INTRODUCTION

Fast fault response, high reliability for energy distribution and low maintenance costs are needs that has to be accomplished in the era of deregulation of power industry. To cope with these demands, initiatives have to be done with recent technologies in control and supervision systems. Implemented solutions have to be reliable with minimal errors and with communication protocols between bay level, station level and center level. Many problems can be solved with installation of proper hardware but communication system has proved to generate most of the problems. 100% reliable communication link is not possible to achieve but it is possible to minimize the problems by implementing various types of communication links (UHF, optics, classic cable line, Ethernet, Frame Relay).

Distribution utility's "Elektroistra" telecommunication system has implemented every of above mentioned technologies taking into account site specifics. Strong connection between remote control and supervision system and telecommunication system of distribution utility "Elektroistra"-Pula are high reliable communication lines, therefore our efforts to raise the efficiency of operations and maintenance will focus on building high reliable and functional telecommunication system.

DISTRIBUTION UTILITY'S "ELEKTROISTRA" – PULA REMOTE CONTROL AND SUPERVISION SYSTEM

Distribution utility's "Elektroistra" remote control and supervision system consists of five Local Control Centers (LCC) with intention of building two more. At the moment these LCC are fully functional: Buzet, Buje, Poreč, Pazin and Pula. By these LCC-s it is possible to remotely control pole mounted switch disconnectors of transformer station (TS) 10(20)/0.4 kV and middle voltage switch gear of TS 35/10 kV. Network Control Center (NCC) Pula remotely controls substations of Pula region, furthermore with 35 kV of TS 110/35/10 kV and TS 35/10 kV of the distribution utility region. Finally, efforts are also underway to develop NCC that could remotely control of every substation in distribution utility region. (to compensate after working hours when there is no personnel in the LCC) Independent UHF radio networks have been constructed for each of currently functional LCC, (same network but different frequencies) by which communication link with remote substations has been established.

Communication links

**UHF radio network.** UHF radio network exists for each LCC region. Repetitor and repetitor with "store & forward" function are marked on Fig. 1. At the moment remote control and supervision system uses location Vidikovac (base station for Pula region), Diklići (repetitor for Buje and Poreč region) and Žbevnica (repetitor for Pazin region and repetitor with "store & forward" function for Buzet region)

Other repetitor locations marked on Fig. 1 are used for voice communication (work personnel), except at location Velanov brijeg which is currently in reserve. Moreover, while remote control and supervision systems expand, the need for higher capacity of radio networks will grow; therefore more demanding control centers will need to have two networks:

- **Simplex**
- **Duplex**

Simplex network is used for pole mounted switch disconnectors and small city substations 20(10)/0.4 kV while duplex network covers transformer stations 35/10 kV.

Communication used for these lines is supported by International Communications Protocol Standard IEC60870–5–101. Every LCC (which represents unbalanced master) communicate with RTU-s with baud rate of 1200 baud in request – response mode. For radio stations in LCC-s and for stations at remote locations Motorola GM 340 is used. In regular operation of duplex radio networks (Pula and Pazin) each location has two radio stations (one for Tx and one for Rx) via duplexer which resulted with very stable network during operation. (Commercial name Motorola GR500)

The fact that base station transmitter is always active in duplex radio networks (which are actually half duplex networks because receiver and transmitter operate on two
distinguished frequencies but not at the same time) resulted in a fact that remote stations always hear the center's request but response will be generated only when appropriate ASDU information is received. "Store & forward" function could be considered as advantage of simplex radio networks (every station at the same time could be both RTU and repetitor with "store & forward" function) by which difficult configuration areas could be covered. The principle of "store & forward" function is that station can store received information and forward it after conversion. Simplex radio network will be used for remote control of low voltage network so that duplex network can operate without overflows. Unfortunately that operation function significantly slows down the whole communication process and therefore can be used with RTU-s with small number of signals.

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Optical fiber network. Optical fiber communication is considered as the future of wired communication in distribution utility (DU) "Elektroistra"-Pula. Using HEP optical cables we managed to define communication links of DU "Elektroistra"-Pula, with baud rate of 19600 baud. Unfortunately, optical connections have just recently been introduced in our DU, so for the purpose of remote control and supervision system, optical fiber is used only on three locations - connecting LCC Buje and TS 110/35 kV Katoro, LCC Poreč and TS 35/10 kV Poreč and multimode optical cable connecting NCC Pula and TS 110/35 kV Dolinka.

Our plan is to connect all TS 110/35 kV in a unique optical ring that would be a part of unique HEP optical fiber network. This ring would embrace all important locations of our distribution utility, including LCC-s. Physical layer of communication would be Gigabit Ethernet and transport layer would be TCP/IP. Since nowadays on the market exist remote terminal units that can be directly connected to Ethernet network (for example - Končar KKU and ABB RTU 561), the advantage of this approach is that it is easy to make a communication link to substation that is connected to HEP business network. By using this type of connection it is possible to address every single RTU with TCP/IP protocol and transfer the telemetry data through International Communications Protocol Standard IEC 60870-104. With this type of communication it would be possible to control any RTU from any LCC on the WAN. On Fig. 3 is marked planned optical ring of DU "Elektroistra".

INTERCONNECTION OF LCC-S

Due to a considerable development costs of remote control and supervision system that would cover all Istria, DU "Elektroistra" developed small local control centers (regional transformer stations) throughout distribution utility region. At the moment five LCC-s are fully functional, and two more are in plan. Furthermore, it is necessary to connect all regional LCC-s with NCC located in Pula, and when completed, by connecting all LCC-s together, it would create a regional remote control and supervision system – "ISTRA" remote control and supervision system. Finally, our goal is to develop direct communication links of each LCC with every large telecontrol station carried by the interconnected HEP optical fiber network using Internet standards. These include the Transmission Control Protocol (TCP), according to RFC 793.
"ELEKTROISTRA" REMOTE CONTROL AND SUPERVISION SYSTEM IN THE COMING YEARS

Interconnection of all local control centers (LCC) in unique remote control and supervision system is our primary goal. Communication link is at the moment carried by T-Com leased lines, but soon will be part of unique HEP optical network.

Moreover, it is important to introduce the telecontrol system on every TS 35/10 kV, and remotely control all important pole mounted switch disconnectors together with small city substations 10/0.4 kV. In the coming years all communication links of important substations will be carried by unique HEP optical fiber network and all communication links for pole mounted switch disconnectors will be carried by simplex radio network.

CONCLUSIONS

Distribution utility's "Elektroistra" remote control and supervision system has intention to become uniform system with NCC in Pula from where important regional substations will be supervised and remotely controlled. Addressing the needs for that system it is a challenge to meet all requirements of telecommunication system: highest standards of reliability and advanced functionality to accommodate diverse system needs. Therefore, it is logically to conclude that this infrastructure has to become part of HEP (Croatian power utility) optical ring which will ensure high quality communication with high speeds (Gigabit Ethernet) and minimal number of bad transmissions. At the same time it is necessary to spread simplex networks for remote control and supervision of low voltage networks to achieve more efficient and more reliable system.

REFERENCES

[1] Control Engineering, 2002, Projekt radijske mreže za upravljanje stupnim rastavljačima i TS 10(20)/0.4 kV