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REMOTE CONTROLL AND SUPERVISION OF MV OVERHEAD DISTRIBUTION NETWORKS

L. Čaršimamović, JP Elektroprivreda Bosne i Hercegovine, Elektrodistribucija Zenica, BiH

Abstract: Power distribution companies of Bosnia and Hercegovina started introducing various aspects of distribution automation over the past couple of years. In the future period of power sector restructuring and deregulation, all aspects of distribution automation will gain in importance. Remotely controlled overhead switches are important in automate distribution networks. This paper presents some challenges and steps to take when upgrading existing disconnector sites with remote control and communication equipment. It also describes some practical experiences gain in working on such a project in Power Distribution Company of Zenica. Paper shows that such projects are comprehensive and that they require joint work of power, software and communication engineers.

Keywords: distribution, automation, disconnector, communication

1. INTRODUCTION

Electric power distribution companies of Bosnia and Hercegovina are going through the process of restructuring and reorganization. Also, environment for power distribution business in Bosnia and Hercegovina changes so that in the future, primary task will be keeping the power consumers satisfied. That is why the power quality and reliability of supply is getting to be very important issue. One of the main ways of improving the reliability of power supplies is to reduce the outage duration once the interruption has occurred. In order to ensure rapid restoration of supply, consideration is being given to increasing the level of system automation.

MV (middle voltage) distribution system of Zenica canton comprises of 1743,2 km of network (mostly based on overhead lines), operating in 10, 20 and 35 km range and of 14 35/x kV substations. Network is spread over the geographically wide area (approx. 3912 km^2), mainly on hilly and mountain terrain. Entire MV networks operates radially. During the harsh weather conditions outages are frequent, job of locating the fault is done by patrolling the network, and it is therefore often hard and time consuming.

Remotely controlled overhead switches are important in automated distribution networks. Field personnel manually operate most of the overhead line switches. Distribution Company of Zenica has started with the process of upgrading these existing installations with remote control and supervision. Prior to introducing the remote control and supervision, comprehensive preparation activities should be undertaken:

1. Determining optimum location and number of remotely controlled overhead switches in the distribution system;
2. Communication technology selection;
3. Control system concept, RTU (remote terminal unit), SCADA (supervisory control and data acquisition) and fault locator selection;
4. Sites preparation (LV supply, overvoltage protection, grounding system, etc);
5. Evaluating the costs and benefits.

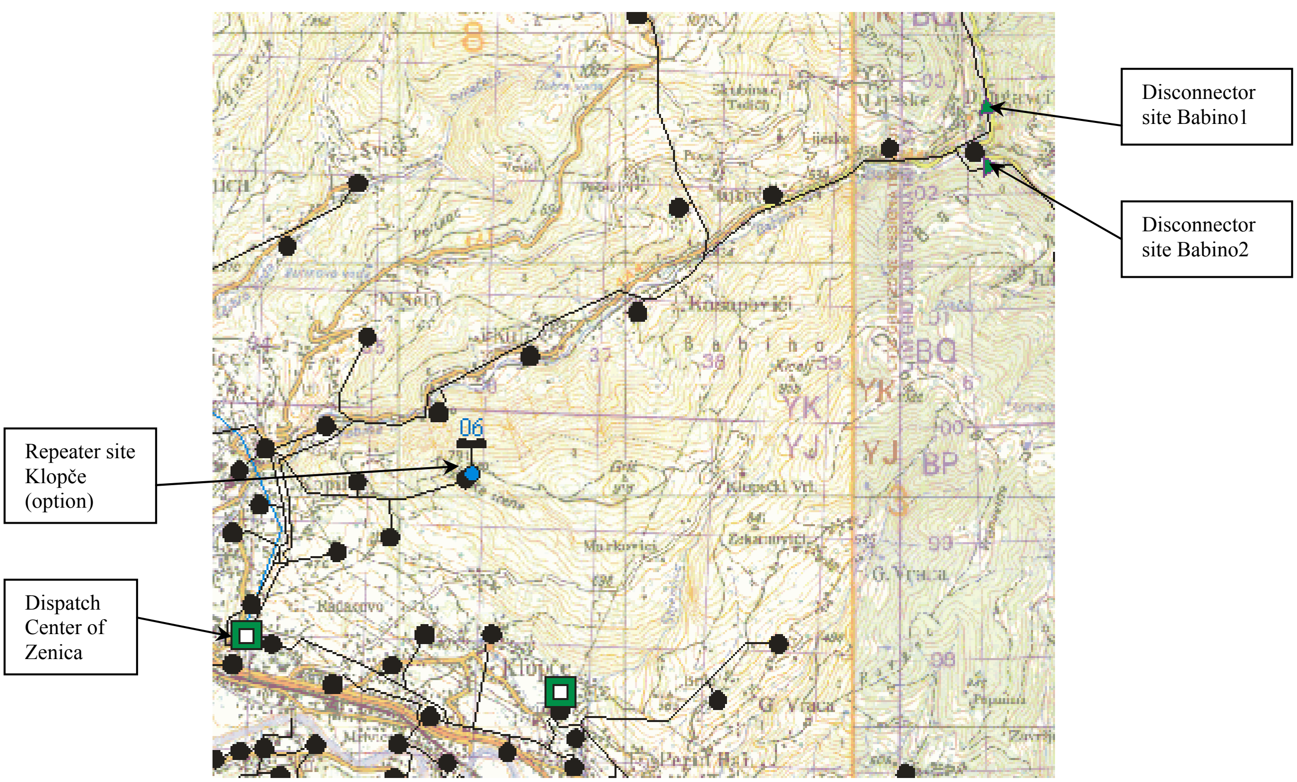
2. DEVELOPING THE SYSTEM

2.1 Determining optimal number and location of sites to be remotely controlled and supervised

The degree of improvement in system reliability is sensitive to the locations and the number of remotely controlled disconnectors. Determining optimum locations and number of these devices is a complex procedure and involves a number of factors and constraints.

Analyses started from the statistic kept by the Dispatching center. Data on power outages regularly collected for every feeder, involve information such as:

- Date of fault;
- Time when fault occurred;
- Outage duration;
- Cause of the outage;
- Site of the fault.



1. Figure 1 – An example of the disconnector, repeater and Dispatch center locations marked in the geographic maps

These data were combined with the data on the feeder installed capacity, load characteristics, consumers' characteristics (industrial/household) and their location/density. Disconnector locations are chosen so that the most critical sections, where problems were likely to occur, would be insulated first, and power would be restored for the most critical consumers without having to wait for action by field crews. Choosing the disconnector location close to the roads and low voltage network (for the provision of power supply to the equipment) gives additional benefits, especially regarding investment and operation expenses. Experience of developed European distribution companies shows that upgrading the disconnector sites with remote control and supervision is economically justified only in rural networks.

It should also be noted that equipping the feeder with remotely controlled and supervised switching equipment is fully justified only if its belonging bay in the feeding substation is automated. For this reason, and regarding the financial limitations, best solution for the feeders and substations is modular and easily upgradable control equipment, which allows introducing the automation in small steps.

After these analyses, chosen disconnector sites (approx. 60 disconnectors planned for the entire MV network of Zenica distribution company) as well as the potential repeater sites were entered into GIS maps (Geographic Information System), which already contain power network installations. This was very useful for the purposes of communication network design.

Due to investment constraints, pilot project was aimed to upgrade only 6 disconnector sites with the remote control and communication equipment.

Communication technology selection

One of the biggest costs associated with distribution automation is the cost of the communications system. For the practical realization of this project, a precise analysis of the various data transmission technologies is necessary.

Mobile Data Transmission Systems e.g. GSM. Installation of the communication equipment would be relatively easy, without a need for separate network construction. We would simply use the infrastructure provided by the network operator, and there are no costs for the communication system maintenance. Although initial costs are low, exploitation costs for the system using polling technique will be substantial, since it includes the price of every call that is made. Main disadvantage of this solution is poor quality of GSM signal on some disconnector sites or no signal at all. Local GSM network overloads, e.g. caused by a traffic jam, make a reliable operation questionable especially in exceptional situations, when the remote control is most needed. By using third party services, with each new GSM station dependency on external network operators becomes greater and since long-term price movements are hard to predict, there is a danger that operating costs rise significantly. Also, there is another hidden risk. Technologies for mobile communication are driven by a mass consumer market and innovation cycles associated with this technology are short - GSM 900 MHz, GSM 1800 MHz, GPRS, UMTS – can hardly be accepted when constructing long-term stable communication solution for the network automation.

Telephone networks PSTN. Telephone lines or other physical communication media are not commonly available along the MV network. Communication solution for the purpose of the disconnectors' remote control and supervision is therefore not possible with this technology.

Radio networks. Apart from the relatively big investment cost, operational costs consisting of maintenance costs and license charges must be considered. Another drawback is dependency of transmission characteristics on the weather. Also, radio channels are subject to interference, fading and noise. In order to minimize this limitation, high quality communication protocol has to be used. On the other hand, the use of radio technology for speech has a long tradition in power distribution companies. Moreover, in Zenica distribution network there is already a 35/10 kV substation controlled using RF (radio frequency) communication, so there was opportunity to use some of the existing communication infrastructure. Main advantage of this technology is its full independence of third-party services.

This comparison is presented in The **Table 1**:

	GSM	Radio	PSTN	Legend:
Investment costs	++	+	-	very positive ++
Life cycle	--	~	~	positive +
Operating costs	--	+	--	adequate ~
Bandwidth (Bit/s)	+	+	+	negative -
Independence	--	+	--	very negative --
Availability	--	~	+	

Table 1 – Communication technologies comparison

Regarding all the above considerations, radio technology was chosen. UHF radio channel is designated for data transmission. It is a half-duplex communication.

Control system concept, RTU, SCADA and fault locator selection

System comprises:
- Supervision point;
- Repeater site;
- Local control equipment.

Supervision point is in Dispatch center of Zenica. The equipment in the center comprises of the radio modem, the computer system and backup AC voltage source. Since there is “Lookout” SCADA system for “12th April” substation already installed, were RF is used for the communication, the disconnectors supervision point is integrated in this system. The same SCADA system is also installed in other distribution companies of JP EP BiH (Public Enterprise of Elektroprivreda of Bosnia and Hercegovina). SCADA platform used is easily upgradable with new applications. It works in Windows environment, which is very useful in terms of connectivity with other applications, i.e. it is possible to transfer numeric data in Microsoft Excel for the purpose of further analyses (load flow, etc). Another interesting feature is networking capability, which could be taken advantage of in the probable future merging of distribution companies.

Mountain peek “Lisac” was chosen to be the repeater site for the pilot project. Equipment there comprises radio modem, master PLC and supply source.

Local control equipment (disconnector sites) is equipped with 24 V DC motor drive, 24 V and 12 V batteries, AC/DC converter 230/12 V, electric heater, radio, RTU, fault detector. All equipment is installed in metal cabinets and mounted on the disconnector posts. In order to take full advantage of the communication and control equipment installed, it was decided to link fault detectors to the remotely controlled switches.
Mostly due to financial limitations, optimal solution was a fault detector that provides a basic level of automation, not requiring any instrument transformer. It signals the passage of current that arises as the result of an earth or short circuit fault, using the magnitude of the magnetic field created by the circuits’ phase conductors as the means of detection. Restriction of the device is that it cannot be mounted at the line crossings. This is because of the interference of magnetic fields of the lines.

System concept is shown on **Figure 2**. Master PLC on Lisac communicates with disconnector (local) stations. Signal from the master PLC is then digitally transmitted to the center, where it is received by another identical radio modem and transferred to the central computers RS232 port. Communication master PLC – local stations is based on the periodical polling of the stations, and spontaneous event calls from the stations, in the case of alarm situations.

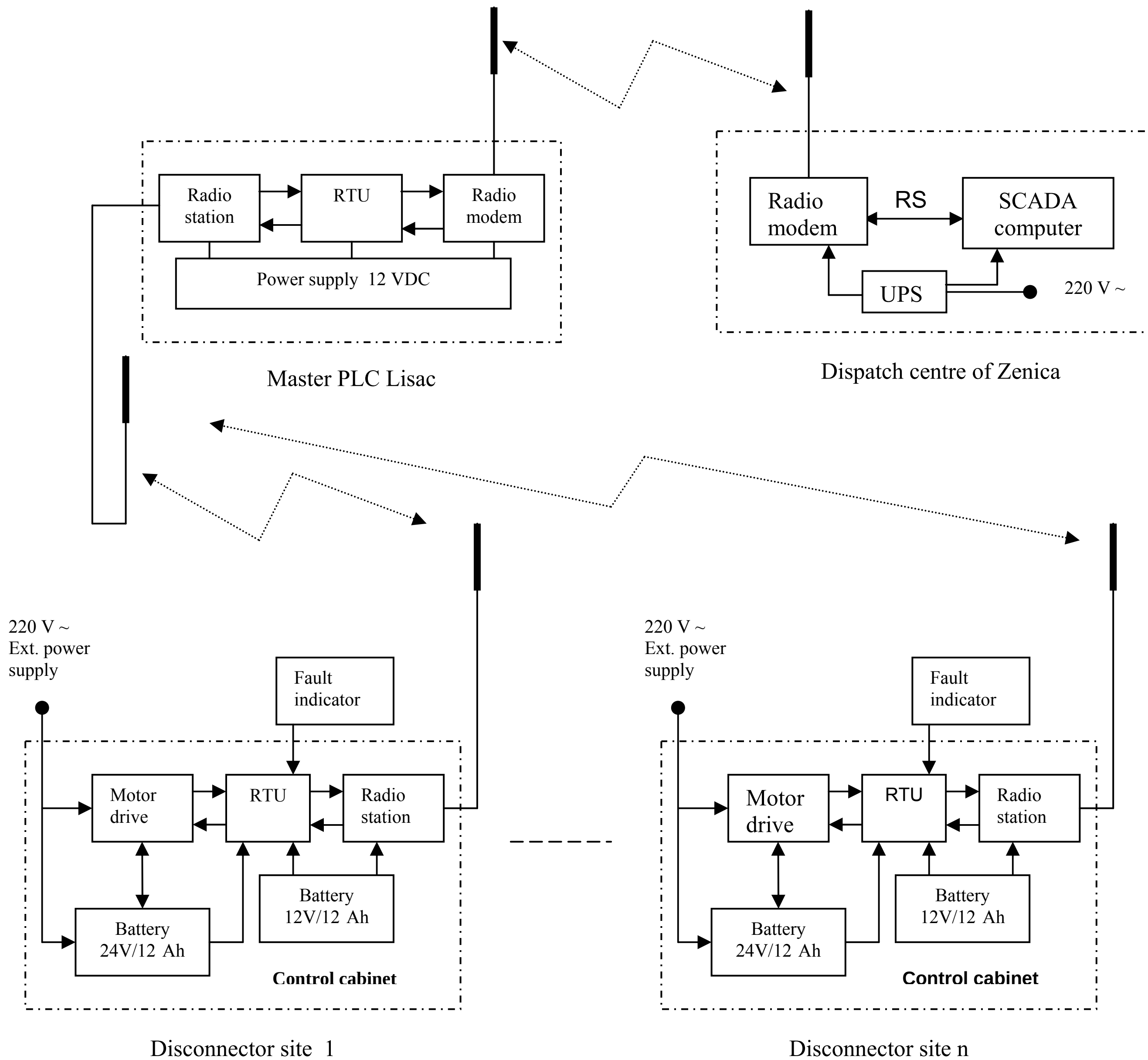


Figure 2 – System concept

Apart from remote open/close operations, following signals could be transmitted to The Center:

- Disconnector status (open/closed);
- Local control;
- Disconnector operation failure;
- Cabinet door open;
- AC supply failure
- Connect/disconnect signals;
- 24 V battery (motor drive) voltage measurement;
- Local/Remote control status;
- Communication status;
- RTU failure;

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- Line voltage (10 kV) measurement (on two sites);
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Protocol used is MDLC protocol, specially developed for radio communications. Some of its features are:
- Based on ISO's OSI (Open System Interconnect) seven – layer protocol recommendation;
- Multiple physical ports (Radio, line, RS232, RS485, Ethernet, dial-up) per each site;
- Multiple logical channels via one or more physical ports, for simultaneous central – to - RTU and RTU – to – RTU sessions;
- Application downloading, monitoring and debugging locally and remotely;
- RTU remote hardware tests.
- Hierarchical system structure (Centrals, Sub-Centrals, Regional Centrals, RTU-s,)

Having in mind that there was ongoing expansion of fiber optic network along the MV and HV power system, it was decided that communication and control equipment must have the feature of simple adaptation to different communication media, without a change of system parts or the application software. As already mentioned, MV network of Zenica distribution company is spread over the wide area, mostly hills and mountains so communication is a big problem. Analyses shows that using analog radio as the single communication technology for the disconnectors' supervision and control in the entire MV network would require a huge financial investments in radio equipment, and consequently, too great maintenance costs. Private fiber optic network of JP EP BiH develops in keeping with the goal that every important power station and business building, (which applies to all 35/10 kV substations and regional Dispatch centers) are connected in fiber optic network. There lies the possibility of radio communication only between 35/10 kV substations and disconnector sites on the feeders belonging to that station.
Signal from the station is then transmitted to the Dispatch center through the fiber optic network. This concept is shown on the **Figure 3**.

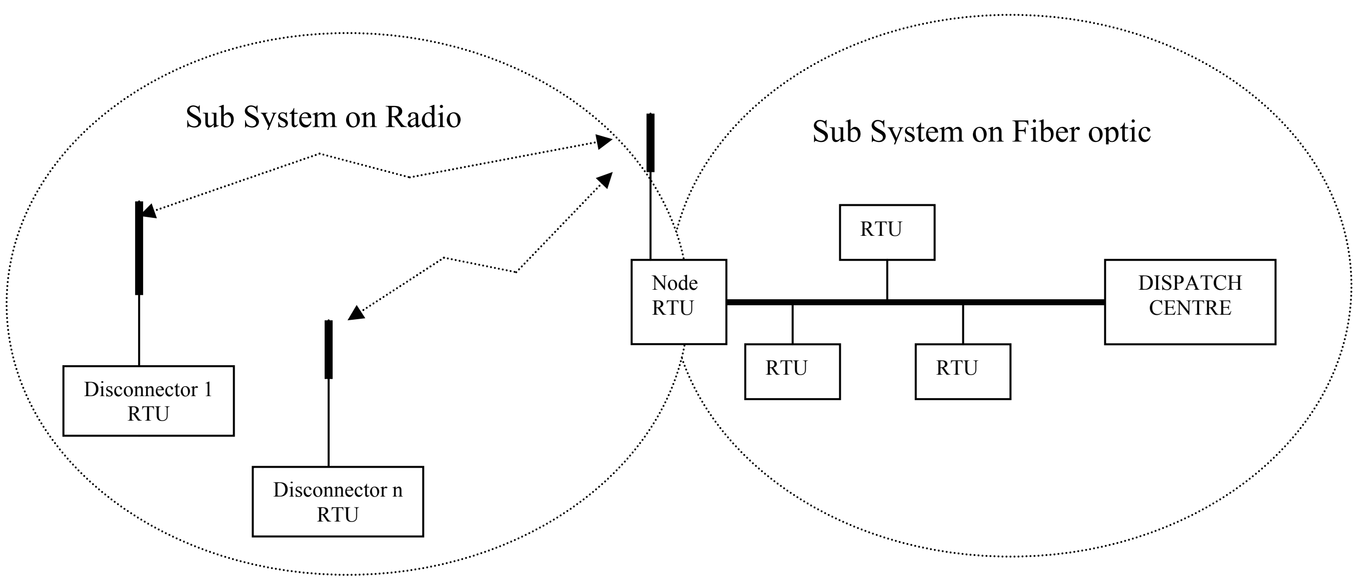

Figure 3 – Combination of radio and fiber optic

Site preparation

Power supply of disconnector cabinet could be provided either from LV (low voltage) network or through an instrument transformer 10(20) kV/220 V. Second option should be avoided for its cost and for the fact that such transformers are sensitive to lightening strokes. In the case that instrument transformer is used for the AC voltage supply, it should be energized from the power source side of the disconnector, so when the disconnector is open, equipment in cabinet is still fed from the network.

Due attention should be given to the overvoltage protection, both from the MV and LV side. Unfortunately, there are no regulations adopted in our country that treat overvoltage protection system, voltage supply equipment and grounding system for remotely controlled disconnector sites.

Cost Benefit evaluation

Evaluating costs and benefits provided by distribution automation system is a complex task. Exact evaluation is hardly possible, especially for the fact that the cost of not delivered energy for JP EP BiH has not been defined yet. It is evident that introducing the automation in a power distribution system should be followed by definition of unique mechanisms for the cost benefit evaluation of such projects.

Among the goals that are going be achieved thanks to this projects are:

- The faulted section detection of a long feeder is located usually by a number of the trial switching operations. Using remote control in combination with the fault detectors decreases the number of required switching operations.
- Reduction of the time required to restore the power following the outage;
- Operator has real time picture that helps him make critical decision;
- Ability to perform faulty section isolation faster and more safely;
- In exceptional situations, significantly reduces time for the field crews intervention and, consequently, reduces operation and maintenance costs.
- Customers' satisfaction and better competitiveness of the utility in the free power market. Benefits in this category are difficult to assess in monetary terms, but it is clear they will in the longer run be of extremely high value.

3. CONCLUSION

Automated disconnector sites are important in distribution networks. They offer a lot of advantages in terms of raising power quality and dependability to a greater level and reducing operation and maintenance expenses. Introducing automation in a power system is a process that brings a lot of challenges, starting with optimum device allocations, communication technology and hardware selection, effect evaluation, etc. Optimum number of the devices and their allocation is mostly driven by financial constraints, and must be followed by careful analyses of many factors – consumers, network, terrain characteristics, load, fault statistics etc.

Taking into consideration communication infrastructure development in BH, and current service prices, radio technology still remains the best choice. Communication and control hardware and software must utilize standard protocols, and must allow simple upgrades and automation system development.

Finances will always be limited, therefore precise methods for cost benefit analyses for automation projects should be developed, in order to help distribution companies decide which investment should be made first.

Literature

1. Ying He, Göran Andersson and Ron N. Alan "Determining optimum location and number of automatic switching devices in distribution systems", IEEE Power Tech'99 Conference, Budapest, Hungary, 1999.
2. Reinhard Krug, "PLC – New means for effective distribution network operation", Distributech 2001, Track2, Session 6.
3. Motorola MOSCAD prospects and manuals.