Station
Automation
& Protection

Station Automation and Protection includes control, monitoring, and protection for power plant, transmission, and distribution applications. Solutions range from single function protection and control units to fully integrated, comprehensive, high-performance substation automation systems.

Application of a modern control and protection system in an existing EHV substation in Maribor, Slovenia

Fig. 1: A view of the 110 kV part of the swithchyard in Maribor S/S.

ABB Network Partner

ABSTRACT

The 400 kV network shown in Fig. 2 forms the backbone of the Slovenian electric power system. Most of the 400 kV network and substations were built in the late seventies and early eighties. The power system was built-up following the most stringent requirements on dependability and security of all primary and secondary equipment. In retrospect it would be correct to state that the system implemented was very modern at the time and proved to be very efficient in more than twenty years of use.

Introduction of new bays in a twenty years old substation requires implementation of the modern concepts and equipment. This is particularly important for the secondary equipment. The basic question is, how to implement the modern equipment and ideas in an existing substation. This entails ensuring that the old and the new installations operate as a unique secondary system. It also means utilizing – in the best possible way – the benefits of the modern solutions also in the existing, older parts of substation. The design must also allow for future changes and extensions of the system, without any interruptions of the electricity supply to the consumers.

The economical aspect of the new solution is also extremely important. The implemented system must allow for easy extensions in the future as well as simple and economically viable exchange of the existing older equipment with the modern one at different time intervals, dependent on the investment policy of the utility.

The following text describes the modern secondary system as delivered by ABB Network Partner AB, Västerås, Sweden and implemented by ELES, Slovenia in the existing 400/110 kV substation at Maribor. It presents the substation and its position within the Slovenian transmission network as well as the reasons, which dictated this implementation of modern technology. It also describes the communication system used for the exchange of information over the station bus as well as the purposes of the station monitoring system. It shows the possibility for further extensions on the system as well as the possibility for future refurbishment of the existing secondary equipment.

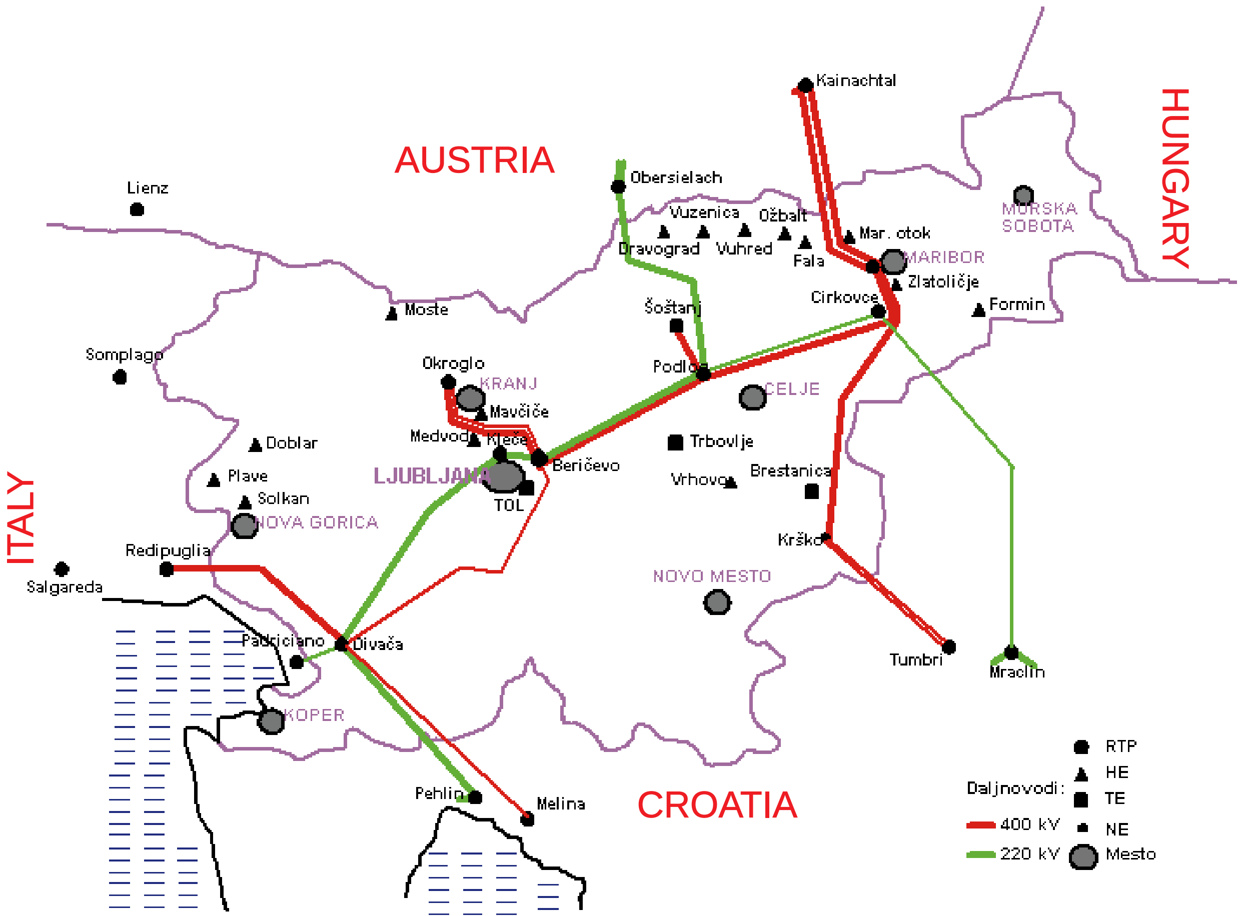


Fig. 2: 400 kV and 220 kV network in Slovenia with interconnections to Italy, Austria and Croatia.

INTRODUCTION

The 400/110 kV Substation at Maribor represents not only the most important transformation point in north-east Slovenia, but also an important connection point between the Central and West Europe on one side and south-east Europe on the other (see Fig. 2). The 400 kV lines towards Krško Nuclear Power Plant (652 MW) and further on to Croatia, S/S Podlog in the vicinity of the Šoštanj power plants (755 MW) as well as double circuit line towards Austria secure reliable power supply to the Maribor region and stability of the connected power system not only in Slovenia, but also in southern European regions. The 110 kV network, connected to the Maribor substation, provides electric power to the region and also connects to the cascade of hydro power plants on the Drava river (528 MW). The substation was built in 1976 and equipped with the state of the art primary and secondary equipment, available on the world market at that time.

Increased demand on electric power required three new 110 kV lines connected on 110 kV busbars in Maribor S/S in 1997. It was obvious that the existing secondary system in Maribor S/S could no longer satisfy all the needs and requirements of the market. A modernisation was essential.

Multifarious economical and technical parameters were analysed, before the final decision was taken.

High degree of availability of the new secondary system was one of the basic technical requirements. It was of common opinion, that only a totally distributed secondary system, based on a concept without master-slave relations could satisfy these very stringent requirements. An additional technical requirement was, that both systems, the new one as well as the existing, conventional one, must operate as one unique secondary system within the complete substation.

The investment cost for the new secondary system played a very important role, but the long term operational costs, together with the expected costs for the total refurbishment of the complete substation, which will take place in the near future, have also been examined thoroughly.

THE 400/110 kV SUBSTATION AT MARIBOR

We shall in this scope present only the most important parameters, which significantly affected the design and implementation of the new secondary system. It is necessary to immediately point out, that even all the existing secondary equipment has been installed in a de-centralised way. All protective relays, interlocking

Fig. 3: A view of the newly modernised control room in the Maribor S/S.

devices, metering equipment, etc. have been installed in small relay kiosks within the 400 kV and 110 kV switchyards; see Fig. 5. Two bays share the space within one relay kiosk.

400 kV switchyard and associated equipment

No significant changes have been introduced within the 400 kV part of the substation. It is necessary to mention the existing numerical distance relays REL 100 on double circuit line to Kainachtal (Austria) and the new numerical line distance protection terminal REL 521 on line towards NPP Krško. All these units have been included with a separate optical communication loop into the station monitoring system (SMS). All other parts, like the remaining distance relays, interlocking system, metering equipment, elements of SCADA and remote control system remained unchanged.

110 kV switchyard and associated equipment

All secondary equipment within the existing 110 kV bays remain unchanged. The only exception is the bus-coupling bay, (which also comprises the measuring and the bus earthing bays) where the bay control unit type REC 561 has been introduced, mostly as an interface unit between the new and the existing interlocking system. The bay control unit REC 561 became in this way the dominant unit towards the existing conventional interlocking system. This is important for further extensions and refurbishment of the existing bays, because it excludes any requirement on some additional hardware and software.

The three new 110 kV line bays are each equipped with line protection terminal REL 511 and bay control unit REC 561. Common to all these units are two ports for serial communication, one for control and connected to the LON station bus and one for monitoring connected to the SPA bus, see Fig. 4. This means, that the protection units communicate directly with the station level equipment and not via the bay computers. According to the information available to the authors, this is the first such implementation in the world. The line protection terminals REL 511 comprises the following functionality:

- full scheme line distance protection (5 zones) with scheme communication logic
- general fault criteria
- fault locator
- one and/or three pole autoreclosing
- supervision functions with broken conductor protection
- event recording function
- disturbance recording function
- etc.

Each bay control unit REC 561 comprises the following functionality (numbers in brackets are valid for the unit in the bus-coupling bay):

- bay interlocking functions for the ”abc” busbar configuration
- accurate measurement of line voltage, current, active power and reactive power
- 3 (5) binary input units, each with 16 binary inputs
- 2 (3) binary output units, each with 24 independent relay contacts, to control up to 6 apparatuses.
- 1 (0) transformer input unit with the A/D conversion unit
- 0 (1) analogue input module for mA signals

All the REx 500 series protection and control terminals are connected in a unique system, as presented schematically on Fig. 4.

Before the extension the existing part of the substa-

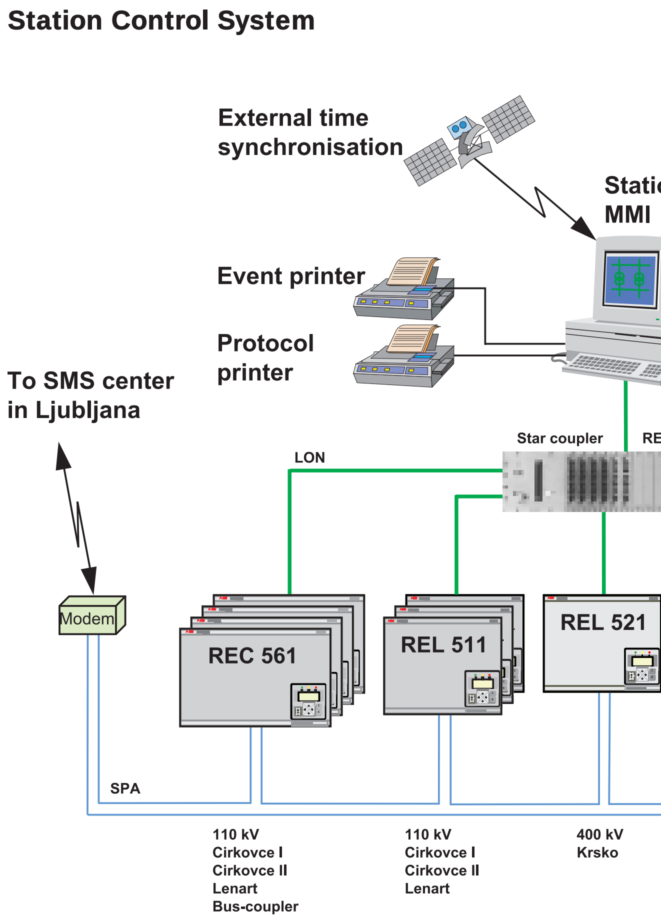


Fig. 4: Schematic presentation of the intelligent station automation syste

tion used a conventional RTU unit. The RTU was connected via a communication link to the regional control centre (CV Maribor). This communication link has been removed and replaced by two new connections towards the modern control system: to the Station MMI and the Gateway computers. Two connections have been chosen due to very high demands on the availability of a complete system. This way it is possible to control the complete substation either:

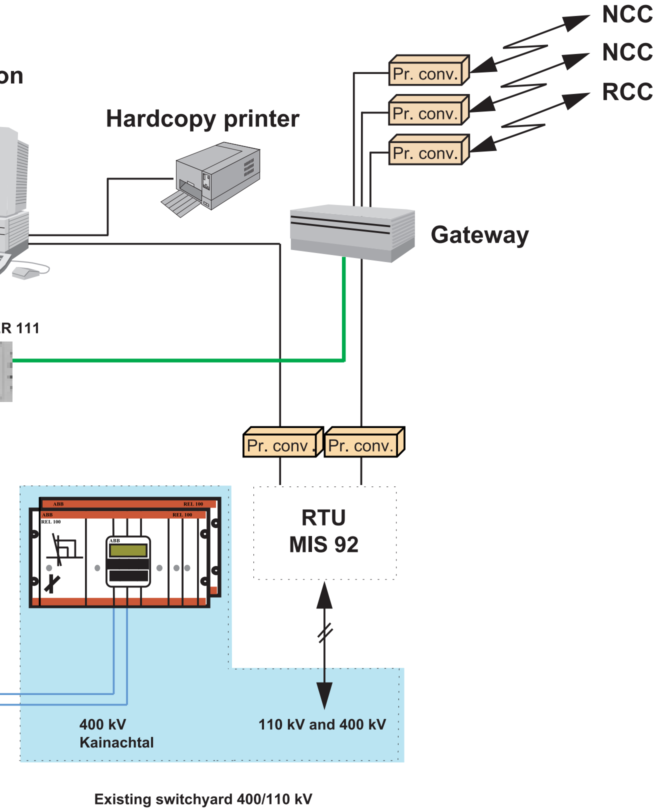
- remotely in substation via the man-machine-interface (MMI) unit
- remotely from the regional control centre - RCC
- remotely from the national control centres - NCC or
- locally by the aid of the back-up panels located together with the bay terminals REC 561 in relay kiosks

The station bus is a LON bus, using an optical star-coupler. The LON bus is based on the well-known Ethernet principles (CSMA/CD), and extended with a more deterministic behaviour. This approach ensures high availability of a complete system and democratically distributed functionality between the different terminals.

There is no master computer within the complete design and the complete system remains operative in case of any single component fault due to built-in full redundancy between the station MMI and gateway computers. Some of the most important functions, like for instance interlocking, will remain operative even if the station MMI and gateway computers fail at the same time.

The station MMI system itself is based on MicroSCADA software, supported by MicroLIBRARY software blocks for different protection and control elements within the system. The basic functionality of the MicroSCADA includes the following:

- commandhandling for apparatuses in different bays
- alarm lists
- event lists
- trends
- reports
- SW engineering tool
- language converter
- authorisation mechanism handling
- note-marker
- etc.



m as introduced in S/S Maribor

Station Monitoring System

The second communication bus is a slower SPA optical loop, which connects all numerical terminals of the REx 100 and REx 500 series into an information system, intended specially for the use of protection engineers. The loop is closed by an opto-electrical converter and a telephone modem, with the remote SMS station located in the Protection System Monitoring Centre (PSMC) at the ELES HQs in Ljubljana. The complete system provides the ELES protection engineers with complete diagnosis and monitoring functionality, like:

- event and disturbance recording
- fault location
- remote setting possibilities
- remote configuration possibilities
- on-line monitoring of the protected objects
- etc.

REFURBISHMENT OF THE EXISTING EQUIPMENT AND FURTHER EXTENSIONS

The existing secondary equipment will be replaced by the modern one within the next few years. One of the prerequisites for the implementation of the existing control system was its flexibility, which allows for further changes in different time stages, without the need for the manufacturer to be included in the extension work.

The system implemented allows for additional bay control and protection terminals, to be included at later stages in different bays and connected to the optical star-coupler with the existing optical fibres. The system is also equipped with all the necessary graphical tools, to make it possible for the user, to change the system configuration by themselves, according to the new situation in the substation. The new equipment will be included in the existing control system practically on-line without any need to interrupt the consumers power supply or shut down the control system.

The existing parallel cable connections between the existing secondary equipment and the RTU will be interrupted in the process, when the new equipment will take over in each bay separately. In this way the modern technology takes over. These interruptions will occur in each bay separately. In this way the modern technology will take over step-by-step and in the end the conventional system together with the existing RTU will disappear completely from the substation.

Fig. 5: Apparatus cubicle containing bay level equipment REL 511, REC 561, back-up control panel, meters, etc. in Maribor S/S.

COMMISSIONING ACTIVITIES AND EDUCATING THE OPERATORS

The modern control system controls the new bays and modern equipment as well as the complete existing substation. This meant that it was necessary to test during the commissioning period not only the newly installed equipment, but also its functionality towards the existing switchyard with its primary and secondary equipment as well as the interaction between both systems.

The commissioning included practically the complete switchyard. All the commands, indications, measuring results, signals, etc., have been tested live. The substation has been in operation the whole time without any interruption of the supply to the consumers.

The commissioning activities also included the on-site education of the operators. They became proficient in their work so efficiently and in such an extremely short period of time, that they operated the system alone during all the functional tests.

The protection system has been parametrised and commissioned by ELES personnel, who have shown a very high degree of knowledge and skill, gained on ABB numerical protective devices during the last few years. This is a typical example of a good partnership in execution which could be attributed to the fact that ABB Network Partner AB recognises the results of ELES work as its own.

OPERATING EXPERIENCES AND CONCLUSIONS

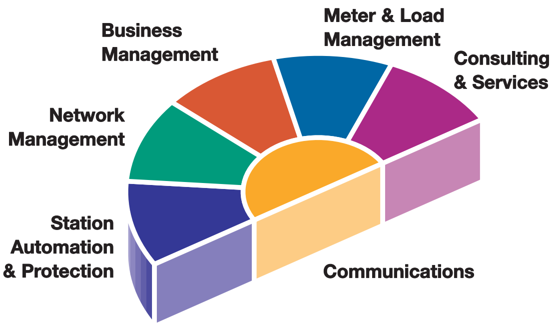
The described secondary system started its regular operation in June 1997 by the permission of the corresponding governmental organisations. It is not possible at this moment in time to write about long-term experiences. All the functions have operated within this short period according to the expectations.

For further information, please contact:

Mr. Joze Podlipnik:
ELES
phone: +386 61 125 03 33
fax: +386 61 21 94 80
E-mail:joze.podlipnik@eles.si

Mr. Janez Zakonjsek:
Lotus Notes: Janez Zakonjsek/SENET/ABB
phone: +46 21 32 17 27
fax: +46 21 14 69 18
E-mail:janez.zakonjsek@senet.mail.abb.com

Mrs. Berith Björklund:
Lotus Notes: Berith Bjorklund/SENET/ABB
phone: +46 21 32 16 99
fax: +46 21 14 69 18
E-mail:berith.björklund@senet.mail.abb.com



Panorama is the standard for a comprehensive range of integrated solutions for the efficient and reliable management of power networks. Using innovative information technology, Panorama delivers total control of the power process, from generation to consumption. The Panorama standard covers six application areas, each offering specific solutions.

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ABB Network Partner AB
S-721 71 Västerås
Telephone: +46 21 32 13 00
Fax: +46 21 18 14 50
Internet: http://www.abb.se/net