, or SCADA, a "self-healing" system can be created by relying on the local intelligence embedded in the "Smarter RMUs". The performance of such a configuration is identical to a conventional SCADA system and the coverage and performance is directly proportional to the number of "Smarter RMUs" installed in a grid string as is the case with the number of remotely controlled motorized units in an analogous SCADA system.

CONCLUSION

The integration in an existing grid of several "Smarter RMU"s with their embedded "local intelligence" can provide a back-up "self-healing" protection function if they are part of a sophisticated DMS/SCADA system in the case of a telecommunications breakdown.
The "Smarter RMU"s can provide as well a cost-effective solution for distribution grids which have not yet installed a SCADA system where an economic (provisional or permanent) "self-healing" protection scheme for fault location and power restoration is required and furthermore these units can be part of any future DMS/SCADA system.

REFERENCES

[1] Aitor ARZUAGA Jose Antonio MORENO Covadonga COCA, "ADVANCED SENSORS FOR THE SMARTGRID: HOW TO DEAL WITH EXISTING SWITCHGEAR IN SECONDARY SUBSTATIONS", CIRED 2011