Uninterrupted power supply with intermediate HF circuit

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Contents: This work presents an uninterrupted monophase power supply with IGBT transistors and HF intermediate circuit. Two three-phase UPS circuits with intermediate HF circuit are also presented, based on the suggested control method. All the suggested versions are characterized by small dimensions and a high fundamental content (0.995) of the alternating output voltages.

1 Introduction

The uninterrupted A. C. supply of some important users (monitoring and control equipment for railway traction, data transmission and processing, medical equipment, aerospace control installations a. s. o.) always needs a special care. This job can be performed by uninterrupted power supplies (UPS) [1 - 3].

The progress registered in the power electronics, namely the elaboration of GTO thyristors and insulated gate bipolar transistors (IGBT) a. s. o., have enlarged the UPS applications [4 - 6].

The UPS are most often supplied by accumulator batteries and allow to get output powers of up to 70 - 100 kVA. It is necessary for these uninterrupted power supplies to have a small weight and volume and a low cost. A possibility to satisfy these conditions consists in performing the DC to AC conversion by means of a HF intermediate circuit. Thus, instead of a special iron core low frequency (50 or 60 Hz) power transformer, a ferrite core transformer can be used with lower size and cost.

In the following, a new UPS version is presented, with HF intermediate circuit, having the advantage of more simple control circuits and a reduced number of power transistors, as compared to the circuit given in [7]. Unlike the version described in the work [8], our version includes only one ferrite core monophase transformer, instead of three, as well as a smaller number of power transistors.

Starting from the suggested monophase UPS version, two circuits are described allowing to obtain three-phase voltages by using also a ferrite monophase transformer.

2 Monophase UPS with HF intermediate circuit

In Fig. 1, the basic circuit of the monophase UPS with HF intermediate circuit is presented. The source is supplied by an accumulator battery of the voltage E and consists mainly of a bridge monophase inverter with insulated gate bipolar transistors (IGBT) $T_A - T_B$, a monophase ferrite transformer and a cycloconverter made of the transistors $T_1$ and $T_2$. The filters $L_1C_1$ and $L_2C_F$ are connected to the UPS input and output. The ferrite core transformer has a secondary coil with centre tap and works at a frequency $f_s$ ranging between 20 and 25 kHz, which allows small dimensions reduced since at this frequency the IGBT devices commutation losses are. The transistors $T_1$ and $T_2$ of the cycloconverter are connected in a commutation valve bridge.

The load impedance can be supplied from the mains by means of the static interrupter with the thyristors $T_{H1}$ and $T_{H2}$ or from the UPS when the mains voltage vanishes.

One can explain the generation of the UPS output voltage by means of Fig. 2. The impulses operation of the inverter produces two voltages $u_2$ as rectangular impulses with the duration $T = 1/2f_s$ (Fig. 2a) in the ferrite core secondary coil of the transformer. The transistors $T_1$ and $T_2$ are also turned on in time intervals of the duration $T$, but delayed with $A_t$, compared to the transistors $T_A$, $T_B$ and $T_C$, $T_D$ (Fig. 2c). This delay $A_t$ may be changed between 0 and...
The continuous component of the voltage $u_{RM}$ will change between $+U_{\text{max}}$ and $-U_{\text{max}}$ (Fig. 2b). The value $U_{\text{max}}$ corresponds to the maximum voltage $E_{\text{max}}$ at the accumulator battery terminals. By changing $\Delta t$ step by step during the period $T_1 = 2\pi/\omega_1$ of the output voltage (the output frequency $f_1$ can be 50 or 60 Hz) one can get a quasi-sinusoidal output voltage $u_{RN}$. For instance, in Fig. 3a the waveform is presented for the voltage $u_{RN}$ consisting of 18 steps. The Fourier series expansion of the $u_{RN}$ waveform is given by the relation

$$u_{RN} = \sum_{n=1}^{\infty} \frac{4 \sin \frac{\pi}{2} \sin \frac{n}{18} \pi}{\pi n} \left[ a_1 + 2a_2 \cos n \frac{\pi}{9} + 2a_3 \cos n \frac{\pi}{3} + 2a_4 \cos n \frac{4\pi}{9} \right] \sin n \omega_1 t$$

(1)

The fundamental content of $u_{RN}$ has a maximum value of 0.9949 that can be obtained for the following ratios between the step levels $rac{a_1}{a_5} = 0.940; \frac{a_3}{a_1} = 0.766; \frac{a_4}{a_1} = 0.5$ and $\frac{a_5}{a_1} = 0.174$. In this case, the $u_{RN}$ voltage higher harmonics amplitudes are less than 5 percent of the fundamental amplitude of this voltage.

Since the accumulator battery voltage $E$ is not constant during the UPS operation, ranging between maximum value $E_{\text{max}}$ and minimum value $E_{\text{min}}$, it is necessary

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**Fig. 1.** Basic diagram of the monophase UPS with HF intermediate circuit

**Fig. 2.** Generation of the UPS output voltage. a inverter output voltage $u_2$, b voltages $u_3$ and $U_{RN}$, c conduction intervals of the transistors for different output voltages

**Fig. 3.** Output voltage waveforms for UPS