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Automatic Fault Isolation and System Restoration in MV Networks

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Overview

Electric utilities worldwide are going through a process aimed at achieving higher reliability, lowering operating and maintenance costs and deferring unnecessary investments. Automation of the Medium Voltage (MV) power grid via DMS (Distribution Management System) enables achieving these objectives without major expansion or refurbishing of the electrical equipment.

Today, most types of installed MV sectionalizers, disconnectors and capacitor banks are manually operated by utility field personnel. Upgrading these existing installations with remote control, requires a Remote Terminal Unit (RTU), equipped with a suitable data communications modem such as a VHF or UHF Conventional radio, Motorola Trunked Radio or MPT1327 infrastructure, Multiple Address Station (MAS) network, Spread Spectrum radio..

To allow remote control of the electrical equipment along the MV grid, utilities must install a DMS control center and field RTUs which control the operation of the motor drive which is mechanically connected to the MV switch. Upgrading of the electric network can be done by use of Circuit Breaker/Recloser units (such as Cooper 4C) which are connected to the MV power grid and a range of sectionalizer switches.

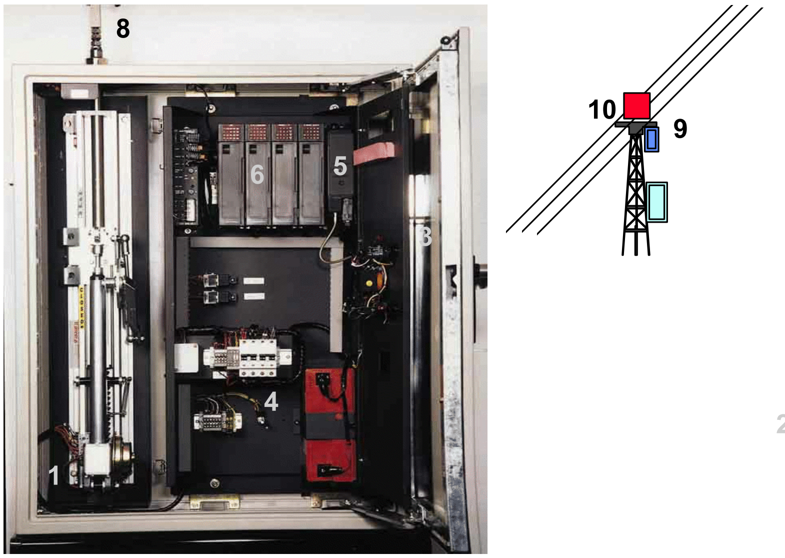
These switches can be either Air Break type or SF-6 (gas), Vacuum or Oil. Utilizing radio based RTUs makes it extremely easy to implement monitoring and control of these MV installations. Some RTUs can be configured simply for remote control of a single switch, while other RTUs may perform automatic fault isolation of specific MV sections along the power grid.

Fault Isolation System Restoration

With MOSCAD RTUs one can perform Fault Isolation and System Restoration (FISR) along the MV power grid, quickly and safely. The basic process involves an algorithm programmed into each of the RTUs as described below. Figure 1 below outlines a control unit which is suitable for a variety of Air Break and SF-6 type switches. The specific switch used with the detailed RTU is mechanically operated, thus it was required to integrate the motorized unit into the RTU. For other motorized switches this item is not required, thus the RTU enclosure can be smaller.

There are different FISR techniques, some involving communications between RTUs managing the operation of the switches, others requiring communications between the RTU and the DMS (Distribution Management System) control center. This paper outlines one of the most reliable processes , which, despite its simplicity, allows detection of the fault and provides for automatic power restoration. Using Motorola MOSCAD RTUs the system performs the entire process and results in power restoration to maximum number of customers within a few minutes.

The MOSCAD RTU shown in Fig. 1 was especially designed and manufactured for controlling Air Break or SF-6 switches, which are supplied by their manufacturers for manual or external motor operation. When used with an Air Break switch, the integrated motor drive comprises a spring loaded mechanism, which assures a very fast switching action. This is necessary in order to minimize arc burnout of the switch contacts resulting from connecting and disconnecting the power under normal load (400 - 600 Amperes).



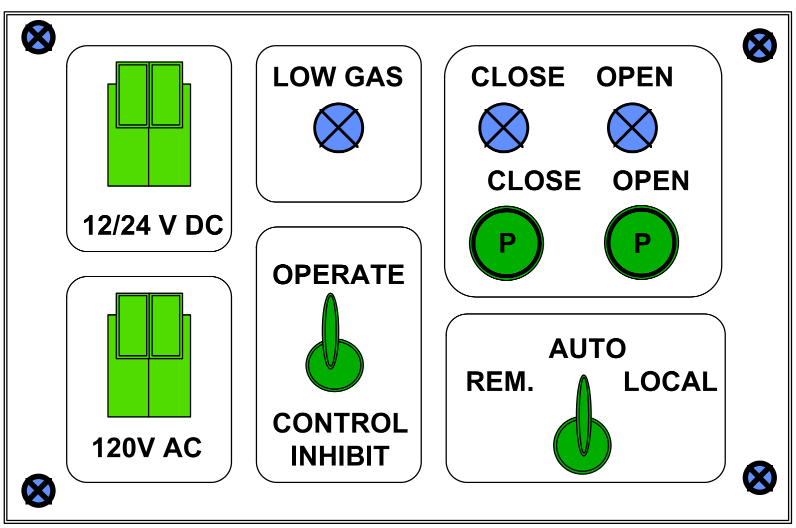
The RTU is powered from a 110V transformer (item 9). The same AC input also serves for fault detection purposes.

Legend:

1- Spring loaded motor drive
2- 12 V or 24 V backup battery
3- 110V AC Power Supply
4- Integrated control panel
5- Integrated radio unit
6- MOSCAD RTU
7- Directional antenna for the radio
8- Mechanical activation rod
9- MV/110V transformer
10- Medium Voltage switch

Figure 1. RTU for mechanically activated MV switch

Figure 2 shows an RTU control panel, designed for local display and local activation of the switch (in case of an Air Break switch the “Low Gas Pressure” indicator is not used).



The RTU control panel serves for human interface. Operation of the lamps, are subject to opening of the RTU door.

The “Control Inhibit” switch disables all possible means for activation of the switch.

The “Remote/Auto/ Local” switch selects the control mode of the MV switch.

Note: Due to operating safety “Local” operation is allowed even in “Remote” mode.

Figure 2. Typical control panel for a MV switch

Automatic FISR Operation

In the automatic mode, the FISR process is based on sensing the presence of AC power along the MV power grid via the pole mounted 110V transformer, and at time intervals between each step in the process. After completion of the FISR process, power is restored to all customers, except those who are connected to the damaged (isolated) section. Only these customers must wait until the damaged section is repaired. Figure 3 (a-j) shows a MV distribution grid built with two substations, one 161/24 kV and another 69 /24 kV, and the entire process step-by-step.

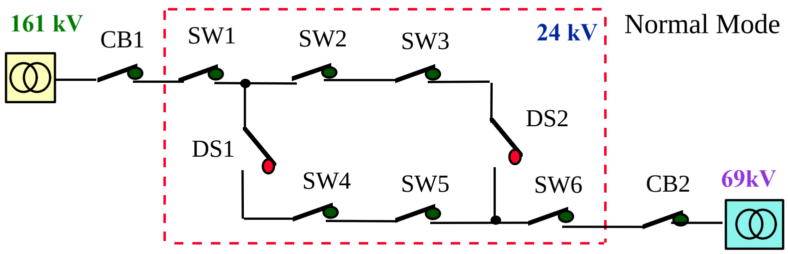
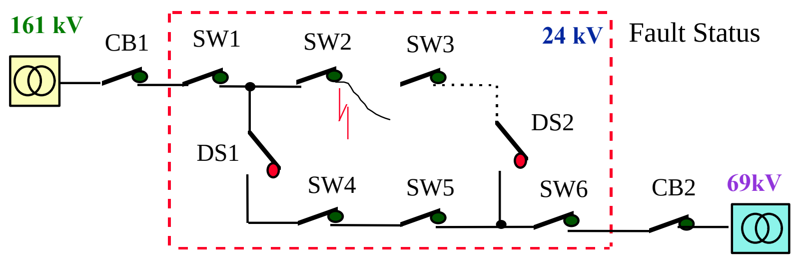


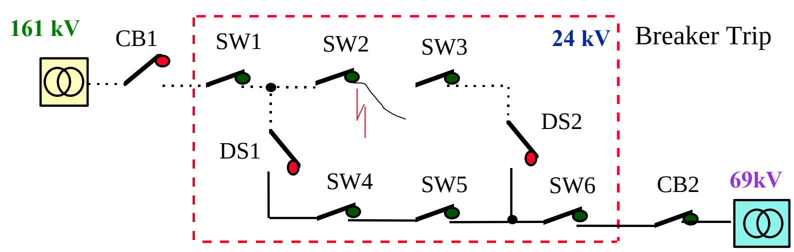
Figure 3a. shows connection to two HV/MV substations. Each of these transformers supply 24 kV. Customers are connected to the MV grid via regional 24kV/220V 3-phase transformers.

Figure 3 a. Normal condition



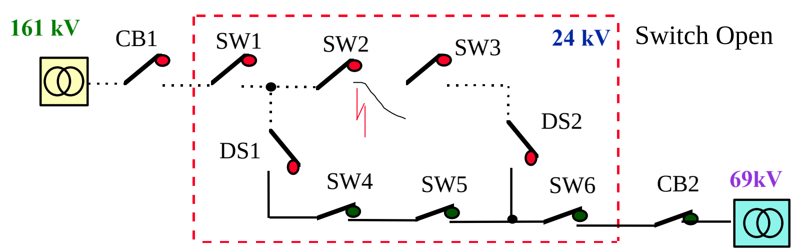
A “broken line” type fault occurred between MV switches SW2 and SW3. The MV wires touched the ground bar, and resulted in phase-to-ground current at the substation.

Figure 3 b. Fault Condition



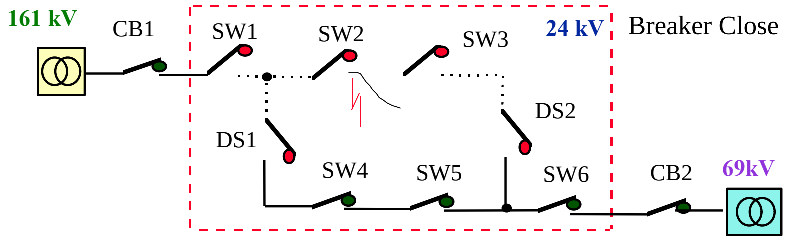
This ground current “trips” the CB1 at the substation. The CBs are “pre-set” to perform two “re-try” connections called reclosing attempts (~1 s intervals). If these attempts fail, the switch remains “Open”

Figure 3 c. Power fail to the whole network



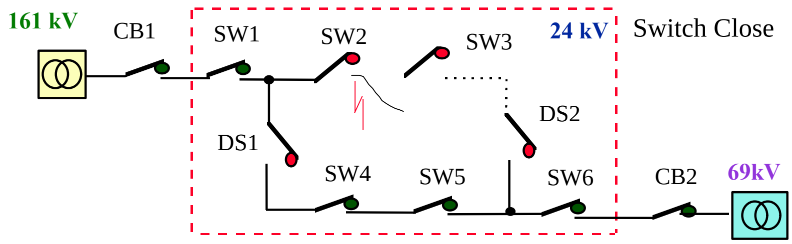
Following loss of power, all RTUs (SW1-SW3) connected to the MV switches, “sense” loss of power. Using their backup battery, each RTU opens the local MV switch it controls.

Figure 3 d. Fault Isolation Process



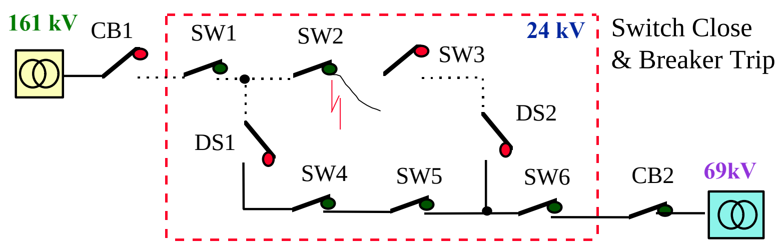
Some 30 seconds after the last attempt (programmable interval), the CB "re-closes" again. Since the other switches, SW1-SW3, remain open, the CB may re-close" and allow renewed supply of power to customers.

Figure 3 e. Start of the restoration process



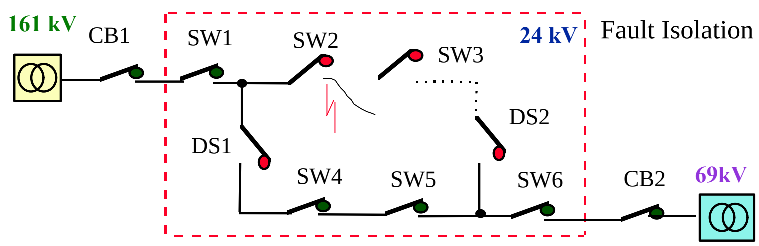
Some 60 seconds after the opening of SW1, its RTU will "re-close" the switch. Since switch SW 2 is open, and the fault between SW2 and SW3 is isolated, the power is restored.

Figure 3 f. System restoration



Some 90 seconds after opening of SW2, its RTU will "re-close" the switch. Since the fault is between SW2 and SW3, this attempt results in tripping of CB1 at the substation.

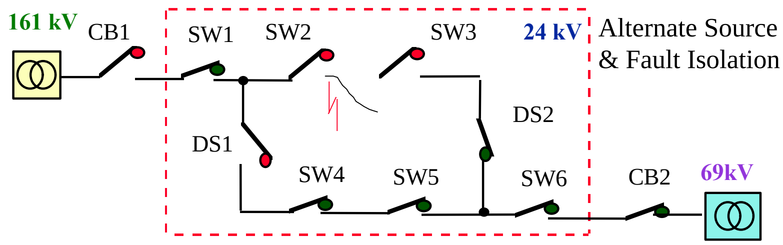
Figure 3 g. Actual Fault detection



The RTU controlling SW2 now "understands" that the fault is located close by, thus it will immediately re-open the switch. The switch remains open, ensuring that the fault is isolated.

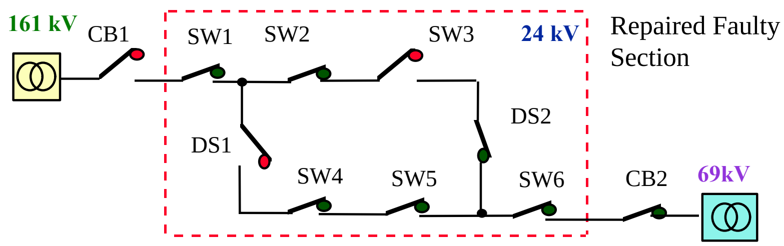
Figure 3 h. Fault Isolation

Note: Following the above detailed process, all customers wired to the section between DS2 and SW3 remain without power. Connection of this section to an alternative source is not done automatically, although technically feasible. Prior to doing it, the operator at the DMS control center must examine the loading condition of the 69/24 kV transformer. If the expected additional load (resulting from connection of customers in section between SW3 and DS2) will not overload that substation, he will remotely, via the communications link, close the disconnector switch DS2. The MOSCAD RTU is capable to monitor the load at the designated location.



Following closing the DS2 switch all customers (except those connected SW2 - SW3 section) will receive power. The DS2 reconnection (performed by the operator) may take few minutes.

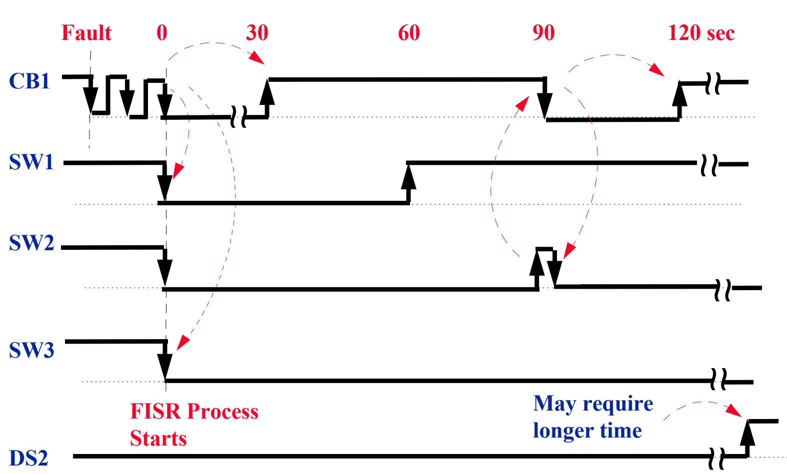
Figure 3 i. Power restoration



After completion of the repair (which might take a day or even longer), power is restored to all customers. The grid may remain in its new configuration, or be restored to the original one.

Figure 3 j. Completion of the FISR process

Figure 4 depicts the FISR timing diagram. It shows the "2 fast" and "2 delayed" reclose functions as typical for the Reclosers (such as the Cooper 4C controller). While the whole process is based on voltage sensing and time delays, its operation can be greatly enhanced by providing radio communications at each RTU site. This allows the operator at the DMS center to watch the process as it actually takes place, and make more intelligent decisions.



Legend:

CB1- MV Circuit Breaker/Recloser at the 161/24 kV substation

SW1 - Switch next to CB1

SW2 - Switch "next" to the fault, (closed after the repair).

SW3 - Switch next to the fault, (closed after the repair)

DS2 - MV Disconnector which connects the two MV segments, powered from the 161/24 kV and 69/24 kV substations

Figure 4. FISR timing diagram

For further details refer to the Motorola web site: http://www.motorola.com/SCADA or to our offices:

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