

Optimization of the Sub - Station Control System and Operative Switching

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Abstract - To prevent personnel errors, reduce transmission-time, which is very essential in emergencies, new substations, having established a full-scale blocking and re-built substations can be brought into the automatic control system. In this paper the optimization of the substation control system and operative switching are considered. The algorithm of switching for a particular case is created, but the principle can be used in switching other devices of substation.

Keywords: sub-station, operation switching, control, smart station

I. INTRODUCTION

Nowadays, many sub – station are built or renovated, so there is a need for new installations and new control systems.

Substation construction is designed to provide consumers with continuous, high-quality, standards-compliant power supply, regardless the necessity to realize periodically the equipment maintenance and service, as well as damage of the equipment and troubles in the operation.

Substation installations are divided into primary switching equipment - transformers, circuit breakers, grounding switchers, current transformers, and voltage transformers as well as secondary switching equipment for primary switching apparatus to control, monitor, protect and provide automation for their operations. Each commutation device of the substation is assigned with an operative sign to realize the operative switching of the equipment. Each substation has a scheme of a routine regime, the routine switching takes place with the use of the switching map.

II. DESCRIPTION OF THE PROBLEM

Substation switching is completed by the operational staff or dispatcher, turning on and switching off the equipment in a particular order. It is determined according to a preliminary completed map of the order of the switching [1, 4]. However, it will take a long time while operating personnel reaches the substation. For faster disconnection of the damaged sector in the emergency case or at maintenance and repair it is logically to develop an automated system. At a local workstation or central dispatcher computer service a necessary switching will be processed selecting a specific operation in a specific order according to the switching map. The system will check the output state, and only if all the necessary conditions are met, the switching process will be started.

Each substation has a defined scheme of a normal regime "Fig.1" with all the conditions of the commutation equipment for the operation of substation. [3,8] The switching maps are developed taking into account the normal operation regime and the initial condition. A particular sequence of switching is determined. For a concrete switching in this case it is: The

main sequence of operation with commutating equipment for the transformers connection:

A. Put into operation

- Disable grounding equipment if such was switched on;
- Check whether the neutral grounding is on, if not – turning it on;
- Put into operation all relay protection;
- Check the power switch and turn on the "bus" and then the circuit breaker of the transformer at the high voltage side;
- Check the power switch and turn on the "bus" and then the circuit breaker of the transformer at the low voltage side;
- Turn the transformer circuit breakers of self-consumption and neutral, if they are connected to a transformer bus or cable bridge;
- Turn on consequently the power switches at a high and then low voltage side;
- Bring into the work the transformer automation;
- Put a neutral mode into a normal mode scheme.

B. Removal for maintenance and service

- Check whether the neutral grounding of the transformer is turned on, if not – turn it on;
- Switch off the transformer automation;
- Turn off consequently the power switches at a low and then high voltage side;
- Check the power switch disable state and turn off the "transformer" and "bus" circuit breakers at the low voltage side;
- Check the power switch disable state and turn off the "transformer" and "bus" circuit breakers at the high voltage side;
- Turn off the relay protection;
- To check the absence of voltage and ground the connection [5,6,7]

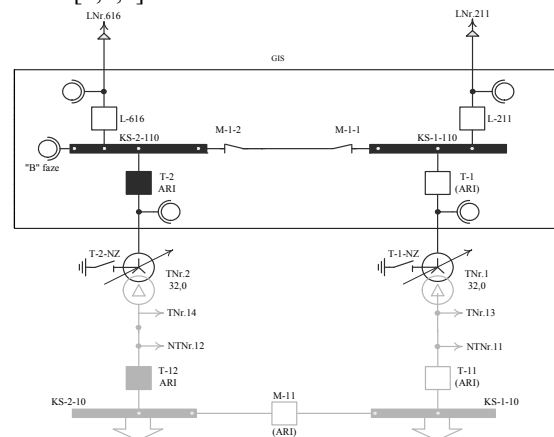


Fig. 1. Scheme of the substation normal regime of operation.

III. OPTIMIZATION OF THE CONTROL SYSTEM AND OPERATIVE SWITCHING

“Fig.2,” represents the algorithm of the given switching map according to which the switching can be realized.

The algorithm in “Fig. 2,” allows to introduce transformer TNr.1 into service from the operation regime of the circuit and switch on TNr.2 without voltage interruption. The switching algorithm of the giving switching map is given in “Fig. 3.a,” “Fig. 3.b,” “Fig.3.c.” From the beginning it is necessary to define marking of all the equipment for switching and provide them with the marker of status: on - 1, off - 0, automatic mode – A, manually - R and to the signal - S. When the terms are defined, the testing of the switching equipment can be started and, if necessary, an appropriate state is assigned.

Starting position TNr.1 in work, TNr.2 in auto regime

Task	Introduce transformer TNr.1 into service and switch on TNr.2 without voltage interruption						
	A	B	C	D	E	F	G
1	le T-1-NZ computer	A T-11 computer	! T-413 -P2	T-11 Trolley in the locked condition	! Breadboard model		
2	le T-2-NZ computer	! U _{KS-1-10} =0 computer	A T-413-0	T-1-1 In the locked condition			
3	S280 R2 ARI off.	! U _{KS-2-10} =0 computer	* T-13-0	T-13-0 In the locked condition			
4	le T-2 computer	A T-1 computer	! U=0 T-13-0 TNr.13 side	S250 R2 To signal			
5	A1 R2 Manual contr.	A1 R4 Auto contr.	le T-13-0Z	S251 R2 To signal			
6	A1 R4 Manual contr.	! T-11	! USPT-1=0 computer	S290 R4 "Off"			
7	! Degree TNr.1=TNr.2 R2;R4	A T-11 Trolley off	le T-1-Z computer	A QF12 -P1			
8	le T-12 computer	! T-1 computer	! U=0 T-11 Bus bridge	A QF6 =P1			
9	! U _{T-13-0} computer	A T-1-1 computer	le T-11-Z	A T-2-NZ computer			

Fig.2. Switching map of the substation.

The first operation of the switching map “Fig.2,” is to switch on T - 1 - NZ. [6, 7] From the beginning, verify the state of T - 1 - NZ comparing it with 0. If the state corresponds to 0 (off), then it should be 1 (on), but if the case does not meet condition 0, then immediately go to the next operation. The situation is similar with T - 2 - NZ. S280 switch state is tested and when it is switched on, it has 0 (off), but if it is disconnected, then the operation goes to the next step. That is to turn on TNr.2 110 kV circuit breaker T - 2. Check the unlocked position comparing it to zero, if it equals to 0, then T - 2 is turned providing state 1 (on), if not, then the program will stop and give the signal to CDS (central dispatcher service) as the state does not corresponds to the normal operation regime and it is the operation with switching equipment, so the further operation is stopped until the failure mode of the circuit operation. .

The next operation is to transmit the operation of both transformers from automatic voltage mode to manual. The state of switches A1 of TNr.1 is examined: whether it is equal to A (automatic) or not. If it is, then TNr.1 A1: = R (manual), if not, the algorithm proceeds to the next operation. The same happens to A1 TNr.2 voltage regulation equipment. Then the two-step comparison of the transformers follows, in the case when the parameters are the same, the next operation comes, but if they are not equal, then the comparison whether TNr.1 level is greater than TNr.2 degree takes place, if the condition is satisfied, then TNr.2 switch is assigned with the level of TNr.1 switch and the execution of the program is continued; if TNr.1 level is less than that of TNr.2, then also TNr.1 switch is assigned with the level of that of TNr.2 and the program is continued.

The next operation is the actuation of 10 kV circuit breaker of T - 12. T - 12 off position is tested, there is a comparison with 0, and if it is off, T - 12 is assigned with state 1 (on), if it is on, the program performs the next operation.

After T - 12 switching on the current should be tested in T - 12 connection from STT - 12 CT comparing it with 0. If the current is not equal to 0, then the whole process will continue; if there is no current T - 12 on state is re-examined and in case of positive result the current existence of T - 12 is re-examined in the connection, if there is – the algorithm proceeds to the next operation, if not – the signal goes CDS and program execution stops. Re-examining of the T - 12 turned on state in the case of negative result results in that T - 12 is switched on again, assigning to it 1, and the current existence of T - 12 is examined, if it exists, then the program moves on to the next operation, if not, the program stops.

After all the operations T - 1, T - 11, T - 2, T - 12 and M - 11 are on. If there is current in T - 12, the process of switching is continued, disconnecting 10 kV circuit breaker T - 11 of TNr.1, assigning it with 0 (off) and testing voltage in KS - 1 - 10 and KS - 2 - 10. If they are supplied, the program goes to the next operation, if not – it gives the start command to T - 11, assigning 1 (on) to provide consumers with electricity, and again sending the signal to CDS.

Disconnecting the power switch 110 kV T - 1, assigning it with 0 the transformer is turned off from the power at both sides, but for its safe operation it should be disconnected. Before the disconnection the TNr.2 voltage regulation equipment should be turned to the automatic mode assigning it with A. Before switching on the disconnectors the off states of the circuit breakers should be tested, starting with the lower voltage side - the 10 kV circuit breaker T - 11; if it is disconnected or equal to 0, then T - 11 should be in off (0) position, in case if the switch is turned on the correspondent signal is sent to CDS. This is also takes place at the 110 kV side, the off state of the switch is tested and if it is off the command for switching off is sent T - 1 - 1.

When the self-consumption part is disconnected 0.4 kV, it is necessary to turn off T - 13 - 0 with a command. Now the connection can be grounded after testing the supply. If there no voltage, then the T - 13 - 0Z is supplied with the switching on command, assigning 1. The same takes place at the 110 kV and 10 kV sides, the voltage is tested and the connections are grounded, turning on T - 1 - Z and T - 11 - Z.

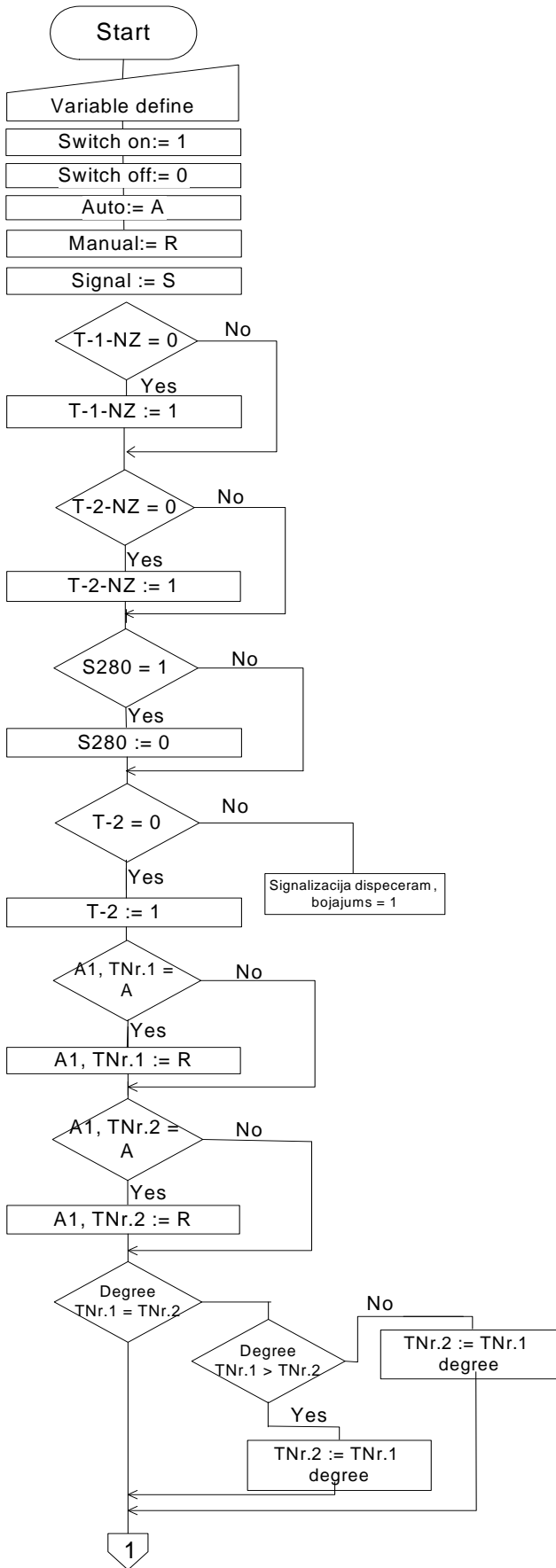


Fig. 3. a.. The switching algorithm for substation to introduce into service of TNR.1 and start the operation of TNR.2.

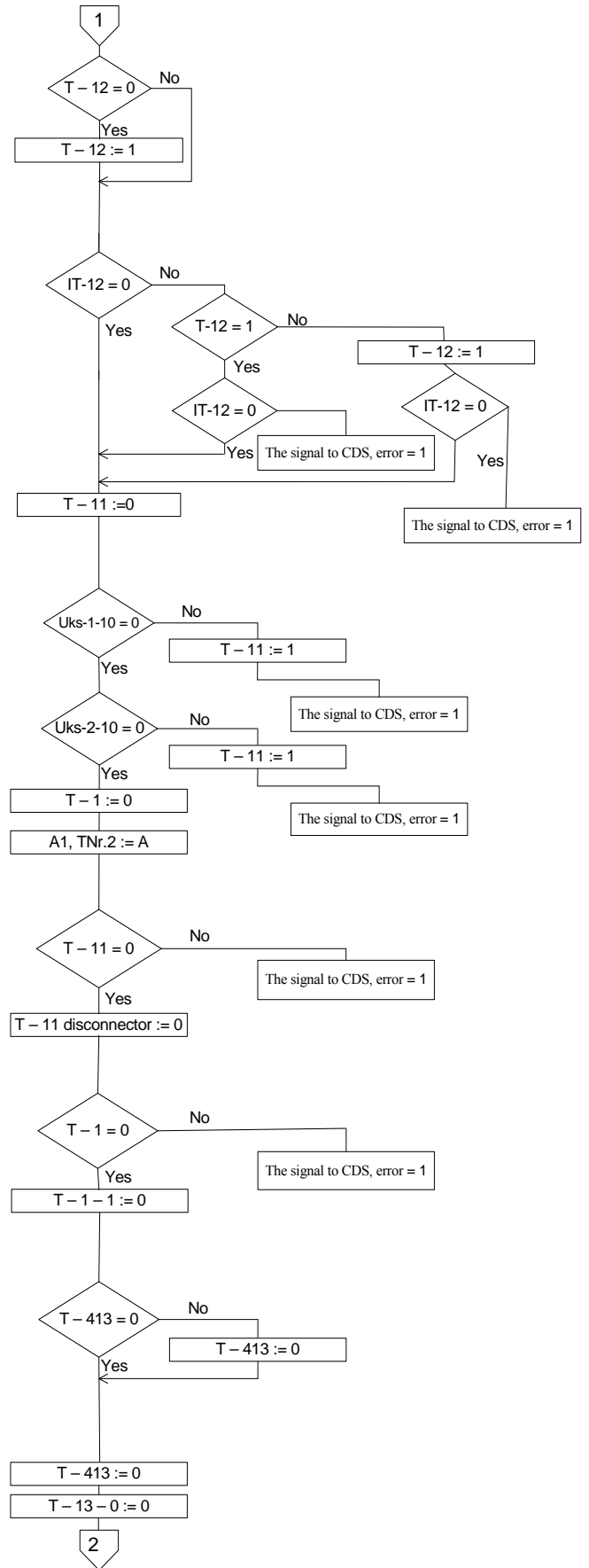


Fig. 3. b. The switching algorithm for substation to introduce into service of TNR.1 and start the operation of TNR.2.

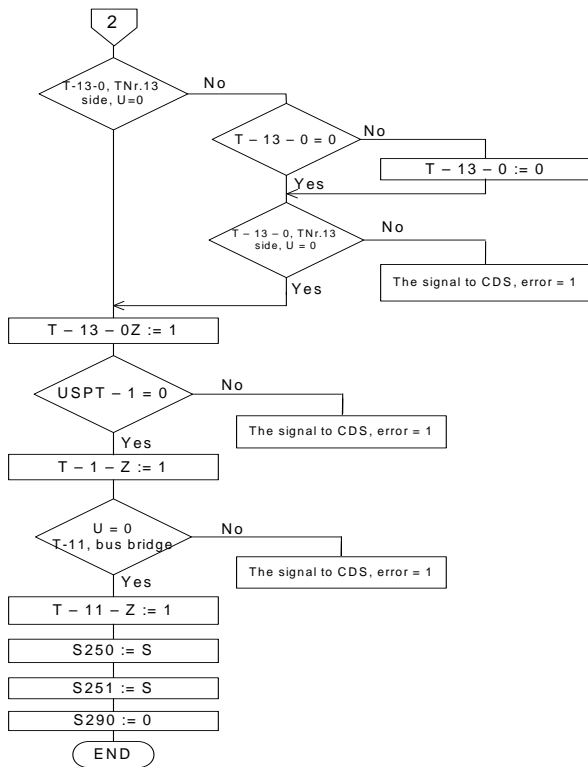


Fig. 3. c. The switching algorithm for substation to introduce into service of TNR.1 and start the operation of TNR.2.

IV. VISUALIZATION OF THE DEVELOPED SYSTEM

For the realization of the new control algorithm software Telemix VENTA is applied; the scheme of the substation in this software window in demonstrated in "Fig. 4". All the commutation equipment is provided with full control and blocking.

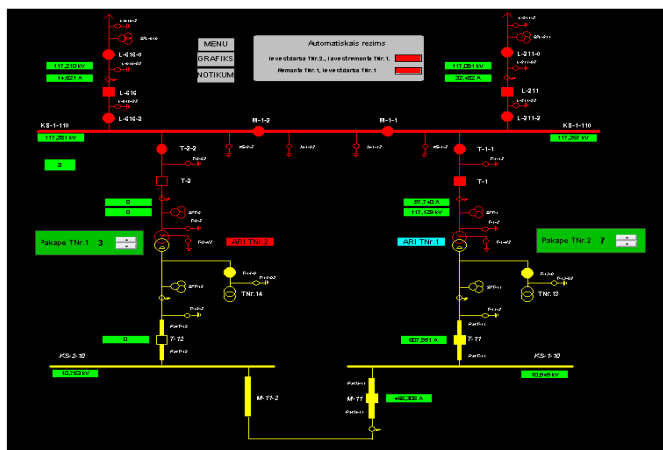


Fig. 4. The scheme of the substation in software Telemix VENTA

In the upper part of 4. figure the menu is given: MENU, SCHEDULE and EVENTS. Pushing button MENU block „Automatic mode” is open where an operation can be selected: switch TNR.2 into the operation and start the service for TNR.1 if the scheme is in normal regime or if TNR.1 is in the service introduce TNR.1 into operation and provide the automatic reserve (ARI) for TNR.2 (Fig. 5).

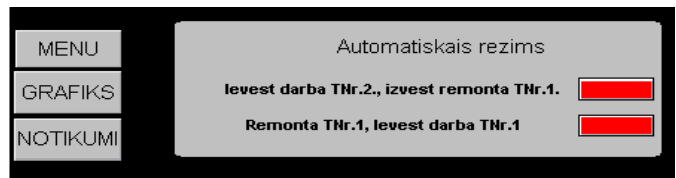


Fig. 5. Menu

Fig. 4 demonstrates the operation regime of the scheme corresponding to the scheme given in Fig 1: both line are in operation - LNr.616 and LNr.211 and TNr.1 operates. TNr.2 is in the automatic reserve (ARI). Thus if it is necessary the first variant can be chosen and TNr.2 is introduced into the operation and TNr.1 is in service, pushing red button with a correspondent command. To be sure that the correct operation is selected a screen with a confirmation appears „Introduce TNr.2 into operation and service for TNr.1”. With pushing the confirmation button the control system realizes the command in accordance with the algorithm given in Fig. 3. While the switching the color of the button is changed for light blue but as soon as the switching is completed it is again red, but if the process is stopped the button of the automatic regime does not change the color and remains light blue –simply determining the end of the process. Similarly the opposite process is taking place - introducing TNr.1 into operation and reserve mode for Tnr.2.

CONCLUSIONS

To prevent personnel errors, reduce transmission-time, which is very essential in emergencies, new substations, having established a full-scale blocking and re-built substations can be brought into the automatic control system. Analyzing the current situation in the substation, choosing programming controller, necessary for the operation, the program will begin the process of switching. If one of the primary switching apparatus initial states is incompatible the program will not start its operations. In the case of on or off commands, switching equipment state may not be changed, then the command will be repeated, even if nothing happens, the switching process will stop and the controller will receive the message.

It is expected that the new designed system will significantly increase the safety of the substation, especially in an emergency situation. It allows a significant reducing of the switching time, which is faster to provide consumers with saving energy and plant recovery after a crash.

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Gļebs Golubovs. Apakšstacijas vadības sistēmas un operatīvo pārslēgumu optimizācija.

Raksts veltīts vadības sistēmas un operatīvo pārslēgumu optimizācijai. Tika apskatīta apakšstacija un uz tās piemēra radīta automātisko pārslēgumu sistēma. Tika radīts arī jaunais operatīvo pārslēgumu algoritms un radīta transformatoru automātiska pārslēgšanas procesa vizualizācija. Autori analizē un sīki apraksta jauno algoritmu. Pateicoties jaunajai sistēmai būtiski palielināsies apakšstacijas drošums, it īpaši avārijas gadījumos, ja operatīvais personāls nevar ātri tikt uz apakšstaciju. Pārslēgumi apakšstacijās veic dežurejošais dispečers no vadības centra, vai operatīvas izbraukuma brigādes personāls uz vietas apakšstacijā. Veicot pārslēgumus augstsprieguma apakšstacijās ir ļoti svarīga secība, kurā tie tiek veikti. Nedrīkst pieļaut kļūdas, jo tas var izraisīt nelabvēlīgas sekas. Ar simulāciju palīdzību tiek radīti visu komutācijas aparātu pārslēgšanas iespējas, kas ļauj redzēt cik efektīva šī sistēma būtu reālajā apakšstacijā, visiem komutācijas aparātiem izveidota bloķēšana pilnā apjomā, kas pasargā no kļūdainām operācijām, veicot pārslēgumus manuāli. Šajā sistēmas izstrādes momentā radīti tikai divi automātiskās pārslēgšanas režīmi – transformatoru pārslēgšanas. Turpmāk planots pilnveidot sistēmu un izveidot automātisko apakšstacijas vadību visiem apakšstacijas pievienojumiem. Darba gaitā tika izpētītas un salīdzinātas jauna automātiska pārslēgumu sistēma ar veco. Secinot, var teikt, ka jauna sistēma ļauj krietni samazināt pārslēgšanas laiku, respektīvi, atbrīvot patērētājus ar elektroenerģiju un ietaupīt līdzekļus iekārtu atjaunošanai pēc avārijas. Turpmāk, izveidojot automātisko vadību visiem pievienojumiem, var panākt, ka apakšstacija strādās pilnīgi automātiskā režīmā un personāla iejaukšana būs nepieciešama tikai remontu nepieciešamības gadījumā.

Глеб Голубов. Оптимизация системы контроля и оперативных переключений подстанций.

Статья посвящена оптимизации систем управления и процессов оперативных переключений подстанций. Рассмотрена подстанция и на её примере создана система автоматических переключений. Создан новый алгоритм оперативных переключений и создана визуализация автоматического переключения трансформаторов. Авторы анализируют и подробно описывают новый алгоритм. Благодаря новой системе, существенно повысится надежность подстанций, особенно во время аварий, если у оперативного персонала нет возможности быстро попасть на определенный объект. Переключения на подстанциях выполняются дежурным диспетчером или персоналом оперативно выездной бригады на подстанции. Выполняя переключения очень важен порядок переключений, так как это может привести к неблагоприятным последствиям. С помощью симуляции создано наглядное переключение всех коммутационных аппаратов, что позволяет отлично увидеть, насколько эффективна была бы эта система на подстанциях, всем коммутационным аппаратам создана полная оперативная блокировка, что позволяет исключить ошибки персонала во время переключения в ручном режиме. Однако, на данном периоде разработок системы, созданы только два режима автоматического переключения – переключения трансформаторов, в дальнейшем система будет улучшена и будет возможно видеть автоматическое переключение всех присоединений подстанции. Во время работы были исследованы и сравнены новая система автоматического управления со старой. Делая выводы, можно сказать, что новая система позволяет намного уменьшить время переключений, соответственно, быстрее обеспечить потребителей электроэнергией и сэкономить средства на восстановлении устройств после аварии. В дальнейшем, создав автоматическое управление всем присоединениям, можно добиться того, что подстанция будет работать в полностью автоматическом режиме и вмешательство персонала будет необходимо только в случае необходимости ремонта.