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DEVELOPMENT OF TECHNICAL SOLUTIONS FOR IMPROVING THE QUALITY OF ELECTRICITY IN ELECTRICAL SUPPLY SYSTEMS OF MINING ENTERPRISES

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ABSTRACT

Drilling and blasting operations in the general public work technology in the development of mineral deposits, composed mostly of rock, are one of the main production processes. Drilling wells is a time-consuming and expensive process. The cost of drilling operations at open-up to 25 - 40% of the total cost of production of 1 ton of rock. Increasing drilling blasting holes can be achieved through the use of new, more effective rock cutting tool, a rational choice of types and more advanced technology of their application in the given mining conditions.

Therefore, with increasing volumes of roller cone drill blast holes in open cast mining development of new standardized types of cutters cone bits it is very urgent scientific challenge.

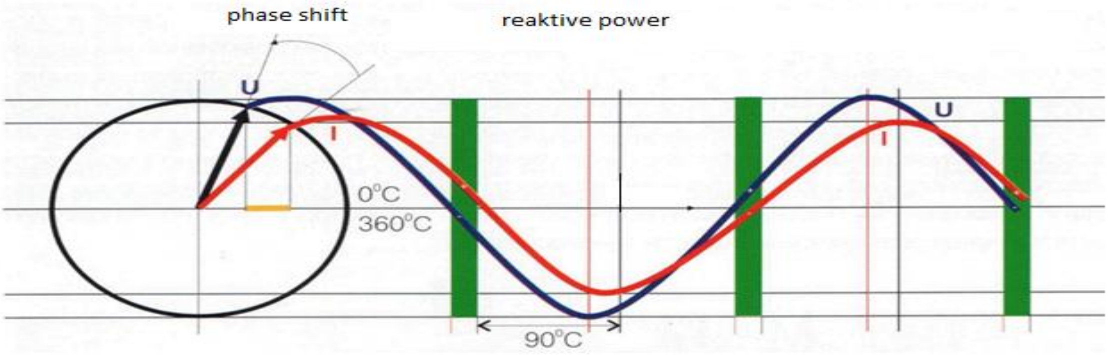
Keywords: articulated coupling, block diagram, mechanism model, input and output links, law of motion, regression, angular velocity, gear ratio.

INTRODUCTION

"Any electrical machine that uses alternating current (motor, transformer) uses two types of energy: active and reactive. The active power consumption (kW) is determined by the active power P (kW) of the power receivers (EP). It is completely converted into mechanical power (work) and heat (losses). Reactive energy (kvar・s) is used to power the magnetic circuits of electric machines. It corresponds to the reactive power Q (kvar) of EP.

Total energy (kV・A・h) is the vector sum of the previous two types of energy. It corresponds to the total power of the ED S (kV・A), that is, the vector sum of P (kW) and Q (kvar)" [17].

In electrical circuits containing a combined load, in particular, active (electric stoves, heaters, electric ovens, etc.) and inductive (asynchronous motors, electromagnets, chokes, reactors, transformers, rectifiers, thyristor converters) components, then their total power, obtained from networks, can be shown in a vector diagram. When the voltage has a positive sign, the current is negative, and vice versa, this determines the time interval during which the current lags behind the phase voltage in the inductive elements. At this time, reactive energy is not consumed anywhere, but is returned to the network only in the direction of the generator. Only in this case, the reactive energy remaining in the inductive elements enters the network, it is not consumed by the active elements, it only performs vibrational actions. Such energy is called reactive.



1-Figure - Phase shift between active and reactive power

If we add the active energy that does useful work and the reactive energy that goes to create a magnetic field, we get the total power. The ratio of the active power to the total power is expressed in the cosine of the phase shift angle of their vectors, which is called the power coefficient (Fig. 2).

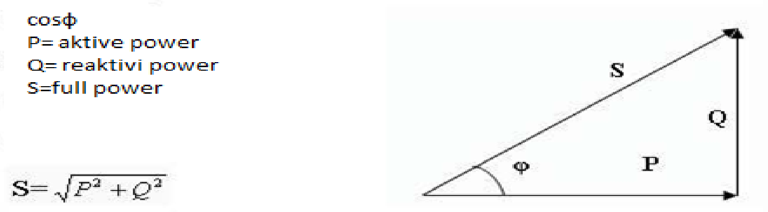


Figure - Power triangle

All active energy goes to mechanical, thermal and other useful work that we need. In turn, reactive energy is not used for useful work, the only thing necessary for this is the creation of electromagnetic fields, without which the transformer and electric motor cannot work. Based on these characteristics, it is not advisable to receive reactive power from the energy supply organization, because it is necessary to increase the power of generators, the cross-section of lines and cables, as their conductivity decreases and active losses increase. Therefore, it is better to generate reactive power directly at the consumer. For this, I use special devices called reactive power compensation units. Basically, these are capacitor batteries. The reactive current passing through the inductive elements is proportional to the reactive power:

“The mean value of RM over a period is zero because it reverses its direction four times during this period. But the circulation of RM through the network has serious technical and economic consequences. Figure 3 shows that the larger the value of PM, the larger the transmitted apparent power and current. For these reasons, PM should be generated as close as possible to the loads to avoid consumption from the network. This solution is called "reactive power compensation"[17]. "In order to avoid an increase in costs for the network, the electricity supply organization encourages consumers to use such solutions by charging a fine if PM consumption is higher than a certain value. Capacitors RM development and used to supply inductive consumers". Since the current lags behind the voltage in inductive elements, the reactive energy is characterized by a delay between the sinusoidal phases of the current and the mains voltage. Between I and U, the power factor numerically equal to cosph indicates the reactive power consumption from the network. For an organization that consumes energy, cosph is calculated as follows: the ratio of the consumed energy P to the consumed energy S from the network. This coefficient describes the total amount of energy Q consumed by the enterprise. The closer to Cosph=1, the less reactive energy is extracted from the grid. It follows that the reactive power current through the network is unfavorable. As a result:

- the transmission power of the lines decreases;
- losses in the conductors increase due to the increase in the passing current;
- nominal deviations of the mains voltage.

For the above reasons, the power supply organization requires the consumer to reduce the share of the reactive component in the network. This problem is solved by reactive energy compensation - the main and necessary condition for the reliability of the operation and efficiency of enterprises. Compensating devices cope with the task - capacitor units, in fact, the main element is capacitors. Correctly selected reactive power compensating devices:

- reducing the load on power lines, transformers and other distribution devices, extending their service life;
- reducing losses;
- reducing the price of electricity;
- increasing the bandwidth of the network allows to increase the load without increasing the cost of the network itself;
- reducing the cost of updating electrical equipment;
- removal of unnecessary formation of the reactive component during minimum loaded hours;
- reduces the cross-section of lines and the capacity of the substation when creating new networks. The installation of compensating devices is effective in enterprises where welding machines, compressors, electrolysis plants, melting furnaces and similar consumers with a sudden change in load work. This is metal production, mining industry, wood processing, i.e. here, due to various production reasons, cosph varies from 0.4 to 0.8.

Depending on the information received on the energy consumption of the enterprise, the necessary reactive power compensation is calculated. It is calculated from the actual value of the reactive power coefficient cosph1 to the required coefficient.

"Here P is the active power of the load.

The specific power of the compensation device is determined by the following formula: "[3]

$Q_{ky} = P(\cos\varphi_1 - \cos\varphi_2)(1.5)$

$k_y = \frac{Q_{ky}}{S_{yc}}(1.5)$

In the industrial power network, distribution transformers and asynchronous motors are the main load. They are reactive energy sources that carry out oscillating movements from the load to the generator. These vibrations are not related to the performance of useful work, but are consumed only to create electromagnetic fields and create a load on power lines. In turn, transformers and electric motors cannot work without electromagnetic fields and create a load on power lines.

Correctly selected reactive power compensating devices (RPD) can reduce the cost of electricity by up to 20%, reduce the load on transformers, reduce the loss of electricity during reactive energy currents along the lines, and also significantly improve the quality of electricity .

Choosing the type and place of compensation

"Unregulated (one-stage) compensation.

A capacitor bank operates on an all-or-nothing basis. Ignition can be manual (knife or switch) or semi-automatic (using a motor-controlling contactor). This type of compensation is used when the PM is relatively low (< 15% transformer capacity) and the load profile is flat.

Stepwise automatic adjustable compensation.

A capacitor bank is recruited (usually automatically) from separate sections with the required number of connections. Such a battery is installed at the head of the network or in a section with sufficient power and is able to regulate the reactive power produced step by step. Switching on and off of sections is controlled by the RM control relay [17].

"- Centralized compensation

The battery is connected at the beginning of the network and provides compensation for its total reactive load. This method is only used if it is necessary to avoid paying a penalty for derating the transformer and consuming significant PM.

- Group compensation

The battery is installed at the beginning of the network section that serves the group of power sources that require compensation. This method is used in extended networks that include sections with different operating modes.

- Individual compensation

The battery is connected directly to the terminals of each inductive EA (electric motors, induction furnaces). This method is recommended when the EP capacity is important compared to the declared maximum load. In this case, the economic and technical efficiency is maximum, because PM is produced at the place of consumption and in the required amount" [17].

"Resonance phenomena at higher harmonics cause large current and voltage distortions in distribution networks, as well as overloading of power capacitors. Consider a simplified diagram representing the electrical installation (Fig. 4), which includes:

supply transformer, linear load,

non-linear load with a source of harmonics (HG), capacitors to cover RM.

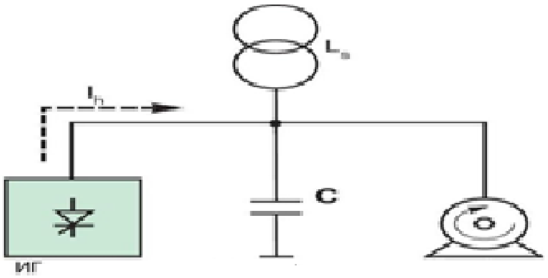


Figure 3 – Simplified diagram of electrical installation

The equivalent circuit for harmonic analysis is:

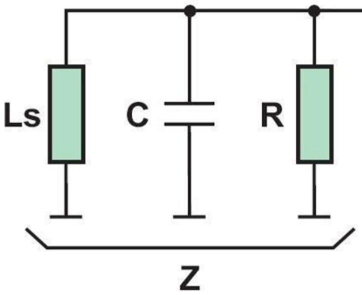


Figure 4 - Equivalent circuit for harmonic analysis.

Ls is the inductance of the supply chain (mains + transformer + line),
C is the capacity of power capacitors,
R - load resistance with linear voltage characteristic (VAC);
Ih - IG.

The frequency dependence of the equivalent resistance modulus Z for high harmonic currents is shown in the figure below:

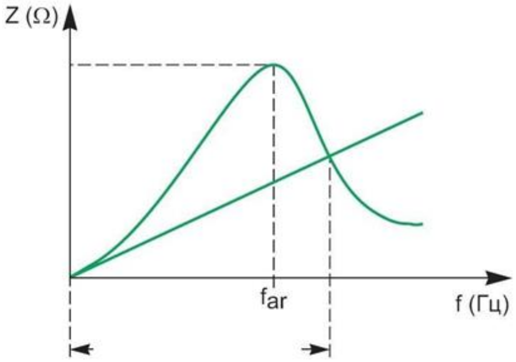
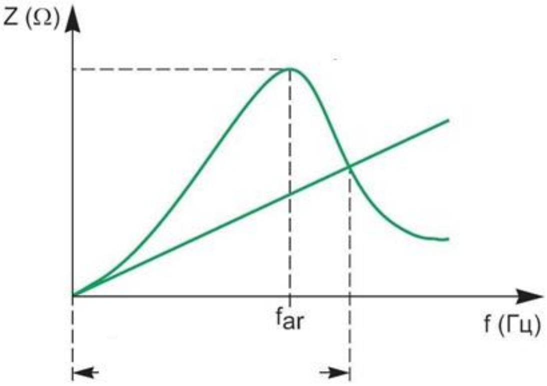


Figure 5 - Modulus of resistance Z as a function of frequency

Physical interpretation:
frequency is long - the frequency of the parallel circuit (Ls - C),

at long frequency, the resistance modulus of the circuit is maximum. Therefore, the voltage of the corresponding harmonics in the direct current is large, and there is a significant distortion of the voltage curve. The harmonic currents of the amplifier zone flowing inside the Ls-C circuit are greater than the currents flowing in the unbranched part of the circuit (ie, the currents sent by the MG).

The diagram below shows the electronic elements loaded with amplified high harmonic currents:



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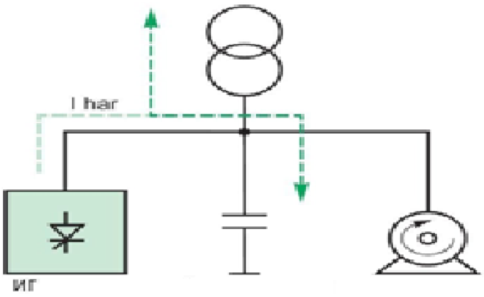

Figure 6 - Rotation of amplified harmonic currents.

For the supply network and PM compensation, the battery is loaded with significant currents of high harmonics, which can lead to overloading[17].

Reactive Power Compensation Solutions.
The solutions described below represent the most advanced and popular applications in the field of reactive power compensation. The challenges faced have changed over the years. Devices and systems to improve reactive power compensation and power quality have also continued to evolve. While a few years ago the focus was on reducing reactive power costs and reducing energy losses, today's challenges are more complex and involve full grid integration.
- uneven compensation
Capacitors with bias compensation are used as a purely capacitive branch (Fig. 7).

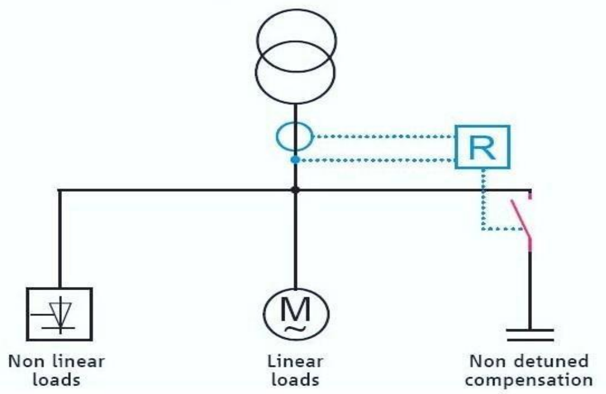

Figure 7 - uneven compensation scheme

This was a standard solution used by the electricity supplier to save on reactive power costs. This is due to the reduction of apparent power in the supply line and thus the reduction of line and transformer losses. As the number of harmonics increases as network conditions change, the risk of power overload due to resonances increases. This leads to improvements in compensation technologies.

- Delay compensation (filter adjustment schemes)

In addition to the real basic function of reactive power compensation, the danger of overcurrent due to resonance can be eliminated by the correct choice of the type of adjustment for the compensation system and the design of the capacitors and inductors used. Today's detection is a modern technology. The level of detection can also be chosen to reduce specially selected low-frequency harmonics in the customer network or to prevent wave frequency control violations in the distribution network. . Increasing harmonic levels due to aging components and changing device technologies mean that equipment and systems must be monitored to detect overload risks in time.

- Thyristor compensation

If the load dynamics does not allow step compensation by passing through the contactor, this is replaced by a combination of thyristors and diodes (Fig. 8).

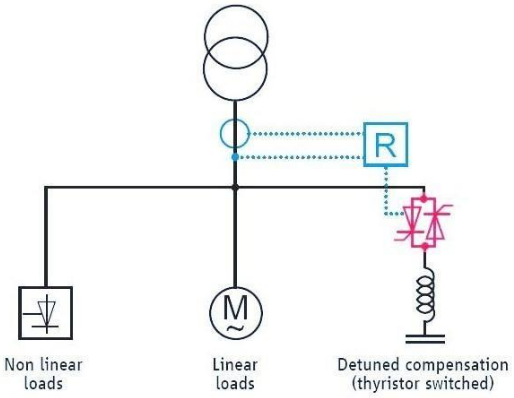

Fig. - Compensation scheme using thyristors

Coupled with fast data acquisition and control, realistic switching operations are possible without transitions between multiple network cycles. This allows rapid changes in reactive power to be corrected almost instantaneously and in some cases eliminates the flickering effect from load surges. The main advantage of this type of semiconductor switching is that it prevents current loads from turning on, for example, which occurs with simple compensation detuning. This soft switching has important advantages, especially for sensitive loads connected to the same power level. - Passive filters (adaptive filter circuits)

Passive filters have a natural resonant frequency very close to the frequency of the filtered harmonic current from the consumer or a group of consumers such as power converters.

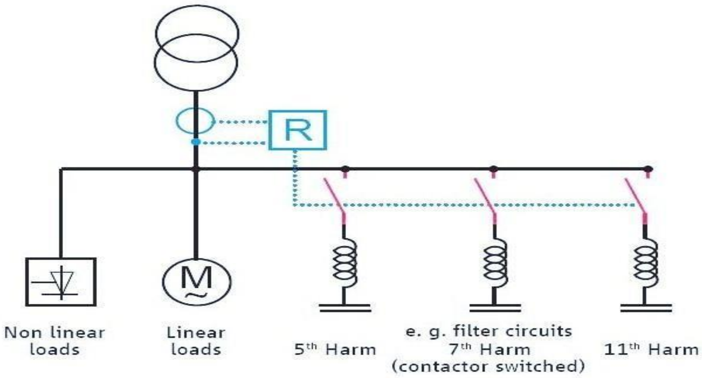

Figure 9 - Scheme of passive filters

To avoid transients in the same filters, the tuning frequency is inductively set to 5-10 Hz

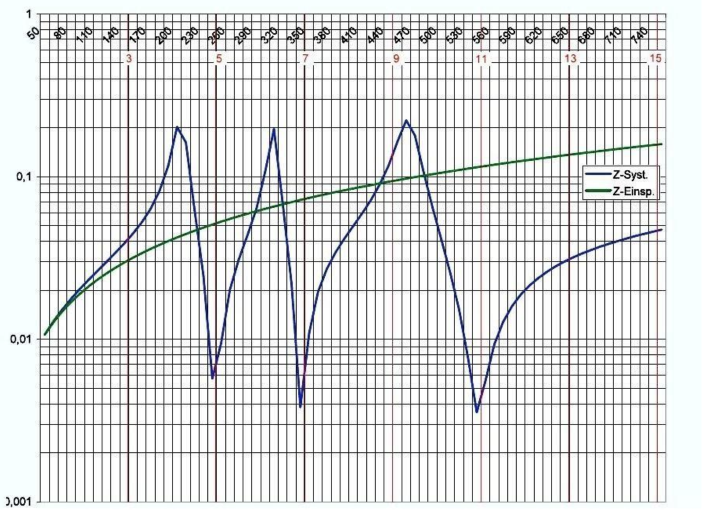

Figure 10 - Diagram of passive filters

It effectively filters the harmonic current from the source and prevents its transfer to the distribution network; this significantly reduces the load from harmonic current on the supply/transformer line (Figure 10). This method works in the 3-5 harmonic range and requires at least one filtering step for each network harmonic. The risk of overload is especially high with passive filters. Constant monitoring and regular care is required. In addition, passive filters can only adapt to partial load changes. High-pass filters for harmonics can be installed by connecting resistors in parallel with filter reactors.

Passive filter circuits, such as filter circuits for the 5th, 7th, and 11th harmonics, can only reduce voltage dropouts if the filter circuits are turned on at the same time. Accurate calculation of the effects of passive filter circuits usually requires skilled technicians and the use of powerful simulation software.

- Inductive compensation.

The sharp increase in the number of cables in our networks, and especially the increase in the number of connected photovoltaic and wind devices, creates the need to cover the capacitive load at certain times of the day with the help of inductors (Fig. 11). Similar to controlled compensation systems, they can be contactors or thyristors operating at low voltage levels, or can be turned on and off at medium voltage levels using circuit breakers with RC circuits. Capacitive reactive power taken from the network is also charged when a certain power factor is exceeded, so these systems pay for themselves in a short time.

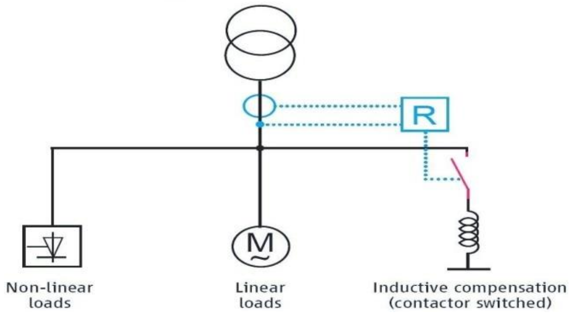

Figure 11 - Inductive compensation scheme

An active filter is an electronic system used to actively improve power quality. Active filtration is a very versatile modern technology. It can remove harmonics of various orders, perform dynamic reactive power compensation both capacitively and inductively, or compensate for voltage imbalance. A certain level of compensation can be set for the harmonic compensation of each individual harmonic. Thus, only the specified limit values agreed with the network operator are filtered. Due to their high dynamics, some active filters are even able to effectively correct changes in the current waveform, which are represented by switching dips. In addition to three-wire compensation, active filters also provide the ability to reduce harmonics in the neutral conductor. The third harmonic is added arithmetically in the neutral conductor, which can cause heavy loading or overloading of the neutral conductor. The active filter reacts immediately with the compensation level set for each harmonic's specific measurement point. In principle, this means that it is not affected by other effects in the network and thus does not change the structure of the network at resonance points. If it is "overloaded", it will continue to give its ratings and limit the level of compensation equally. The advantage of this is that the maximum efficiency of filter coverage is available even at excessive harmonic loads.

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