Abstract: Disclosed in the present invention are a fast bus transfer method and device to reduce, by transferring between a main power supply and a backup power supply, the impact on a load connected to a bus caused by a power cut. The method comprises: 1) calculating the amplitude of the voltage vector difference between the bus and the backup power supply and the phase angle difference between the bus and the backup power supply; 2) transferring the load on the bus to said backup power supply only when the amplitude is less than its limit value and the phase angle difference is less than 90°. The device comprises: a detection module; a calculation module; a comparison module; and a transfer module. By calculating the real-time residual voltage, it is unnecessary for a user to know all the details of the residual voltage characteristic, and he/she can easily achieve fast transfer simply by setting the limit of the voltage difference at the moment when a circuit breaker of the backup power supply is closed.

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Description

Fast bus transfer method and device

Technical Field
The present invention relates to a fast bus transfer method, and especially, to a real-time fast transfer method. The present invention also relates to a fast bus transfer device, and especially, to a real-time fast transfer device.

Background Art
Fast bus transfer (FBT) can quickly transfer a bus connected to a load (for example, a motor) to a backup power supply when a main power supply fails, and its function is not only to maintain the continuous operation of the equipment, but also to avoid damage to the motor or other connected loads. Usually, such fast bus transfer is manually started, or in the case of failure, it is started by an external device, and its conventional transfer modes comprise three types: fast transfer, in-phase transfer, and residual voltage transfer. Each transfer mode is aimed at a particular situation, and the transfer modes each have their own criteria. Since fast transfer can theoretically keep the power interruption of the bus within the shortest time period and protect the motor or other loads from excessive or accumulated stress, fast transfer is usually preferred. If the criterion for fast transfer fails to be met, then the fast transfer equipment cannot send out a close command to the circuit breaker of the backup power supply, and the in-phase transfer mode will be subsequently started, that is, the in-phase transfer mode serves as a backup solution to the fast transfer mode. Likewise, the residual voltage transfer mode serves as a backup solution to the in-phase transfer mode.

The criteria for these three different transfer modes are as follows:

1) Criteria for fast transfer: $\Delta \phi < \Delta \phi_{FT\text{parameter}}$ and $\Delta f < \Delta f_{FT\text{parameter}}$,
Here, $\Delta \phi$ is the phase angle difference between the attenuated bus voltage and the backup power supply voltage, $\Delta f$ is the frequency difference between the attenuated bus voltage and the backup power supply voltage, $\Delta f_{\text{parameter}}$ is a limit parameter of $\Delta f$, $\Delta f_{\text{parameter}}$ is a limit parameter of $\Delta f$, in which $\Delta \phi$ and $\Delta f$ are real-time measurement values, while $\Delta f_{\text{Transferred}}$ and $\Delta f_{\text{Transferred}}$ are instantaneous values when the circuit breaker of the main power supply opens and are determined by the user.

2) Criterion for in-phase transfer: $\Delta \phi_{f\text{ast trans}} < 10^\circ$.

Here, $\Delta \phi_{\text{forecast}}$ is a forecast phase angle difference between the attenuated bus voltage and the voltage of the backup power supply, $\Delta \phi_{\text{forecast}}$ being a forecast value. If the fast transfer is missed, then the fast bus transfer device will automatically convert to the in-phase transfer. In-phase transfer is suitable for the situation where the phase angle difference is zero at the moment when the circuit breaker of the backup power supply is closed.

3) Criterion for residual voltage transfer: when the bus voltage drops to a predefined value, for example 30% of the rated value, then close the circuit breaker of the backup power supply.

This transfer is the slowest of all the transfer modes.

The criteria for the above various transfer modes are all restricted by the characteristics of the motor or other loads. The terminal voltage of the motor caused by the voltage difference across the circuit breaker should not exceed a permitted over-voltage value. It is usually 1.1 times the rated voltage $U_n$. Fig. 1 shows the characteristic an attenuated residual voltage, in which are illustratively shown a fast transfer section 30, an in-phase transfer section 20 and the voltage $u_n$ of the backup power supply. Supposing that the voltage difference is 1.0 $U_n$, on the right side of the curve
A'-'A'' is a safe area for re-supply. When the voltage difference is lower than 1.0 \( U_n \), a new voltage level will form a new safe area, i.e., the right side of B'-B''.

Since the premise for determining parameters is to comprehensively analyze the residual voltage characteristic, it is hard for the user to use fast transfer mode correctly. When the motor disconnects the electrical connection with the power supply, the energy stored in the magnetic field of the motor will generate an induced voltage which is referred to as residual voltage. The amplitude and frequency of this induced voltage will attenuate, the attenuation trend and attenuation rate depending upon a variety of factors, such as the type of motor, the load of the motor, the inertia of the motor and so on. Therefore, it is difficult for the user to determine the values for the parameters \( \Delta \varphi_{\text{Parameter}} \), \( a_n \) and \( \Delta \varphi_{\text{Parameter}} \) properly. At the same time, theoretically, the residual voltage characteristic will change if any one of the factors varies, therefore \( \Delta \varphi_{\text{Parameter}} \), \( a_n \) and \( \Delta \varphi_{\text{Parameter}} \) will also need to be re-determined accordingly, however, it is quite difficult. In view of this, the user usually determines relatively small values for \( \Delta \varphi_{\text{Parameter}} \) and \( \Delta \varphi_{\text{Parameter}} \), so as to avoid the fast bus transfer exceeding its application range, with the result that the fast bus transfer cannot function adequately, thereby losing the best occasion for re-supplying the motor connected to the bus and maintaining operation continuity, while waiting for in-phase transfer to respond takes a time period of several hundreds of milliseconds. This delay will prolong the transfer time, and increase the impact current and impact moment.

Contents of the invention

The object of the present invention is to provide a fast bus transfer method to reduce, by transferring between a main power supply and a backup power supply, the impact on a load connected to a bus due to a power cut. The method comprises:

1) calculating the amplitude \( A U_{\text{forecast}} \) of the voltage vector
difference between the bus and the backup power supply and calculating the phase angle difference $\Delta \phi_{\text{forecast}}$ between the bus and the backup power supply; 2) transferring the load on the bus to said backup power supply only when $\Delta U_{\text{forecast}}$ is less than its limit value $AU_{\text{limit}}$ and $\Delta \phi_{\text{forecast}}$ is less than $90^\circ$.

According to one aspect of the present invention, both $\Delta U_{\text{forecast}}$ and $\Delta \phi_{\text{forecast}}$ are forecast values at the moment when the circuit breaker of said backup power supply is closed.

According to another aspect of the present invention, $\Delta U_{\text{forecast}}$ is obtained by calculation according to the following formula:

$$\Delta U_{\text{forecast}} = \sqrt{U_{\text{forecast}}^2 - 2\times U_{\text{forecast}} \times U_{\phi} \times \cos \phi_{\text{forecast}}},$$

in which $U_{\text{forecast}}$ is a forecast value of a motor's residual voltage, and $U_{\phi}$ is the voltage of the backup power supply.

According to yet another aspect of the present invention, $\Delta \phi_{\text{forecast}}$ is obtained by calculation according to the following formula:

$$U_{\text{forecast}} = U_\phi \left(1 + \lambda \times 1 + \frac{1}{2} \times \lambda \times 1\right)^2,$$

in which $U_\phi$ is the real-time amplitude at the moment $t_1$; $\lambda$ is the time difference between the moment $t_1$ and the moment $t_2$, that is, the time period for the circuit breaker to close; and $t_2$, $t_1$ being a time constant.

According to yet another aspect of the present invention, $\Delta \phi_{\text{forecast}}$ is obtained by calculation according to the following formula:

$$\Delta \phi_{\text{forecast}} = \Delta \phi_{\phi} + \Delta \omega_{\phi} \times \Delta t + \frac{1}{2} \times \alpha \times \Delta t^2,$$

in which $\Delta \phi_{\phi}$ is the phase difference at the moment $t_2$, $\Delta \omega_{\phi}$ is the angular velocity difference at the moment $t_1$, and $\alpha$ is the attenuation rate of an angular velocity defined according to a residual volt-
age transfer mode, and \( \Delta' \) is the time difference between the
moment \( t_2 \) and the moment \( t_1 \), that is, the time period for the
circuit breaker to close.

According to yet another aspect of the present invention, \( \lambda \) is obtained by calculation according to the following for-
u-\n\[
\lambda = \frac{1 - \sqrt{\frac{2 U_h}{U_1} - 1}}{t_2 - t_1}
\]
ula: \( \lambda = \frac{1 - \sqrt{\frac{2 U_h}{U_1} - 1}}{t_2 - t_1} \), in which \( U_h \) is the real-time amplitude
at the moment \( t_1 \).

According to yet another aspect of the present invention, \( \Delta\omega_1 \) and \( \alpha \) are obtained by calculation according to the fol-
loowing formulae respectively:
\[
\Delta\omega_1 = \frac{\Delta\phi_1 - \Delta\phi_1}{t_2 - t_1}
\]
and
\[
\alpha = \frac{\Delta\omega_1 - \Delta\omega_1}{t_2 - t_1}
\]
in which \( \Delta\omega_1 \) is the angular velocity difference
at the moment \( t_1 \), and \( \Delta\phi_1 \) is the phase difference at the mo-
ment \( t_1 \).

The object of the present invention is to further provide
a fast bus transfer device to reduce, by transferring between
a main power supply and a backup power supply, the impact on
a load connected to a bus due to a power cut. The device com-
prises: a detection module, for detecting signals at the main
power supply, the backup power supply and the bus; a calcula-
tion module, for receiving said signals, and calculating the
amplitude \( AU_{\text{forecast}} \) of the voltage vector difference between
the bus and the backup power supply and calculating the phase
angle difference \( A\phi_{\text{forecast}} \) between the bus and the backup power
supply; a comparison module, for receiving \( AU_{\text{forecast}} \) and
\( \Delta\phi_{\text{forecast}} \), comparing \( A\phi_{\text{forecast}} \) with its limit value \( AU_{\text{RTTparameter}} \), and
comparing \( A\phi_{\text{forecast}} \) with 90°; and a transfer module, for receiv-
ing the comparison results from the comparison module, and
transferring the load on the bus to said backup power supply
only when \( AU_{\text{forecast}} \) is less than its limit value \( AU_{\text{RTTparameter}} \) and
According to one aspect of the present invention, said calculation module obtains $\Delta U_{f,\psi_{\lambda}}$ by calculation according to the following formula:

$$\Delta U_{\text{forecast}} = \sqrt{U_{M,\text{forecast}}^2 + \Delta^2} - 2 - \Delta U_{M,\text{forecast}} \cdot \Delta \cos \Delta_{\text{forecast}}$$

in which $U_{M,\psi_{\lambda}}$ is a forecast value of a motor's residual voltage, and $U_A$ is the voltage of the backup power supply.

According to another aspect of the present invention, said calculation module obtains $U_{f,\psi_{\lambda}}$ by calculation according to the following formula:

$$U_{\text{Delta}} = U_{\text{t}} \left(1 + \lambda \cdot \Delta t + \frac{2}{3} \lambda ^2 \cdot \Delta t^2 \right)$$

in which $u$ is the real-time amplitude at the moment $I_1$; $\Delta t$ is the time difference between the moment $I_2$ and the moment $I_1$, that is, the time period for the circuit breaker to close; and $\lambda = \frac{1}{\tau}$, $\tau$ being a time constant.

According to yet another aspect of the present invention, said calculation module obtains $\Delta \psi_{\lambda}$ by calculation according to the following formula:

$$\Delta \phi_{\text{Delta}} = \Delta \omega_{\lambda} \cdot \Delta t + \frac{1}{2} \cdot \Delta \omega_{\lambda} \cdot \Delta t^2$$

in which $\Delta \phi_{\lambda}$ is the phase difference at the moment $I_2$, $\Delta \omega_{\lambda}$ is the angular velocity difference at the moment $I_2$, $\Delta t$ is the time difference between the moment $I_2$ and the moment $I_1$, that is, the time period for the circuit breaker to close, and $\alpha$ is the attenuation rate of an angular velocity defined according to a residual voltage transfer mode.

According to yet another aspect of the present invention, said calculation module obtains $\lambda$ by calculation according to the following formula:
$\lambda = \frac{1 - \frac{2 \cdot U_{t}}{U_{n}} - 1}{t_{2} - t_{1}}$, in which $U_{t}$ is the real-time amplitude at the moment $t_{1}$.

According to yet another aspect of the present invention, $\Delta \omega_{h}$ and $\alpha$ are obtained by calculation by said calculation module according to the following formulae:

$\Delta \omega_{h} = \frac{\Delta \varphi_{2} - \Delta \varphi_{1}}{t_{2} - t_{1}}$, and $\alpha = \frac{\Delta \omega_{2} - \Delta \omega_{1}}{t_{2} - t_{1}}$, in which $\Delta \omega_{h}$ is the angular velocity difference at the moment $t_{1}$, and $\Delta \varphi_{h}$ is the phase difference at the moment $t_{1}$.

The advantages of the present invention lie in the following: by way of calculating a real-time residual voltage, it is unnecessary for the user to be well-acquainted with the residual voltage characteristic; he only needs to set the limit of the voltage difference at the moment when the circuit breaker of the backup power supply is closed, and fast transfer can then be easily achieved; moreover, it is unnecessary to adjust previous settings in response to variation of the residual voltage characteristic, thereby making it extremely convenient for the user to operate, and overcoming the imperfections in the prior art.

Brief description of the accompanying drawings

The features and advantages of the present invention will become clearer in combination with the following accompanying drawings, in which identical symbols represent identical components or means:

- Fig. 1 illustratively shows the characteristic of an attenuated residual voltage in the prior art;
- Fig. 2 illustratively shows a system in which the method and device according to the present invention are used;
- Fig. 3 illustratively shows a vector relationship among the amplitude $\Delta \nu_{\text{forward}}$ of the voltage vector difference between
the bus and the backup power supply, the phase angle difference $\Delta \phi_{\text{forecast}}$ between the bus and the backup power supply, the forecast value $U_{\text{forecast}}$ of a motor's residual voltage, and the voltage $u_B$ of the backup power supply; and

Fig. 4 illustratively shows the characteristic of an attenuated residual voltage in the present invention.

Exemplary embodiments

Fig. 2 illustratively shows a system in which the method and/or device according to the present invention are used, in which the buses BB are electrically connected to each other during normal operation and can be connected to other loads such as a motor. A main power supply MP and a backup power supply BP can be respectively connected to the buses BB through a fast bus transfer device FB.

The fast bus transfer method according to the present invention reduces the impact on the load connected to the buses BB (such as an electric motor) due to a power cut by transferring between the main power supply MP and the backup power supply BP, and comprises two steps:

1) calculating the amplitude $A_{U_{\text{forecast}}}$ of the voltage vector difference between the bus BB and the backup power supply BP and calculating the phase angle difference $A \phi_{\text{forecast}}$ between the bus BB and the backup power supply BP;

2) transferring the load on the bus to the backup power supply BP only when $A_{U_{\text{forecast}}}$ is less than its limit value $\Delta U_{\text{RTTparameter}}$ and $A \phi_{\text{forecast}}$ is less than $90^\circ$.

In this case, $A_{U_{\text{forecast}}}$ and $A \phi_{\text{forecast}}$ are forecast values at the moment when the circuit breaker of the backup power supply BP is closed, while $\Delta U_{\text{RTTparameter}}$ and $90^\circ$ are permitted values at the moment when the circuit breaker of the backup power supply BP is closed.

Fig. 3 illustratively shows a vector relationship among the amplitude $A_{U_{\text{forecast}}}$ of the voltage vector difference, the
phase angle difference $\Delta \psi_{\text{forecast}}$, the forecast value $U_{\text{forecast}}$ of the motor's residual voltage, and the voltage $u_f$ of the backup power supply. The voltage difference depends upon the angle difference between the residual voltage of the bus and the voltage of the backup power supply. $\Delta U_{\text{bus}}$ is obtained by calculation according to the following formula (1):

$$\Delta U_{\text{bus}} = \sqrt{U_{\text{bus}}^2 + U_f^2 - 2U_{\text{bus}}U_f \cos \alpha},$$

in which $U_{\text{bus}}$ is the forecast value of the motor's residual voltage at the moment when the circuit breaker of the backup power supply BP is closed, and $U_f$ is the voltage of the backup power supply.

It can be known from the residual voltage characteristic formula $u(t) = u_0 \cdot e^{-\frac{t}{\tau}} \sin((\psi_0 - \alpha + \omega t) + \varphi_0)$ that the real-time amplitude of the residual voltage at a certain moment is $u(t) = u_0 \cdot e^{-\frac{t}{\tau}}$, in which $U_0$ is the initial amplitude of the residual voltage, $\tau$ is a time constant of the attenuated residual voltage, $\omega_0$ is the initial angular velocity of the residual voltage, $\varphi_0$ is the initial phase of the residual voltage, and $\alpha$ is the attenuation rate of the angular velocity. In view of the fact that both $U_0$ and $\alpha$ are constants, the amplitude $u(t)$ at any moment can be obtained by calculation as long as the value of the time constant $\tau$ is known. This can be achieved using the following algorithm, for example, if the amplitude at the moment $t_1$ is $U_{e,t_1} = U_0 \cdot e^{-\frac{t_1}{\tau}}$ and the amplitude at the moment $t_2$ is $U_{e,t_2} = U_0 \cdot e^{-\frac{t_2}{\tau}}$, then $u_{t_1}$ is obtained, and this is expanded using Taylor's formula to:

$$u_{t_1} = u_{t_0} - \frac{u_0}{\tau} \cdot \frac{t_1-t_0}{\tau} - \frac{1}{2} \left( \frac{t_1-t_0}{\tau} \right)^2 \cdot \frac{u_0}{\tau} \cdot \left( \frac{t_1-t_0}{\tau} \right),$$

where $\lambda = -\frac{1}{\tau}$,

$$\frac{(t_1-t_0)^2}{2} \cdot \lambda^2 + (t_1-t_0) \cdot \lambda + (1-\frac{U_{e,t_1}}{U_0}) = 0$$

is thus obtained, and the value of the time constant $\tau$ can be obtained by calculation through $\lambda$. Suppose that the time consumed by the closing of the circuit breaker is $\Delta t$, then the predicted residual voltage of the motor is

$$U_{\text{forecast}} = U_0 \cdot e^{-\frac{t_1+\Delta t}{\tau}} \approx U_{e,t_1} \cdot e^{-\frac{\Delta t}{\tau}} = U_{e,t_1} \cdot e^{-\frac{t_1+\Delta t}{\tau}},$$

and the formula (2)
\[ U_{\text{forecast}} = U_1 \left( 1 + \Delta t + \frac{1}{2}(\Delta \omega \Delta t)^2 \right) \]

is obtained by expanding using Taylor’s formula.

In the residual mode which is already defined, the frequency attenuates linearly, therefore the following formula (3) can be used to predict the phase difference at the connecting moment, \( \Delta \phi_{\text{forecast}} \) is obtained by calculation according to the following formula:

\[
\Delta \phi_{\text{forecast}} = \Delta \phi_i + \Delta \omega_i \Delta t + \frac{1}{2} \Delta \omega^2 \Delta t^2,
\]

in which \( \Delta \omega_i = \alpha \Delta \omega \), \( \alpha = \frac{\Delta \omega_i}{\Delta t} \), \( \Delta \phi_i \) is the angular velocity difference at the moment \( t_2 \), \( \Delta \phi_i \) is the phase difference at the moment \( t_1 \), \( \Delta \phi_i \) is the phase difference at the moment \( t_1 \), \( \alpha \) is the attenuation rate of an angular velocity defined according to the residual transfer mode, \( \Delta t \) is the time difference between the moment \( t_2 \) and the moment \( t_1 \), that is, the time period for the circuit breaker to close. By substituting the above formulae (2) and (3) into formula (1), the amplitude \( \Delta U_{\text{forecast}} \) of the voltage vector difference can be obtained.

According to another embodiment of the present invention, a fast bus transfer device comprises: a detection module, for detecting signals at the main power supply, the backup power supply and the bus; a calculation module, for receiving said signals, and calculating the amplitude \( \Delta U_{\text{forecast}} \) of the voltage vector difference between the bus and the backup power supply and calculating the phase angle difference \( \Delta \phi_{\text{forecast}} \) between the bus and the backup power supply; a comparison module, for receiving \( \Delta U_{\text{forecast}} \) and \( \Delta \phi_{\text{forecast}} \) and comparing \( \Delta \phi_{\text{forecast}} \) with its limit value \( \Delta U_{\text{RTF parameter}} \) and comparing \( \Delta \phi_{\text{forecast}} \) with 90°; and a transfer module, for receiving the comparison results from the comparison module, and transferring the load on the bus to said backup power supply only when \( \Delta U_{\text{forecast}} \) is less than its limit value \( \Delta U_{\text{RTF parameter}} \) and \( \Delta \phi_{\text{forecast}} \) is less than 90°.
The signals detected by the detection module are various physical quantities that can be obtained without calculation in the present invention, and these physical quantities can be used as the basis for further calculation carried out using various formulae in the present invention and are sent to the calculation module.

Said calculation module obtains $\Delta U_{\text{forecast}}$ by calculation according to the following formula:

$$
\Delta U_{\text{forecast}} = \sqrt{\mu_{3,\text{forecast}}^2 + \mu_{4,\text{forecast}}^2 + 2 \cdot \mu_{3,\text{forecast}} \cdot \mu_{4,\text{forecast}} \cdot \cos \Delta \rho_{\text{forecast}}},
$$

in which $\mu_{3,\text{forecast}}$ is a forecast value of the motor's residual voltage, and $U_{\lambda}$ is the voltage of the backup power supply.

Said calculation module obtains $U_{M_{\text{forecast}}}$ by calculation according to the following formula:

$$
U_{M_{\text{forecast}}} = U_{t_1} \left(1 + \lambda \cdot At + \frac{1}{2} \cdot (\lambda \cdot At)^2\right),
$$

in which $U_{t_1}$ is the real-time amplitude at the moment $t_1$; $\Delta t$ is the time difference between the moment $t_2$ and the moment $t_1$, that is, the time period for the circuit breaker to close; and

$$
\lambda = \frac{1}{\tau},
$$

$\tau$ being a time constant.

Said calculation module obtains $\Delta \phi_{\text{forecast}}$ by calculation according to the following formula:

$$
\Delta \phi_{\text{forecast}} = \Delta \rho_{t_1} + \Delta \omega_{t_1} \cdot At + \frac{1}{2} \cdot \alpha \cdot (At)^2,
$$

in which $\Delta \rho_{t_1}$ is the phase difference at the moment $t_1$, $\Delta \omega_{t_1}$ is the angular velocity difference at the moment $t_2$, $\Delta t$ is the time difference between the moment $t_2$ and the moment $t_1$, that is, the time period for the circuit breaker to close, and $\alpha$ is the attenuation rate of an angular velocity defined according to the residual voltage transfer mode.

Said calculation module obtains $\lambda$ by calculation accord-
\[ \lambda = \frac{1 - \sqrt{2 * U_n}}{U_n} \]

In the following formula, \( U_n \) is the real-time amplitude at the moment \( t_1 \).

Said calculation module obtains \( \Delta \omega_n \) and \( \alpha \) by calculation according to the following formulae:

\[ \Delta \omega_n = \frac{\Delta \phi_n - \Delta \phi_{n1}}{t_2 - t_1} \]

and

\[ \alpha = \frac{\Delta \omega_n}{t_2 - t_1} \]

in which \( \Delta \omega_n \) is the angular velocity difference at the moment \( t_1 \), and \( \Delta \phi_n \) is the phase difference at the moment \( t_1 \).

Fig. 4 illustratively shows the characteristic of an attenuated residual voltage in the present invention. As compared with the prior art shown in Fig. 1, the present invention has a real-time fast transfer section which is composed of two parts: a real-time fast transfer section 11 and a real-time fast transfer section 12, as well as an in-phase transfer section 2. The real-time fast transfer section in the present invention is not only greater than the fast transfer section 30 shown in Fig. 1, but also greater than the fast transfer section 3 shown in Fig. 4. The method and device according to the present invention can utilize the safe area for re-supply more fully, thereby achieving better technical effects.

Although embodiments of the present invention are illustrated above, the described embodiments are not intended to exhibit all possible forms of the present invention. In addition, the contents of the description are illustrative rather than restrictive. All kinds of variations and modifications can be made to the contents of the description by those skilled in the art without departing from the spirit of the present invention and the scope of the claims.
Claims

1. A fast bus transfer method to reduce, by transferring between a main power supply and a backup power supply, the impact on a load connected to a bus caused by a power cut, characterized in that the method comprises:
   1) calculating the amplitude $AU_{\text{forecast}}$ of the voltage vector difference between the bus and the backup power supply and the phase angle difference $\Delta \phi_{\text{forecast}}$ between the bus and the backup power supply; and
   2) transferring the load on the bus to said backup power supply only when $\Delta U_{\text{forecast}}$ is less than its limit value $\Delta u_{\text{RTFPt,par,et et}}$, and $\Delta \phi_{\text{forecast}}$ is less than $90^\circ$.

2. The method as claimed in claim 1, characterized in that both $AU_{\text{forecast}}$ and $\Delta \phi_{\text{forecast}}$ are forecast values at the time when a circuit breaker of said backup power supply is closed.

3. The method as claimed in claim 1 or 2, characterized in that $\Delta \phi_{\text{forecast}}$ is obtained by calculation according to the following formula:
   
   $\Delta \phi_{\text{forecast}} = \sqrt{U_{\text{M,forecast}}^2 + U_{\lambda}^2 - 2U_{\text{M,forecast}}U_{\lambda}\cos \Delta \phi_{\text{forecast}}}$

   in which $U_{\text{M,forecast}}$ is a forecast value of the residual voltage, and $U_{\lambda}$ is the voltage of the backup power supply.

4. The method as claimed in claim 3, characterized in that $U_{\text{M,forecast}}$ is obtained by calculation according to the following formula:
   
   $U_{\text{M,forecast}} = U_0 \left(1 + \lambda \Delta t + \frac{1}{2} (\lambda \Delta t)^2 \right)$

   in which $U_0$ is the real-time amplitude at the moment $t_1$; $\Delta t$ is the time difference between the moment $t_2$ and the moment $t_1$, that is, the time period for the circuit breaker to close; and $\lambda = \frac{1}{\tau}$, $\tau$ being a time constant.

5. The method as claimed in claim 3, characterized in
that \( \varphi_{\text{forecast}} \) obtained by calculation according to the following formula:

\[
\varphi_{\text{forecast}} = \varphi_0 + \int_{t_i}^{t_f} \omega(t) \, dt = \varphi_0 + \frac{1}{2} \Delta \omega_i t + \Delta \alpha t^2,
\]

in which \( \varphi_0 \) is the phase difference at the moment \( t_i \), \( \Delta \omega \) is the angular velocity difference at the moment \( t_i \), \( \Delta \alpha \) is the attenuation rate of an angular velocity defined according to a residual voltage transfer mode, and \( \Delta \tau \) is the time difference between the moment \( t_f \) and the moment \( t_i \), that is, the time period for the circuit breaker to close.

6. The method as claimed in claim 4, characterized in that \( \lambda \) is obtained by calculation according to the following formula:

\[
\lambda = \frac{1 - \sqrt{2 U_i}}{U_i},
\]

in which \( U_i \) is the real-time amplitude at the moment \( t_i \).

7. The method as claimed in claim 5, characterized in that \( \Delta \alpha \) and \( \lambda \) are obtained respectively by calculation according to the following formulae:

\[
\Delta \omega_i = \frac{\Delta \varphi_i}{\Delta \tau},
\]

and

\[
\alpha = \frac{\Delta \omega_i - \Delta \varphi_i}{t_f - t_i},
\]

in which \( \Delta \varphi_i \) is the phase difference at the moment \( t_i \), and \( \Delta \omega_i \) is the angular velocity difference at the moment \( t_i \).

8. A fast bus transfer device to reduce, by transferring between a main power supply and a backup power supply, the impact on a load connected to a bus caused by a power cut, characterized in that the device comprises:

- a detection module, for detecting signals at the main power supply, the backup power supply and the bus;
- a calculation module, for receiving said signals, and calculating the amplitude \( A U_{\text{forecast}} \) of the voltage vector difference between the bus and the backup power supply and the
phase angle difference $\Delta \phi_{\text{forecast}}$ between the bus and the backup power supply;
a comparison module, for receiving $A_{\text{Uforecast}}$ and $\Delta \phi_{\text{forecast}}$;
comparing $A_{\phi_{\text{forecast}}}$ with its limit value $A_{\text{URTFFparameter}}$, and comparing $\Delta \phi_{\text{forecast}}$ with $90^\circ$; and

a transfer module, for receiving the comparison results from the comparison module, so as to transfer the load on the bus to said backup power supply only when $\Delta A_{\text{Uforecast}}$ is less than its limit value and $\Delta q_{\text{forecast}}$ is less than $90^\circ$.

9. The device as claimed in claim 8, characterized in that said calculation module obtains $\Delta A_{\text{Uforecast}}$ by calculation according to the following formula:

$$\Delta A_{\text{Uforecast}} = \sqrt{U_{\text{Mforecast}}^2 + U_A^2 - 2 \cdot U_{\text{Mforecast}} \cdot U_A \cdot \cos \Delta \phi_{\text{forecast}}}$$

in which $U_{\text{Mforecast}}$ is a forecast value of the residual voltage, and $U_A$ is the voltage of the backup power supply.

10. The device as claimed in claim 9, characterized in that said calculation module obtains $U_{\text{Mforecast}}$ by calculation according to the following formula:

$$U_{\text{Mforecast}} = U_t \left( 1 + \lambda \cdot At + \frac{1}{2} \cdot \lambda ^2 \cdot At^2 \right)$$

in which $U_t$ is the real-time amplitude at the moment $t_2$; $\Delta t$ is the time difference between the moment $t_2$ and the moment $t_1$, that is, the time period for the circuit breaker to close; and $\lambda = \frac{1}{\tau}$, $\tau$ being a time constant.

11. The device as claimed in claim 9, characterized in that said calculation module obtains $\Delta \phi_{\text{forecast}}$ by calculation according to the following formula:

$$\Delta \phi_{\text{forecast}} = \Delta \phi _i + \Delta \omega \cdot At + \frac{1}{2} \cdot \beta \cdot At^2$$

in which $\Delta \phi _i$ is the phase difference at the moment $t_2$, $\Delta \omega$ is the angular velocity difference at the moment $t_2$, $\Delta t$ is the time difference between
the moment $t_2$ and the moment $t_1$, that is, the time period for
the circuit breaker to close, and $\alpha$ is the attenuation rate
of an angular velocity defined according to a residual volt-
age transfer mode.

12. The device as claimed in claim 10, characterized in
that said calculation module obtains $\lambda$ by calculation ac-
cording to the following formula:

$$\lambda = \frac{1 - \sqrt{\frac{2*U_h - 1}{U_h}}}{t_2 - t_1},$$

in which $U_h$ is the real-time amplitude at the moment $t_1$.

13. The device as claimed in claim 11, characterized in
that said calculation module obtains $\Delta \omega_i$ and $\alpha$ by calcula-
tion according to the following formulae:

$$\Delta \omega_i = \frac{A_\varphi_i - A_\varphi_h}{t_2 - t_1},$$

and

$$a = \frac{\Delta \omega_i - \Delta \omega_h}{t_2 - t_1},$$

in which $\Delta \omega_i$ is the angular velocity differ-
ence at the moment $t_i$, and $\Delta \varphi_i$ is the phase difference at the
moment $t_i$. 