Improving the quality of electricity using the application of reactive power sources

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Abstract. This article includes measures to improve the quality of electricity, reactive power sources, as well as various factors and circumstances affecting electricity. The technological processes of any production largely depend on the quality of electricity. In general, low electricity quality can be characterized as any changes in power supply. The result is a violation of the normal directions of the production process, damage to equipment, transformers, electric motors. Modern methods of improving its quality in the transmission and distribution of electricity are very numerous and significant. In parallel, the article studied the components of the power supply system in order to achieve high-quality electricity in order to improve the living conditions of the population and increase production efficiency.

1 Introduction

Due to the fact that electricity is located at a distance from consumer power plants, external influences on overhead power lines are slightly affected. External influences are caused by various types of disturbances and damage in the air power transmission lines causing the network voltage to drop or the power supply system to completely disconnect. The duration and level of hazard of breakdowns and damage depends on the structure of the network and the time required for its repair. Another type of damage to the power supply system is in the process of network control, such as reinstalling or unexpectedly appearing during the growth of the load. Sources of disruption within a network include: fluctuations specific to a particular network, fluctuations occurring between different network elements and filters, etc. A number of measures are being developed to eliminate various types of disorders and injuries. There is also a catastrophic effect on power plant power generators under synchronous vibrations.

2 Results and discussion

Currently, reactive power compensation is an important factor in solving the issue of energy saving and reducing the load on the power grid. The share of energy resources and, in particular, electricity is of great importance in the cost of production [1].

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 https://doi.org/10.1051/e3sconf/202339006032

This has sufficient capacity to take seriously the analysis and verification of the enterprise's energy consumption, the development of techniques and the search for reactive power compensation tools. The reactive load produced by electricity consumers can be organized with capacitance loading by connecting capacitors that are accurately calculated. This makes it possible to reduce the reactive power consumed from the network and is called increasing the power factor or compensating for reactive power. We perform reactive power compensation using capacitor batteries. Advantages of using capacitor devices:

1. Small specific losses of active power as a means of compensating for reactive power (the own losses of modern low voltage capacitors do not exceed 0.5 W per 1000 var;
2. Absence of rotating parts;
3. It is not necessary to install and use simple;
4. Relatively low investments;
5. Ability to choose any desired compensation capacity;
6. Possibility of installation and connection at any point of the power grid;
7. Lack of noise during Operation;
8. Organization of small operating costs.

Types of compensation may refer to:

1. Individual or permanent compensation, in which reactive power is directly compensated at the place of its occurrence, also includes (asynchronous motors, transformers, welding machines, lighting lamps, etc.for long - term consumers with constant or relatively high power) (Figure 1).

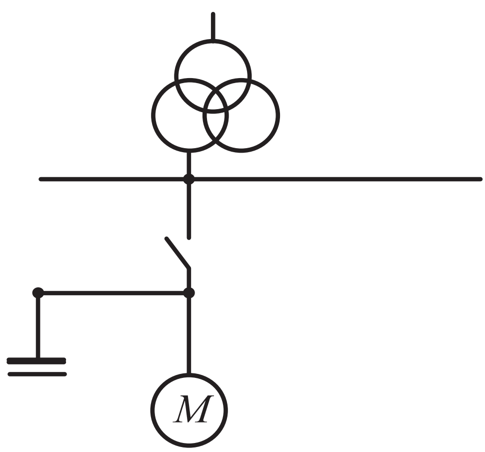

Fig. 1. Indvidual compensation.

2. Common to consumers of several inductive types running simultaneously, calculated capacitors (electric motors close together, for groups of discharge lamps) are connected group compensation (Figure 2).

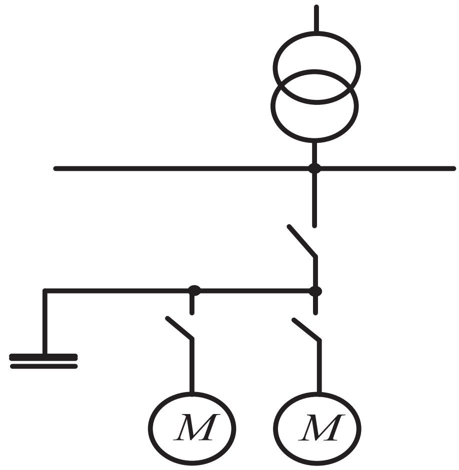

Fig. 2. Group compensation.

3. The next appearance of compensation is centralized compensation, where a certain number of capacitors are connected to the main or group distribution cabinet. Such compensation is usually used in large power supply systems with variable loading (Figure 3).

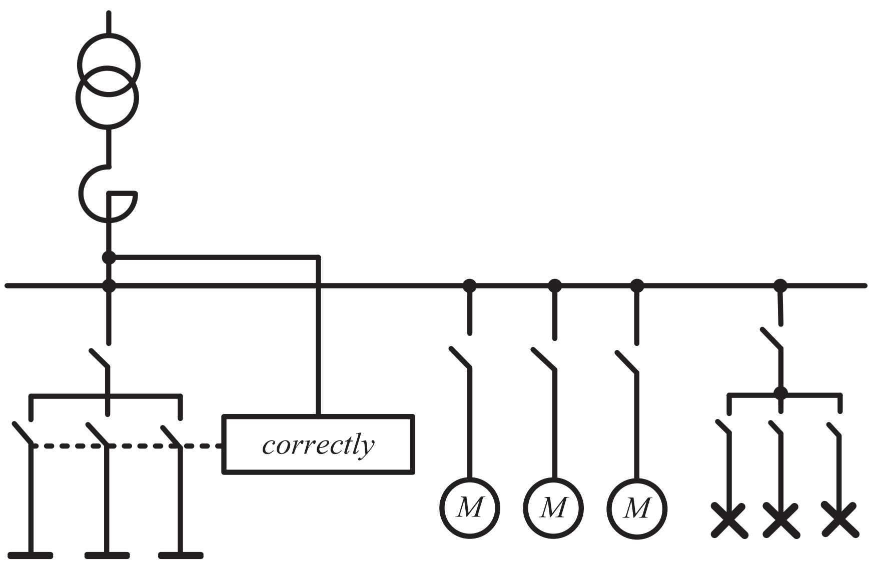

Fig. 3. Centralized compensation.

Control of such a capacitor device is carried out by an electronic regulator - controller, which constantly analyzes the reactive power consumption from the network. Such regulators turn on or off capacitors, with which the instantaneous reactive power of the total load is compensated, and thus the total power consumed from the network is reduced. The installation of reactive power compensation consists of a certain number of capacitor networks, which are selected in their construction and stages based on the characteristics of each specific electrical network and its reactive power consumers. More common than others are 5kVar, 7.5kVar, 10kVar 12.5kVar, 20kVar, 25kVar, 30kVar, 50kVar types. In load surpluses, however, compensation is achieved by combining 100 kvar or even more, several small capacitor batteries. Thus, the load on the network created by harmonic vibrations is reduced. If there is a large part of the upper harmonica at the voltage of the electrical network, then the capacitors are usually protected by (filter circuit reactors) [2,3].

The use of reactive power compensation devices allows you to solve a number of problems:

- Reduce the load of power transformers (reduce full power consumption by reducing reactive power consumption);
- Providing a certain part of the load through the cable (not allowing the insulation to overheat);
- Connecting additional load by providing power transformers and cables with a small current;
- Prevents voltage drop in remote consumer power supply lines;
- Maximum use of the power of autonomous diesel generators;
- Engine start and ease of operation (with individual compensation);
- The change in the reactive load power in the Compensated network is automatically monitored and the value of the power factor in accordance with the established cosφ; increased;
- The occurrence of overvoltage in the network is excluded, since there will be no recompensation when using unregulated capacitor devices;
- All basic parameters of the Compensated network are directly monitored [4,5].

Nonlinear fluctuations caused by overloading of power and measurement Transformers adversely affect electrical circuits and systems. The increase in the quality of electricity in recent years has reached the level of urgent tasks of industrial enterprises, and research is being carried out to standardize electrical loads with increasing cases of decrease in the quality of electricity in the power grid. Also, the fact that passive filters have been used in conjunction with high-power thyristors or diode rectifiers for many years also leads to quality degradation. To date, as the electronic elements to be encoded begin to appear, it is possible to produce semiconductors that allow to increase the quality of electrical energy, such as BTIE (bipolar transistor, whose insulation is encoded), CT (coded thyristor) or LTWCUI (lockable thyristor, on which the control unit is installed). With the installation of active filters for low voltage, it was possible to apply them at medium voltages, and this technology is actively developing in the last years in modern networks of energy.

Let's consider a comparison of the voltage drop before and after the introduction of reactive power sources at the end of every 220 kV line of nymstantiations. Analyzing the data, an increase in the voltage level is generated after the introduction of reactive power sources. At the same time, the violation of the quality of electricity is also directly related to the harmonics of sinusoidal fluctuations, and the following three main problems arise in the transmission of electricity:

- Lack of stability in transmission.
- Inability to control voltage and regulate voltage deviation in the absence of load.
- Occurrence of resonance [6,7].

The result of the electrical power quality problem is the condition that causes the sinusoidal graph to break voltage or deviate from its face value. Problems with the quality of electricity will last from milliseconds to several hours. The main effect of voltage drop is premature equipment failure, loss of electrical machine efficiency, distortion in equipment, loss of stability. Economic costs associated with problems in the quality of electricity are enormous, especially industrial costs. Costs include production losses, damage, payroll costs,

https://doi.org/10.1051/e3sconf/202339006032

restart costs. Reactive power is required to transmit active power to the consumer through a transmission and distribution system.

The construction of new power transmission lines is a process that is directly related to large costs and often also to external influences. It also makes it possible to reduce wastes and increase the quality of electricity by increasing the voltage of electricity transmitted through existing lines. Transverse and longitudinal compensation tools can be used to control the quality of electricity [8].

High-voltage overhead power lines also have inductive resistance, and the voltage drop in it is associated with various situations. In this case, the inductive resistance value is compensated by the capacitance connected in series. Currently, several projects and solutions are being used in the application of compensation. In reactive power compensation, mainly capacitor batteries and controlled thyristors can be used (Figure 4).

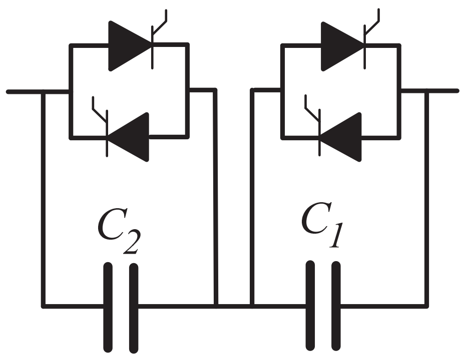

Fig. 4. Control of capacitor batteries using a thyristor.

Capacitor batteries and thyristors are mainly used in transverse compensation. In most cases, static capacitor batteries are used in compensation. Reducing the reactive power coefficient in the network due to the use of static capacitor batteries leads to a significant reduction in active power waste in networks with a voltage of 6-220 kV. This reduces the load on power transformers in overhead power transmission networks and systems [9,10].

For an increase in the transmission capacity in the main and Distribution Power Networks, the possibilities of creating reliable, low-cost electrical networks or their modernization are being increased, without increasing the power of transformers (Figure 5).

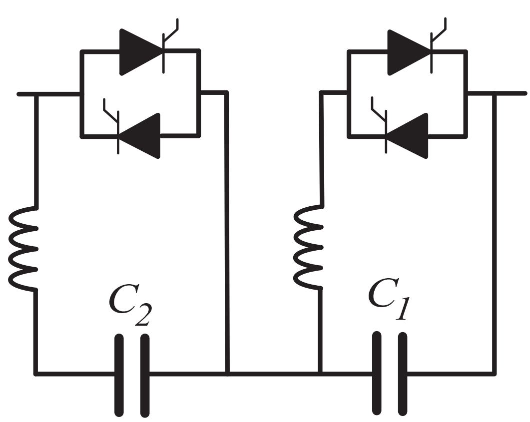

Fig. 5. Control of capacitor batteries using thyristor and inductance.

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The level of compensation is regulated at almost any level. This solution allows control of transmission stability and the generation of synchronous vibrations. The operation of the capacitor thyristor control system characterizes oscillations with variable capacitance and inductance. However, due to resonance events, it is important that the capacitance occurs without intermediate interruptions in the mode of inductive and reverse transitions. Static synchronous capacitor expansion joints can also be like active filters. Of course, the additional functions of the extender joints of compensators require sufficient funding. Among the many functions of these compensators, the following are classical:

- Voltage regulation by compensating reactive power;
- Synchronous vibration reduction;

The share of voltage wastes in energy transmission in networks can reach 8-12%. A static capacitor provides the ability to control the current power in the reactor and generate harmonica in the network [11-13].

Providing novel proposals for static synchronous transverse compensation is that static synchronous compensation has a higher speed compared to, which allows the following to compensate for the rapid change in load:

1. Allowing compensation of 70% to 80% of total reactive power by a static synchronous compensator;
2. Voltage regulation by compensating reactive power;
3. Power is provided by static synchronous transverse compensation from 20% to 30%; [14].

Since the installation of reactive power sources partially or completely solved several problems: stabilizing and increasing the voltage level at the control points of the power unit, thereby improving the quality of electricity. Improving the static and dynamic stability of the power grid by lowering the networks from reactive power, thereby increasing power. Power lines, stabilization of modes in case of an accident. Increase the reliability of electrical networks. Data analysis shows that voltage values are increased after the introduction of reactive power sources.

Compensation issues are systematically analyzed, data on a significant decrease in the amount of active power losses in the network and reactive power compensation are collected, on the basis of which air power transmission allows to increase the power of the lines is listed in Table 1.

Table 1. Increasing line capacity.

N_1	N_2	Designation	Type	Before reactive power sources		After reactive power supplies		General Difference	
				ΔP	ΔP%	ΔP	ΔP%	ΔP	ΔP%
1	2	Hes A-SA17	OPTL	5.23	2.78	4.87	2.60	0.36	0.18
1	3	Hes B- SA 17	OPTL	9.26	6.21	8.53	5.84	0.73	0.37
1	4	Hes D- SA 17	OPTL	11.91	6.92	11.12	6.47	0.79	0.45
2	4	Hes A – Hes B	OPTL	6.63	4.25	6.20	3.97	0.43	0.28
3	10	Hes D- Hes Z	OPTL	3.12	2.52	2.83	2.32	0.29	0.2
10	11	Hes Z- Hes F	OPTL	0.70	1.46	0.60	1.25	0.1	0.21
10	15	Hes Z- Hes V3	OPTL	2.82	2.76	2.46	2.44	0.36	0.32

 https://doi.org/10.1051/e3sconf/202339006032

13	14	Hes A- Hes Z	OPTL	0.90	1.15	0.80	1.04	0.1	0.11
14	15	Hes B- Hes D	OPTL	1.22	1.44	1.07	1.27	0.15	0.17
4	9	Hes F- Hes V2	OPTL	0.33	0.61	0.31	0.57	0.02	0.04
9	11	Hes D- Hes V3	OPTL	0.45	1.00	0.42	0.91	0.03	0.09
11	12	Hes D- Hes V	OPTL	0.00	0.00	0.00	0.00	0	0
11	12	Hes Z- Hes V	OPTL	0.00	0.00	0.00	0.00	0	0
4	10	Hes V- Hes F	OPTL	0.24	0.44	0.32	0.57	-0.08	-0.13

Voltage drops have been compared before and after the introduction of reactive power sources, indicating a decrease in active power wastes. The project of reactive power sources implemented in nimstans is a new project with a voltage of 220 kV in Uzbekistan, and it has fully justified itself. At the end of the substations, the voltage is quoted as rising from 206 kV to 220 kV, by 6,4%, and the average voltage on the network is increased by 5,6% (Figure 6).

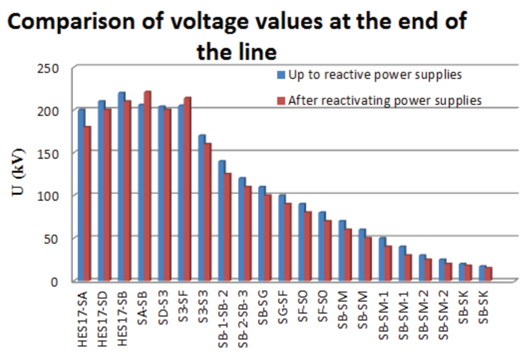

Fig. 6. Reduction of voltage wastes after installation of reactive power supplies.

After the installation of 2x100MVar reactive power sources on the tires of nimstans, normative voltage levels are achieved in normal and repair modes at the control points of the Zarafshan-Uchkuduk power plant. The main criteria for organizing reactive power sources are compensating reactive power, providing regulatory voltage values for consumers, and reducing network losses.

3 Conclusion

Currently, the issues of providing production enterprises with uninterrupted, reliable and high-quality electricity remain relevant. In this case, it is an important process to calculate voltage wastes, develop measures to reduce them, in addition to active and reactive power wastes, mainly in the transmission of electricity through air power lines. The quality of power supply is very important in any power grid, especially for electricity consumers. Electricity transmission and distribution networks are the most important means for a modernized energy system. The quality of electricity is mainly related to the processes of its transmission and distribution, and is important for industrial and manufacturing enterprises. Also, the possibilities of improving the quality of electricity and supplying uninterrupted and reliable electricity to consumers were studied and analyzed through the existing solutions mentioned above. The quality of electricity includes the presence of a power source, the frequency and magnitude of the voltage, as well as the characteristics of the signal form of the power source.

https://doi.org/10.1051/e3sconf/202339006032

When the power supply is constant at optimal, stable voltage and frequency values, the power is described as qualitative and has a flat sinusoidal graph shape.

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