CONFERENCE ON COMPUTATIONAL PROBLEMS IN ELECTRICAL ENGINEERING-2023

SOME ISSUES AND IMPLEMENTATION PROBLEMS FOR DIGITAL SUBSTATIONS IN MONGOLIA

Nomin Lkhagvasuren[1], Zagdkhorol Bayasgalan[2], Adarsuren Sukhbaatar[2]

[1] Instrument&Control Supervisor, Mongolian University of Science and Technology, Ulaanbaatar, Mongolia

[2] Dept. of Electrotechnics, Mongolian University of Science and Technology, Ulaanbaatar, Mongolia

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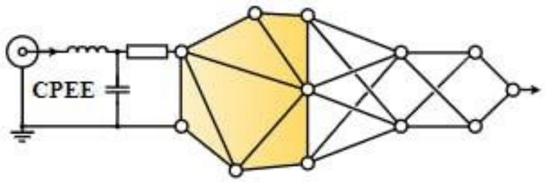
INTRODUCTION

- Due to the non-stop and increasing consumption of electricity, the need to deliver more reliable and quality energy to consumers is increasing day by day. In this requirement, the quality of the model increases the proper use and operation of electrical equipment introduction of microprocessor-based relay protection system, telemechanic, control, and automation.
- Globally, projects of power and energy are focused on digital substations. International engineers believe that the digital substation has many advantages. By lowering the potential risks, digital substations can contribute to reducing labor costs associated with hazardous work environments. However, this digital substation project hasn’t yet been implemented in Mongolia. For Mongolia, digital substation research has been explored several times before.



THE CURRENT STATE OF THE MONGOLIAN ELECTRIC SYSTEMS, ITS RELAY PROTECTION, AND AUTOMATION

SUMMER

WINTER

Electrical circuit equipment is equipped according to this climate.

***Mongolia has a strongly continental climate, with four fluctuations of temperatures, low precipitation, and marked regional variations depending on latitude and altitude. In summer, depending on the region, it heats up to 30-40° C and it rains a lot. In winter, it gets cold to minus 35-40° C and it snows a lot. It is related to global warming.

***Mongolia's energy relay protection and automated system was started in 1916 with a 20kW power generator in the capital. It was based on an electromechanical base. During this century, the electromechanical base evolved into the microprocessor-based. Now, the existing substations are equipped with modern equipment.

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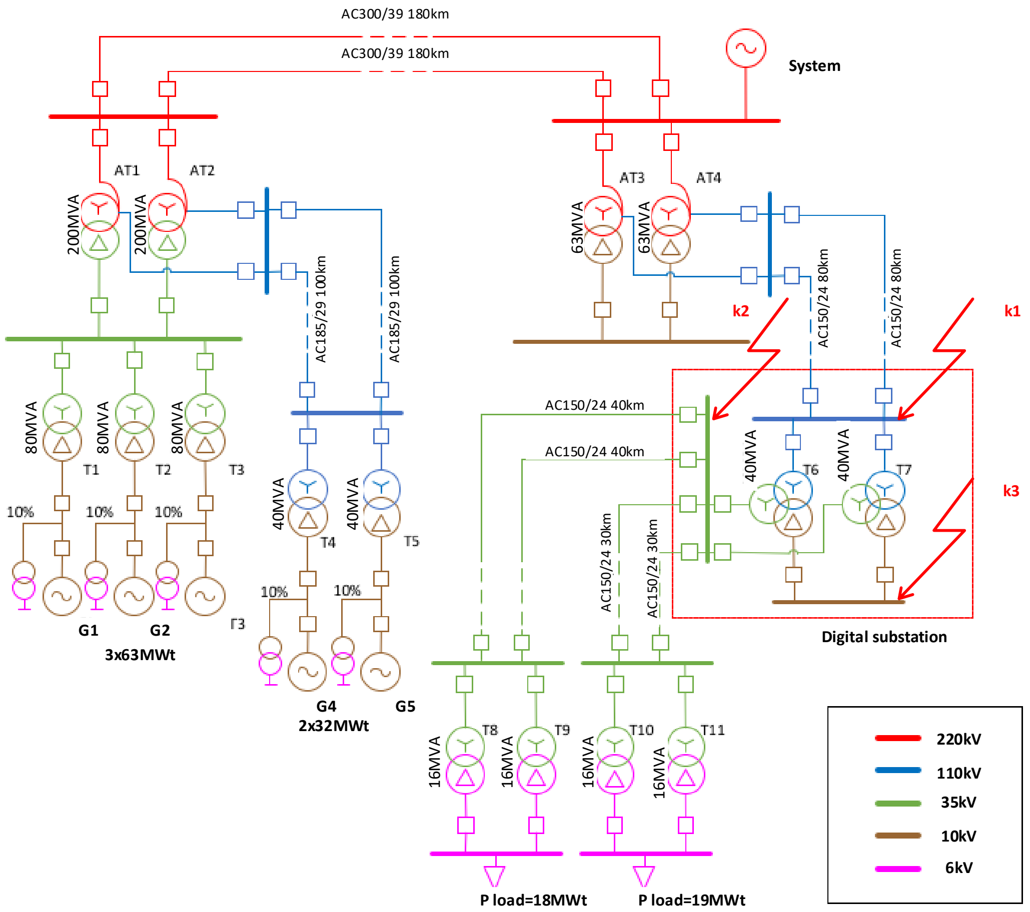
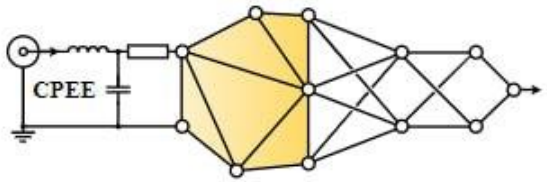


The PowerFactory-DigSilent licensed software is used for the Mongolian energy system to calculate the short circuit at each point of the substation.

In Mongolia, the maximum short-circuit value is 2-3.5kA at 110kV, and this value is used for relay protection and automation layout calculations.

kA	K1	K2	K3
$K^{(3)}$	2.473	4.93	12.971
$K^{(2)}$	2.142	4.269	11.233
$K^{(1)}$	2.024	4.705	0
$K^{(1.1)}$	1.508	3.215	12.971



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- SF6 and oil circuit breakers are used in combination. Existing conventional substations have been electromagnetic current and voltage transformers, connecting them to intelligent relay protection and automation equipment.

- In Mongolian conditions, we calculate the value of relay protection after calculating the short-circuit equation. The PowerFactory-DIgSILENT licensed software is used for the Mongolian energy system to calculate the short circuit at each point of the substation.

- A microprocessor-based relay instruction manual is used to calculate the substation’s protection. And the characteristics of the relay’s function are adjusted correctly.

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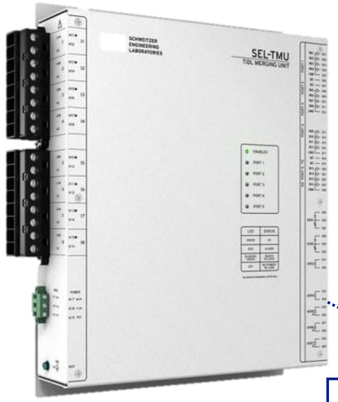
MERGING UNITS AND FIBER OPTIC EQUIPMENT

When connecting between a measuring transformer and an intelligent device, a merging unit is used at a digital substation, but in our country, the direct analog input is transmitted to the smart device without the merging unit. Information of the primary circuit is transferred by the digital signal from current and voltage transformers to relay protection and automation devices through the merging unit. We can change the secondary circuit by having a new process bus.



SEL TMU – TiDL Technology

Fiber optic current transformer

Fiber optic voltage transformer

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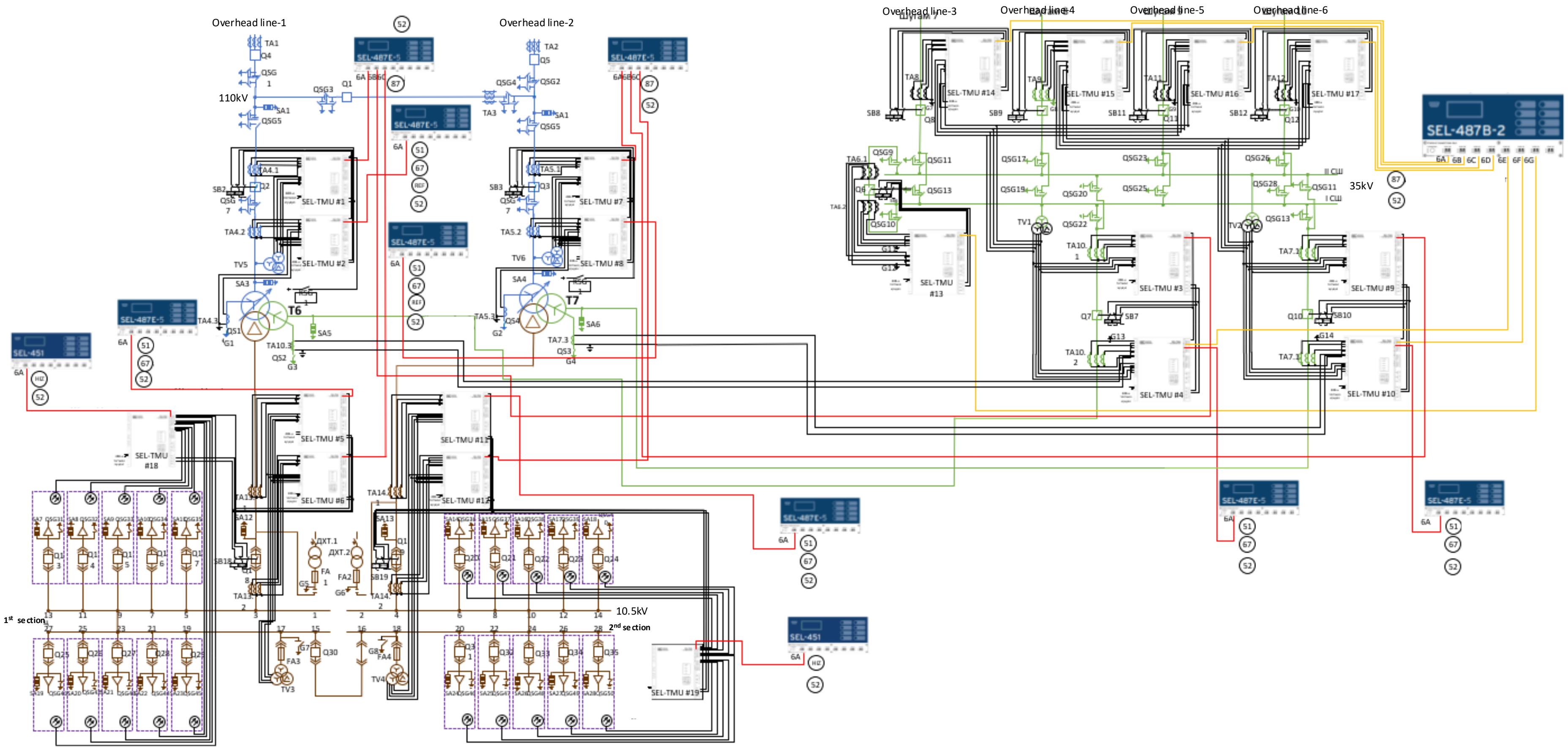
SCHEME OF RELAY PROTECTION



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We calculated this relay protection. Mentioned the below.

BUS PROTECTION:
Differential protection

TRANSFORMER:
Basic: Differential protection
Basic: Gas protection
Assistance: Overcurrent protection
Assistance: Overload protection
Assistance: Earth-fault protection

CLOSED SWITCHGEAR:
Flash-arc protection

A microprocessor-based relay instruction manual is used to calculate the substation's relay protection. And the characteristics of the relay's function are adjusted correctly.

DIFFERENTIAL PROTECTION OF TRANSFORMER’S CALCULATION

First, the primary current of the transformer is found at each voltage level.

$$TAP = \frac{MVA \cdot 1000 \cdot C}{\sqrt{3} \cdot VTERM \cdot CTR}$$

TAPs=0.669, TAP_T=0.857 and TAP_U=0.84 in 110/35/10kV transformer with 40MVA power by this formula. The current transformers are directly star-connected, so there is a need for compensation. Because the connection of the power transformer is Y/Y/D. It was solved $TSCTS_s$=5, $TSTS_S$=5, $TSCTS_U$=0. And formula for finding the minimum operating value of the differential element:

$$087P \geq \frac{0.02 \cdot I_{nom}}{TAP_{MAX}}$$

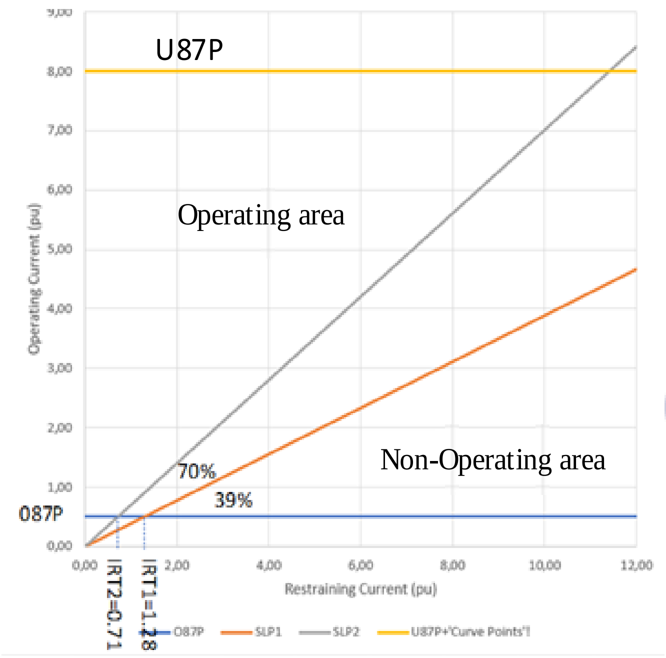
Considering Inom=0.84, the answer to the above equation was decided as 1. Also when finding a differential element that will work without restriction:

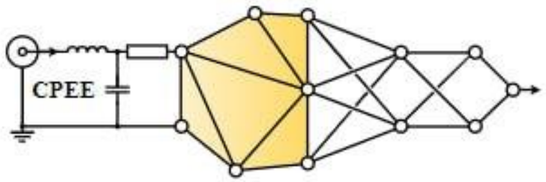
$$U87P < \frac{31 \cdot I_{HOM}}{TAP_{MAX}}$$

The answer is solved U87P=31. But we got 8 as suggested in the relay documentation. Then the characteristics of the relay were established, the formula of which is:

$$I_{dmax} = (1+e) - \frac{1-e}{1+a} = \frac{(2 \cdot e) + a + (e \cdot a)}{1+a}$$

When making this calculation, the error of the current transformer is 10 percent. The transformer's tap changer error was considered to be 16 percent.





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OVERCURRENT PROTECTION OF TRANSFORMER'S CALCULATION

High voltage point of transformer (110kV)

- Maximum loading current:

$I_{load.max} = I_{nom} \cdot 1.4 = 200.82 \cdot 1.4 = 281.148$ A

- Working current of protection:

$I_{p.c} = (K_c/K_r) \cdot I_{load.max} = (1.3/0.95)*281.148$ A $= 384.73$A

There: $K_c = 1.3$ reliability coefficient

$K_r = 0.95$ return coefficient (microprocessor-based relay's value is 0.95-0.98)

- Working current of relay:

$I_{r.c} = I_{p.c}/n_{TA} \cdot K_{sk} = 384.73/(300/1) \cdot 1 = 1.28$ A

- Defense Sensibility:

$K_d = I_{sc.min}/I_{p.c} = 2142/384.73 = 5.57 > 1.5$

- Duration of protection:

$t_{ocp} = t_{ocp}1 + \Delta t = 1 + 0.5 = 1.5$s

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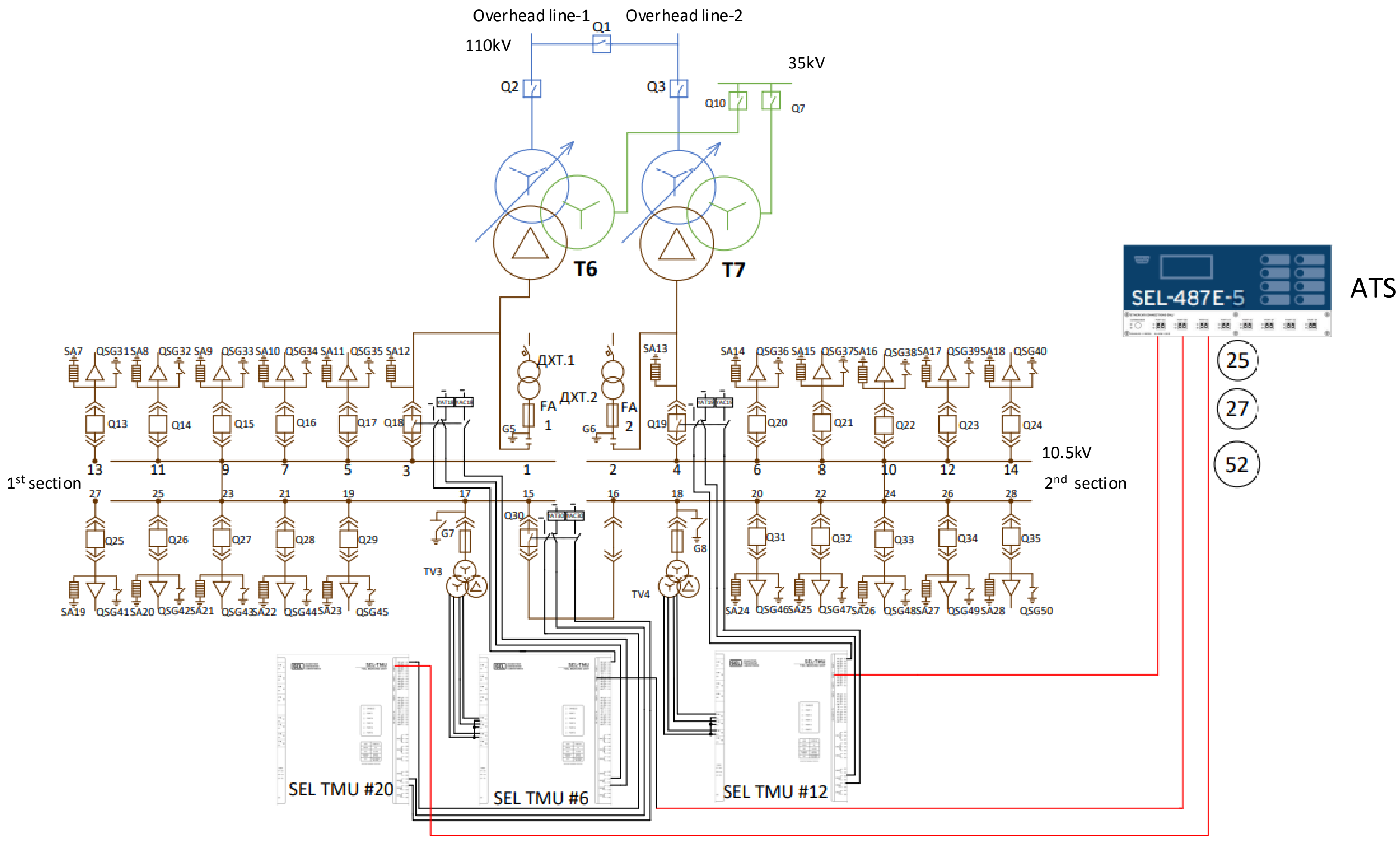
ATS LOGIC SCHEME FOR 10kV CLOSED SWITCHGEAR



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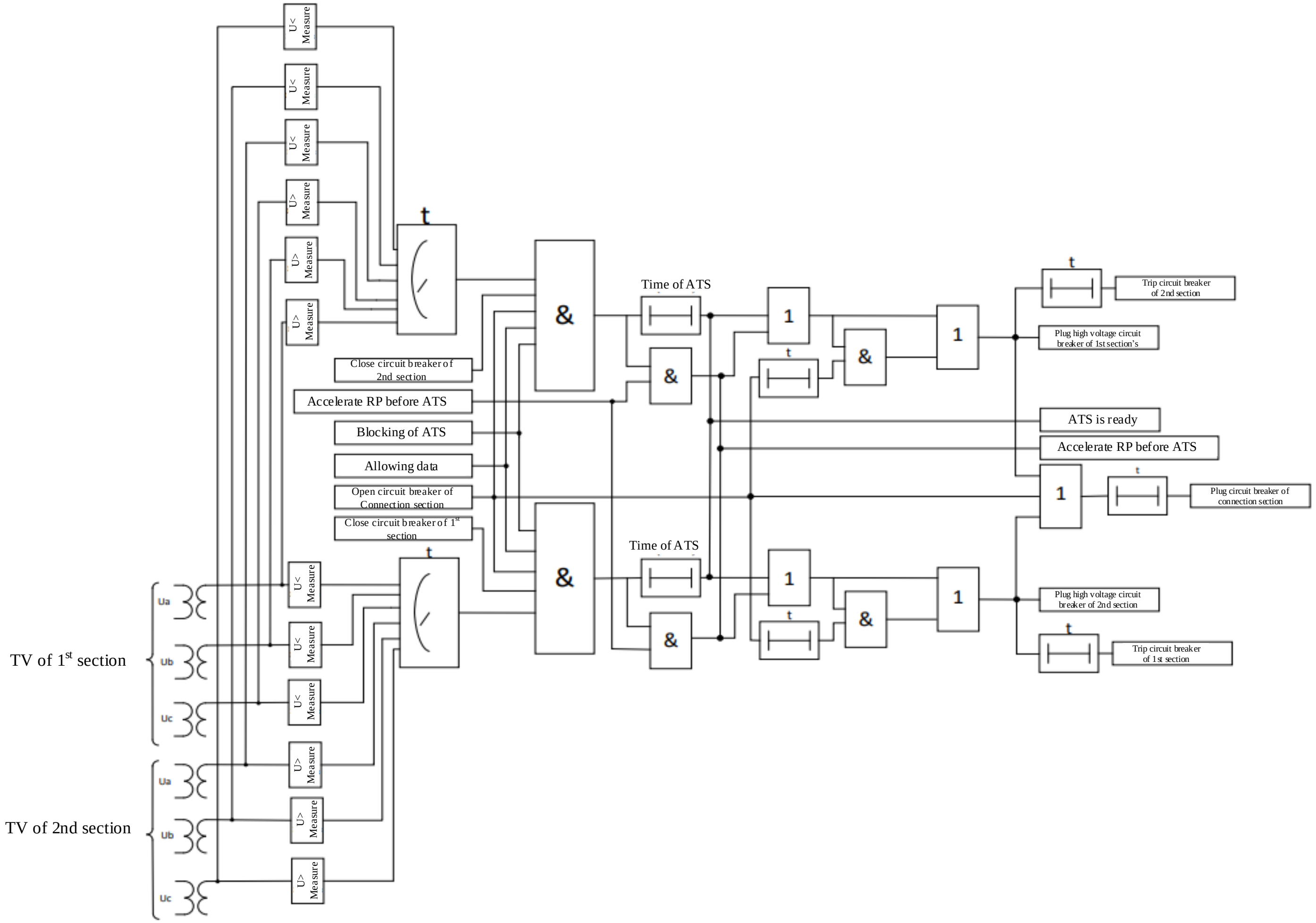

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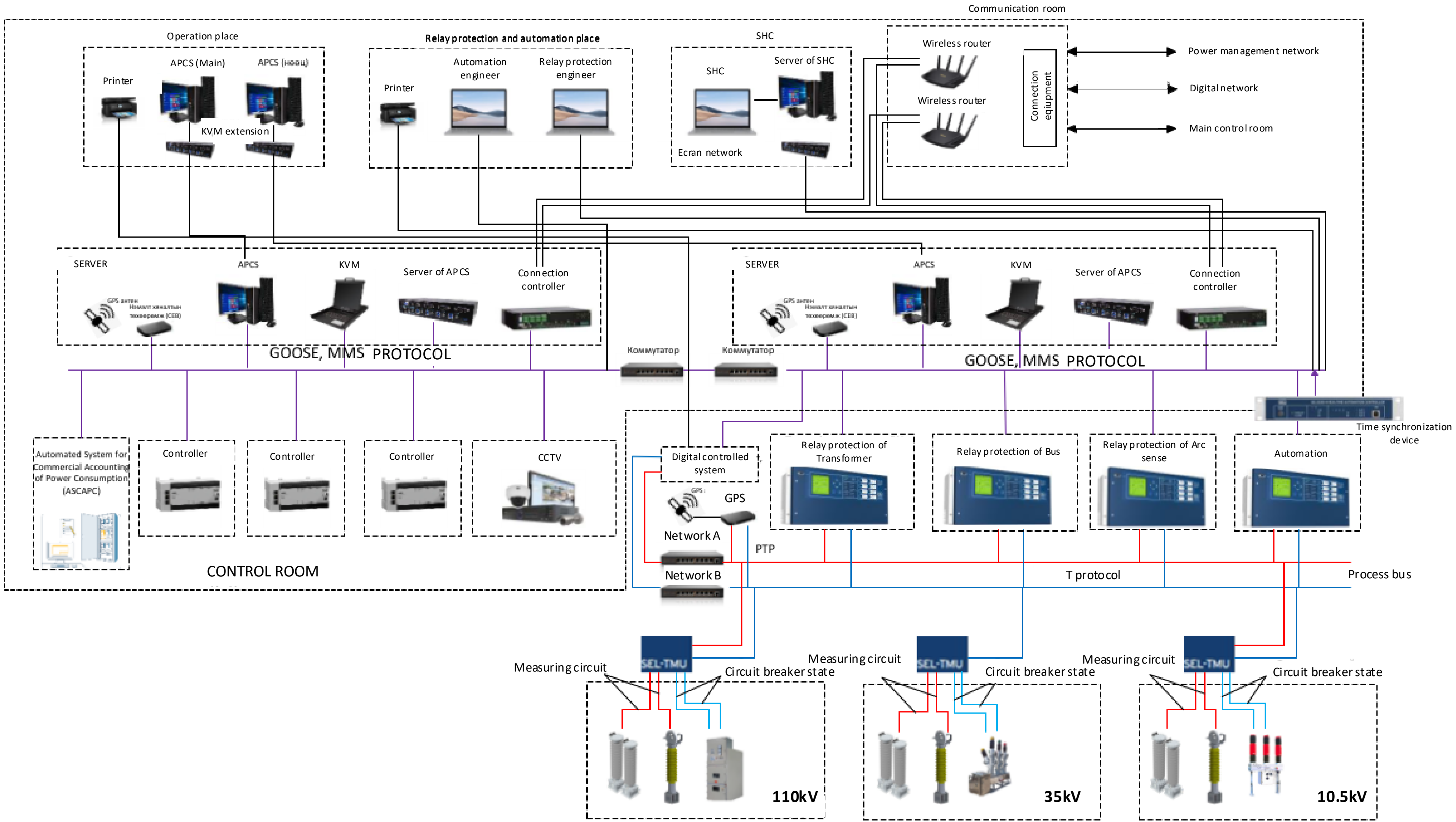
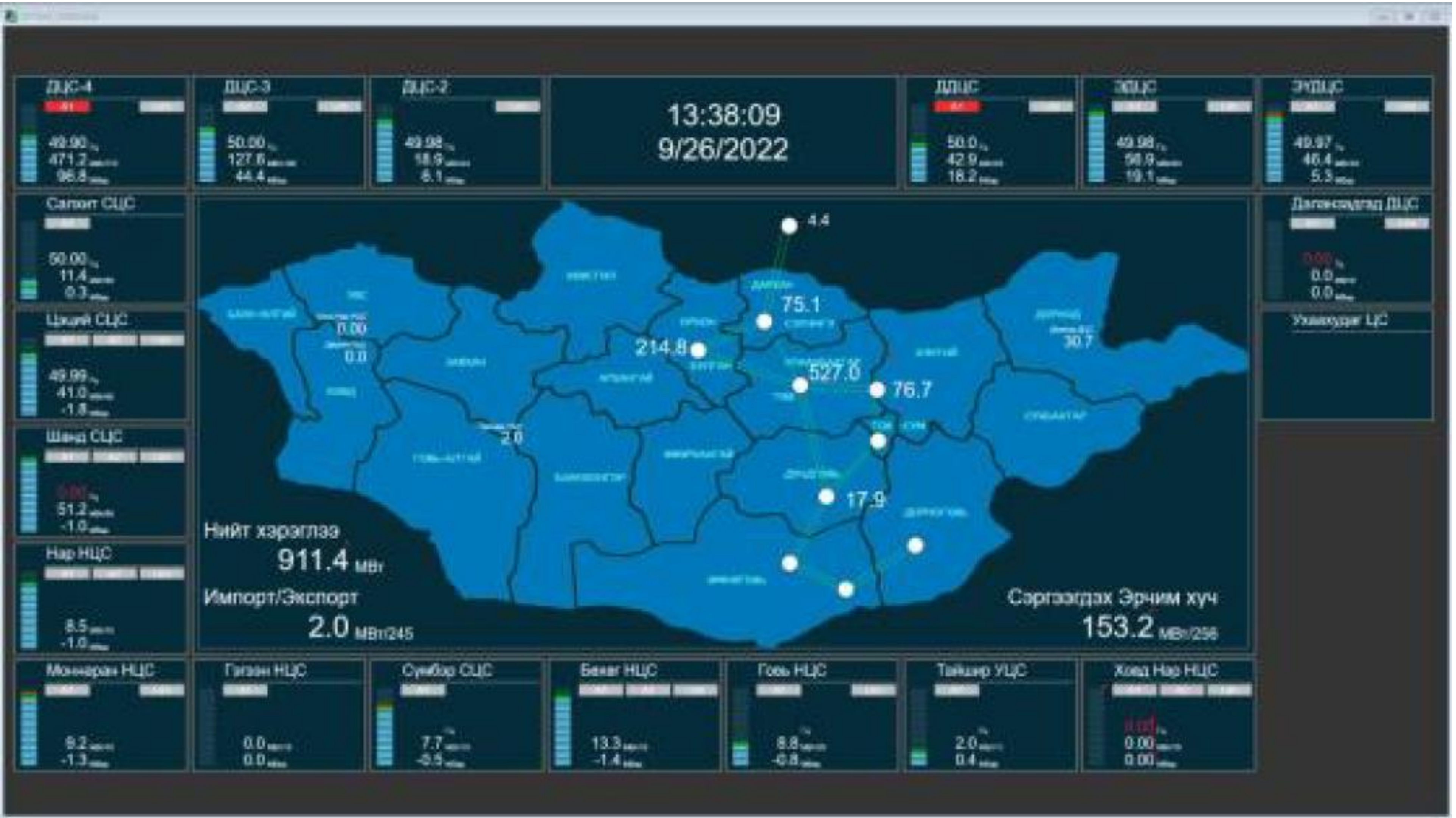
DIGITAL SUBSTATION'S ARCHITECTURE



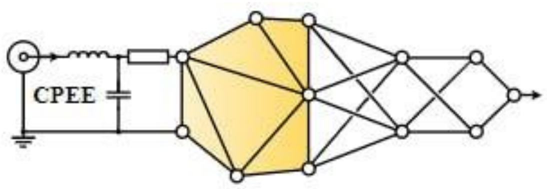
PENETRATION OF SCADA, WAMS INTO THE SYSTEM AND FEATURES



- 2024 km of 220 kV,
- 5500.7km of 110km,
- 10167.5km of 35kV,
- 4357km of 15-20kV,
- 15250.1km of 6-10kV
- 20899.1km of 0.22-0.4kV power transmission and distribution lines.

Total is 58188.4km

8709 substations in total.



PENETRATION OF SCADA, WAMS INTO THE SYSTEM AND FEATURES

ШУТИС

The “Electrical Main Transmission System Company of Mongolia” plans to connect 23 220kV high voltage lines, 82 110kV lines, 15 power plants, and 4 transformers to a total of 124 points in 31 locations with WAMS.

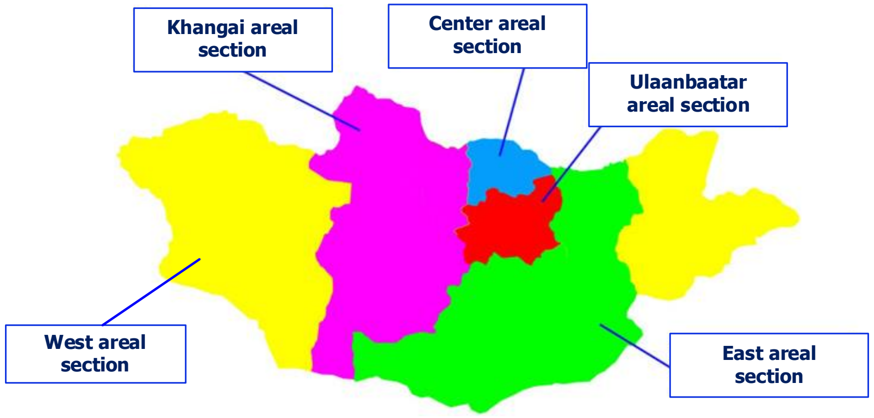
SOFTWARE: COPADATA

RS485:

DNP3:

COMMUNICATION:

To improve the reliability of the network, a fiber optic RING network was created by creating an infrastructure between the points “Television”, “Nairamdal”, “Songino” and outdoor switchgear using network-managed switches.



IMPLEMENT ISSUES

An incomplete conventional substation shows us the great risk in Mongolia due to global warming and massive flooding. We know that all work in the electrical industry has a lot of risks. Due to the wide variety of existing control systems, there are many problems with inter-protocol data exchange. And this can’t provide cyber security. Differences in protocols do not maintain good time synchronization. By using IEC61850 standard protocols, we will benefit more in terms of better speed and a wider range of data.

We need to exchange experience with qualified engineers on international digital substations. Our point is mostly to convert existing substations into digital substations. Therefore, from which substation will electricity be supplied to the consumers of that substation? The problem will appear. But we can work it out. We can solve this when we exchange experience with experienced engineers to convert our conventional substation into a digital substation according to the country's characteristics.

CONCLUSION

Cybersecurity and systemic inadequacies exist in Mongolia's energy system. Therefore, digital substation solutions are highly needed to compensate for the lack of application of SCADA and WAMS systems. In this article, it is intended to develop a digital substation on the existing station in Mongolia. Because digital substations have many positive effects on the environment, health, and safety work. Fiber networks require less energy, they also generate less heat, and require less cooling than copper cable networks. And less cooling means even fewer carbon emissions.

When building a digital substation in Mongolia, there is a problem of changing and testing the entire secondary circuit. During the development of the digital substation, the general architectures were established sequentially. To become a country with digital substations, Mongolia must solve the new experience of engineers and system changes. It is quite possible to create a digital substation in Mongolia.

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E-Mail: nomin.l@mcsi.mn, adarsuren@must.edu.mn, zagdkhorol@must.edu.mn