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The Guaranteed Power Supply System Using Distributed Generation on The Base of Alternative and Renewable Energy Sources

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The problem description

The problem of uninterruptable power supply ensuring for responsible consumers in different kinds of industry is quite actual.

In each kind of industry there are several responsible technological consumers, which define the reliability and continuity of whole technological process. We can extract such **different industries** as oil-production enterprises and difficult digital telecommunication and automation systems and complexes. Each of these industries contains responsible consumers.

This kind of consumers in some cases is very **sensitive** to short-time power supply interruptions and voltage dips. That’s why it’s very important to ensure the continuity mode of power supply for mentioned consumers. It will help to provide the reliability and continuity of whole technological process.

The problem description

The results of theoretical and experimental researches showed that the duration of power supply interruptions more than 0,15-0,2 s. leads to malfunctions of responsible consumers and correspondingly to disorder of whole technological process.

For example it is possible to identify the following relationship for determination of the permitted interruption time in a power supply for the electric centrifugal pumps with submersible motors in oil production:

$$\Delta t = 0{,}06 + 0{,}03Tj - 0{,}01\Delta U$$

In this equation Tj — the time constant of the motor inertia, ΔU — volume of the voltage dip.

The similar relationships with different coefficients were obtained by authors for other technological consumers of raw mineral industry and other industrial sectors for evaluation of permitted interruption time value

The problem description

The main causes of power supply interruptions and unreliability are the main reasons of guaranteed power supply system creation

•The frequent inability of centralized power supply systems to ensure the necessary level of power supply reliability.

•The significant remote allocation from centralized power supply systems.

Main steps for creating the structure

Step 1. The extracting of base modes of industrial power supply system functioning, which must be taken into account in designing proposed guaranteed power supply system.

The main functioning modes are:

1. Normal.

2. Post accident.

3. Transient.

4. Maintenance.

Main steps for creating the structure

The normal is the mode related to steady-state condition of power supply system.

The post accident is the mode related to steady-state condition after emergency shutdown of damaged element of power supply system.

The transient is the mode when the speed of changing of power supply system parameters and conditions is very fast.

The maintenance mode is the mode when all repairing measures can be provided.

Main steps for creating the structure

Step 2. The choosing of alternative and renewable power sources for proposed system.
According to results of theoretical and experimental researches it was detected that using of wind-diesel installations, solar electrostations and micro-turbine installations, which work on the following oil gas, is most effective nowadays.

Step 3. The choosing of storage elements, which can accumulate the demanded value of electrical energy.

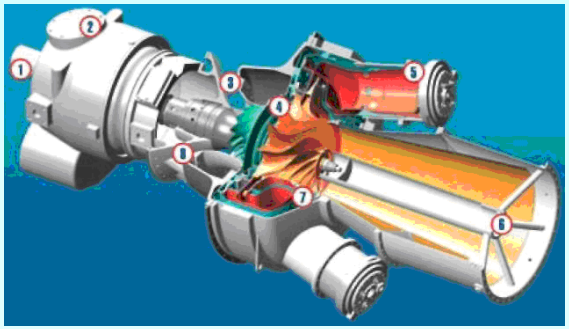
Step 4. The choosing of algorithm support for effective combined using of different alternative and renewable power sources.

Main steps for creating the structure

The main kinds of alternative and renewable power sources

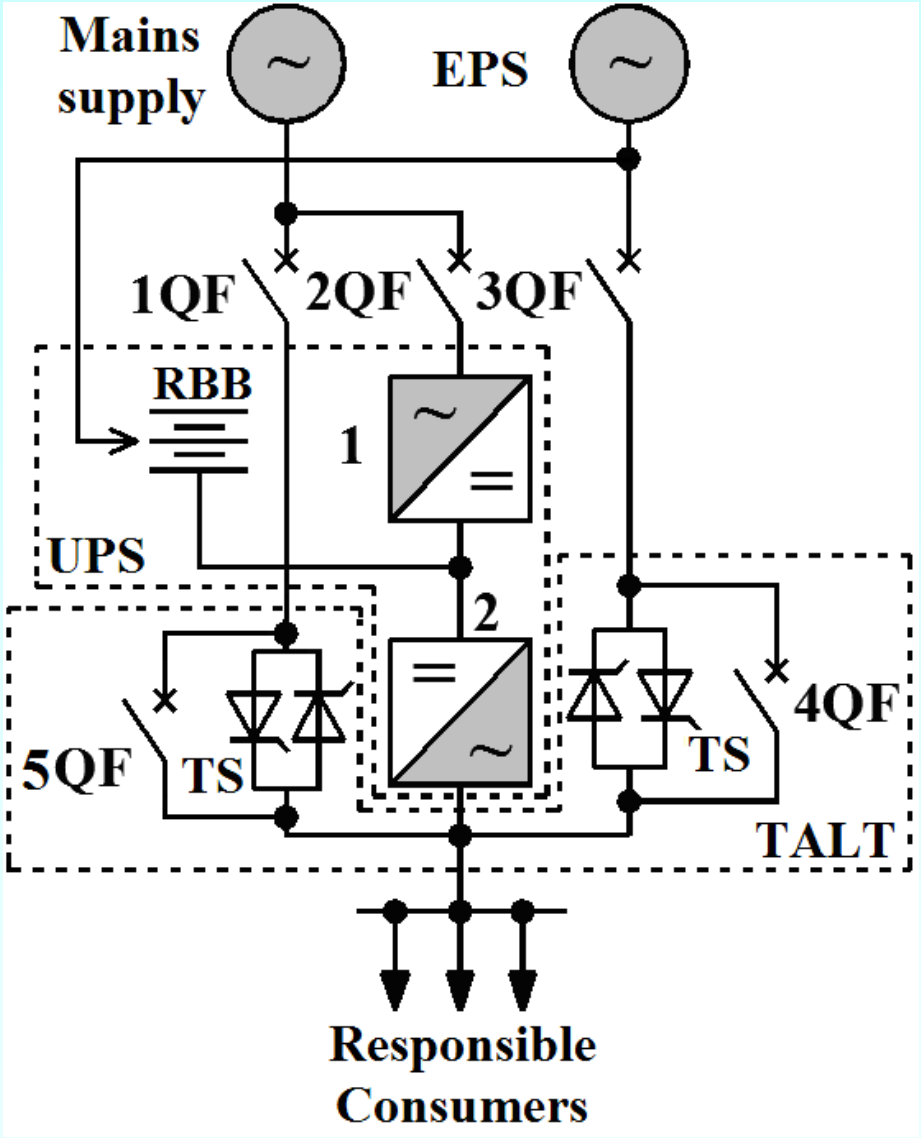
Wind energy

Solar energy



Micro-turbine on following oil gas

The developed structure



The responsible consumers are powered from the uninterruptible power supply (UPS), which consist of the rectifier 1, inverter 2 and rechargeable battery bank (RBB). The value of energy stored in the batteries should be enough for the starting period and for the time to lead the emergency power source (EPS) in normal mode.

The key factors for RBB

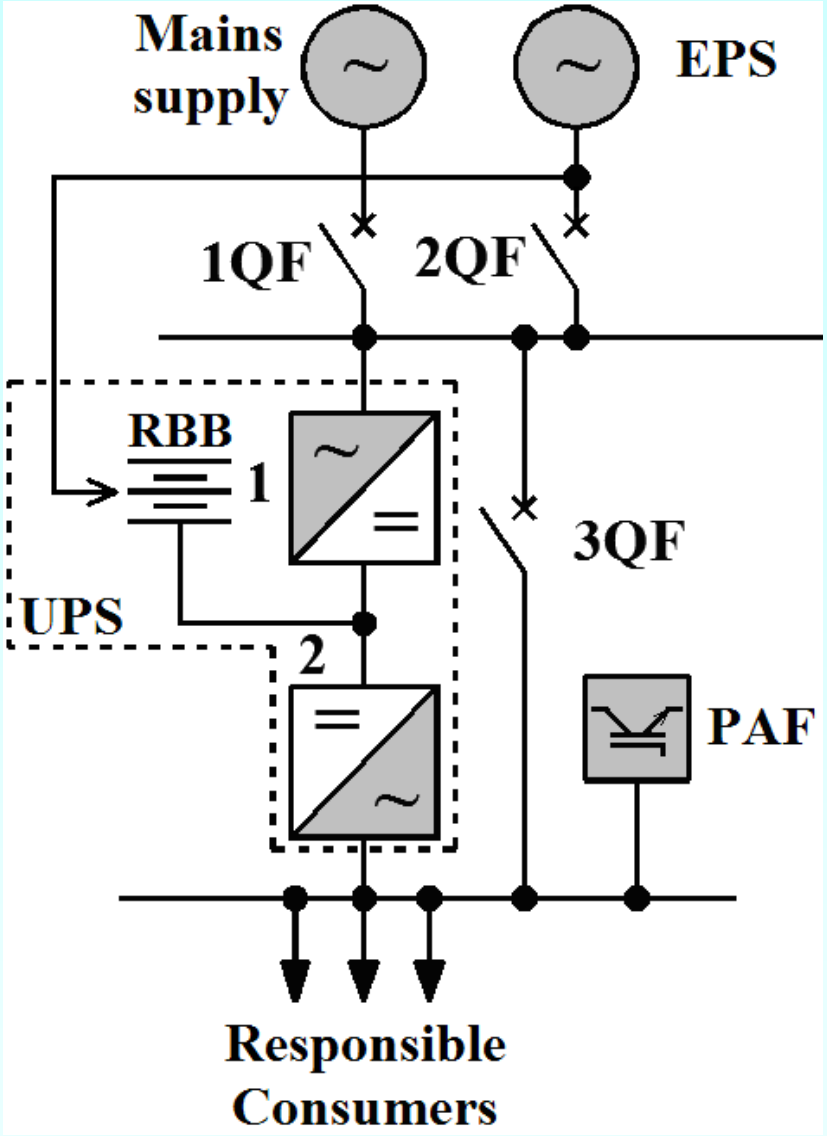
The value of battery energy is depends on the ***following key factors*:**

•Maximum value of power supply interruption duration for consumers.

•Rated power of connected consumers.

•Degree of technological responsibility of connected consumers.

The developed structure



The consumer's feeding is continuously implemented through the rectifier 1 and inverter 2 which are implemented the double conversion of energy. According to the standards in power quality area, permitted harmonic distortion level of the voltage form can be controlled by the parallel active filter (PAF) as option

The base methodology

Two main moments

The first is the proper determination of UPS main parameters.

The second is the studying UPS and EPS interference and, according to it's results, detecting main technical decisions for damping possible problems.

Also it is necessary to provide effective storage elements and methods of its charging and discharging.

UPS key parameters and factors:

- UPS rated power.
- The duration of off-line work.
- The type of applied power storage devices.
- Power storage devices capacity.

The base methodology

The total power of consumers S_{cons}, connected to UPS, is defined by means of the following equation:

$$S_{cons} = \sqrt{\left(\sum_{1}^{n} P_{cons.i}\right)^2 + \left(\sum_{1}^{n} Q_{cons.i}\right)^2}$$

$P_{cons.i}$ and $Q_{cons.i}$ - correspondingly active and reactive power of some *i* consumer from group of *n* consumers, connected to AC busbars of UPS.

The rated UPS power S_{UPS} is defined by means of the following equation:

$$S_{UPS} \geq \frac{k_r \cdot (1 - \Delta U) \cdot S_{cons} \cdot cos\varphi_{cons}}{cos\varphi_{UPS}}$$

k_r – coefficient of UPS power reserve, which has a value 1,1-1,2; ΔU – calculated value of permissible voltage decrease in conditions of dynamic stability ensuring of responsible consumers; $cos\varphi cons$, $cos\varphi UPS$ - correspondingly equivalent power factor of consumers and UPS output.

The base methodology

The capacity of storage battery C_{bat} can be defined according to following equation:

$$C_{bat} = \frac{I_d t_f}{K_g \cdot K_P}$$

C_{bat} – is the required capacity [Ah]; I_d – discharge rated current [A]; t_f – required functioning time [s]; K_g – coefficient of available capacity, for 0,5 hour discharge mode K_g = 0,4, for 1 hour discharge mode K_g = 0,5, for 2 hour discharge mode K_g = 0,65, for 10 hour discharge mode K_g = 1; K_P – recommended coefficient of storage battery discharge depth equal 0,5-0,7.

Discharge rated current I_d is the current, demanded by consumer from storage battery, and can be defined by means of the following equation:

$$I_d = \frac{P_{cons}}{\eta_e \cdot U_{bat}}$$

I_d - discharge rated current [A]; P_{cons} – average consumers power [W]; η_e – inverter efficiency during AC/DC conversion; U_{bat} – storage battery voltage [V].

The advantages and disadvantages

The base structure has following advantages:

•Absence of the significant harmonic distortion due to short time of rectifier and inverter work.

•Synchronization of the phase mismatch angle between UPS and EPS voltages.

Also the base structure has following disadvantages:

The RBB are resided in constant booster charge mode, that reduces their lifetime.

The double conversion of energy reduces the total performance factor of the system.

The switching time from the maintenance to the UPS is conditioned by poor performance of the TS.

The advantages and disadvantages

The simple structure has following advantages:

•Absence of power supplying interruption during the switching time from the major maintenance to RBB feeding.

•Protection from the short-time mains failure.

•High level of power quality due to the PAF working.

The simple structure has following disadvantages:

•The double conversion of energy reduces the total performance factor of the system.

•Absence of synchronization of the phase angle mismatch between UPS and EPS voltages.

•The RBB are resided in constant booster charge mode, that reduces their lifetime.

•Additional losses in EPS generator due to its parallel working with UPS.

Conclusion

The proposed guaranteed power supply system in comparison with existing developments has several advantages: the opportunity of combined using of solar, wind and followed oil gas energy, the opportunity of guaranteed power supply of geographically distributed responsible consumers, which have different rated power, functioning mode and immunity to short time power supply interruptions, the opportunity to store significant power.

The developing guaranteed power supply system with complex using of alternative and renewable energy sources in distributed generation and fast-acting devices of TALT provide continuity of the responsible technological processes and stability of power supply mode for every kind of industry.

Thank You for attention!