

The invention is based on a mains operated phase-control circuit according to the preamble of claim 1.

In a known circuit of this type, the serial connection of an inductance and a transistor acting as a switch is connected to the output of a mains rectifier, in which the middle point of the serial connection is connected via a diode to a charging capacitor. The charging capacitor supplies the operating voltage stabilized via a phase-control circuit. Such a phase-control circuit has the advantage that owing to the switch operation the power dissipation within the circuit is low, and the operating voltage generated can be altered within wide limits by altering the phase operating angle. The known circuit described is also designated as a "step-up" circuit. Such a circuit is known from "IEEE TRANSACTIONS ON AEROSPACE AND ELECTRONIC SYSTEMS" Vol.24, No.6, November 1988, New York pages 800-807.

Such circuits with phase control generates harmonic waves in the current drawn from the mains supply which are undesirable and can cause interference. Thus, there are requirements regarding the maximum amplitude of the harmonics in the current drawn from the mains. According to the latest requirements, the maximum permissible amplitude of the harmonics depends upon the power drawn from the mains in the power range below 300 W.

It is the object of the invention to further develop the known circuit described without any great additional expense in such a way that the amplitude of the harmonics in the current drawn from the mains is reduced.

This object is achieved by the invention specified in claim 1. Advantageous further developments of the invention are given in the subclaims.

The circuit according to the invention is an advantageous and, as far as

circuitry is concerned, simple combination of the known "step-up" circuit and a switch mode power supply. In doing this, the transistor acting as a switch fulfils two tasks simultaneously. Firstly, the transistor serves as a switch for the known step-up circuit. In addition, the transistor serves as an electronic power switch for the switch mode power supply combined with the step-up circuit. Consequently, the same switch, in the form of a transistor, is used for both functions effective in the overall circuit.

An embodiment of the invention is now explained with reference to the drawing. It shows in:

Fig.1 a detailed circuit diagram of the invention; and

Fig.2 the course of a voltage occurring in Fig.1.

The symbols used in the description and the drawing have the following meaning:

- Ci capacitor with low capacitance of approx. $5 \mu\text{F}$
- Cb electrolytic capacitor with high capacitance of approx. $150 \mu\text{F}$
- La inductance of approx. 1mH
- D1 diode of type BYT 13-600
- D2 diode of type BYT 13-600
- T1 power transistor of type BUV 56 serving as switch
- td conducting time of diode D2
- ton conducting time of T1
- imains current drawn from the mains
- Umains mains voltage

In Fig.1, the mains bridge rectifier BG is connected to the mains terminals

1. The capacitor C_1 is connected to the output 'a'. C_1 has a relatively small capacitance of $5 \mu\text{F}$. It serves only for the RF suppression and does not cause any significant filtering for the mains voltage of 50 Hz. Connected to output 'a' is the inductance L_a , the other end of which is connected via the diode D_1 to the charging capacitor C_b . C_b is an electrolytic capacitor with a high capacitance of approx. $150 \mu\text{F}$. The middle point b of the serial connection L_a/D_1 is connected via the diode D_2 to the collector of the transistor T_1 . In addition, the collector is connected via the primary winding L_p of the transformer Tr to the charging capacitor C_b . T_1 and L_p form a switch mode power supply. The transformer Tr contains two secondary windings L_{s1} and L_{s2} which supply two operating direct voltages V_1 , V_2 via rectifiers GL_1 and GL_2 .

The transistor T_1 is controlled by the control circuit 2 in the sense of a phase control, periodically conducting and nonconducting. The control circuit 2 is synchronized by the secondary winding L_{s2} via line 3. The transistor T_1 acting as a switch functions, on the one hand, as a switch for the known step-up circuit which would contain only the components L_a , T_1 , D_1 and C_b . In addition, the transistor T_1 functions as an electronic power switch for the switch mode power supply, with the switch mode power supply transformer Tr , combined with the step-up circuit.

During the conducting time of the transistor T_1 , the inductance L_a stores an amount of energy proportional to the square of the input voltage. This energy is transmitted via the diode D_1 to the charging capacitor C_b . The charging capacitor C_b has a capacitance which is so high that it evens out the output voltage of the rectifier BG , and a pure direct voltage V_b ensues at the terminal 4.

The voltage V_b is greater than the peak voltage of the mains power rectifier and is dependent upon the conducting time of the transistor T_1 . The

following applies here:

$$V_b = V_i * (t_{on} + t_d)/t_d.$$

The capacitor C_b , the transformer T_r and the transistor T_1 form a switch mode power supply with reverse rectifying. In the normal stationary operation, the conducting time ' t_{on} ' of the transistor T_1 changes slowly according to the charge in the secondary windings. The time ' t_{on} ' is essentially constant during one-half of a period and depends upon the power transmitted. The inductance L_a must be sized sufficiently small, in fact in such a way it can be completely discharged during the blocking time of the transistor T_1 . Consequently, the current through the inductance L_a is very nearly linearly dependent on the time ' t_{on} ', i.e. on the power which is transmitted via the transformer T_r . On the other hand, the time ' t_{on} ' is essentially constant during one-half of a phase-angle period. Therefore, the average current flowing through the inductance L_a is approximately proportional to the voltage V_i .

The capacitor C_i is sized so small that it merely causes a filtering effect for high frequencies. From this it results that the voltage V_i is roughly equal to the rectified mains voltage, i.e., represents a so-called pulsed direct voltage according to Fig.2. Therefore, the current through the inductance L_a is essentially equal to the current supplied by the rectifier BG and hence more or less sinusoidal. If the operating frequency of the transistor T_1 is fixed and the switch-on time ' t_{on} ' is constant, then the current supplied by the rectifier BG is, theoretically, not completely sinusoidal. Rather, the current contains harmonics, the amplitudes of which are relatively small and lie within the permissible tolerances.

Fig.2 shows that the voltage V_i at the capacitor C_i is, practically, unfiltered by a correspondingly small capacitor C_1 , i.e. represents a so-called

pulsed direct voltage consisting of half sine waves. The relatively small capacitor C_i only serves for the suppression of RF voltages. It acts together with the inductance L_a as a low pass filter and prevents RF voltages from entering the mains. The small capacitor C_i also contributes to keeping low the amplitudes of the harmonics of the current drawn from the mains. Moreover, a smaller capacitor is cheaper than an electrolytic capacitor with a high capacitance of approx. 100 μF which would otherwise be used as charging capacitor.

It is essential that the switch mode power supply functions with the transistor T_1 and the transformer Tr according to the principle of the blocking oscillator with reverse rectifying. This means that the rectifiers GL are conducting and energy is transferred into the capacitors when the transistor T_1 is blocked. The reverse rectifying is achieved through polarizing the secondary windings L_s and the connected rectifiers GL in a certain manner. The polarization of the windings for reverse rectifying is indicated in Fig.1 by the points on the individual windings.

In order to generate further secondary voltages V_3 and V_4 , the transformer Tr contains two further rectifiers GL_3 and GL_4 which are fed from further secondary windings L_{s3} and L_{s4} . Another advantage of the circuit is that the voltage at the capacitor C_b can alter over wide limits of approx 50% - 100%.



CLAIMS

1. A mains operated phase-control circuit with a mains rectifier, connected to the output of which is the serial connection of an inductance (La) and a periodically operated switching transistor (T1), in which the middle point (b) of the serial connection is connected via a first diode (D1) to a charging capacitor (Cb), and to the charging capacitor (Cb) there is connected a switch mode power supply with a transformer (Tr) and operating according to the blocking oscillator principle with reverse rectifying, characterised in that a second diode (D2) is located between the middle point (b) and the switch (T1) and is poled in the same sense as the collector/emitter path of the switching transistor (T1) and the switching transistor (T1) is connected via the primary winding (Lp) of the transformer (Tr) of the switch mode power supply to the charging capacitor (Cb).
2. A circuit according to claim 1, characterized in that only one relatively small capacitor (Ci) for RF suppression, effecting no significant filtering of the mains voltage, is connected to the output (a) of the mains rectifier (BG).
3. A circuit according to claim 1, characterised in that the transformer (Tr) comprises a plurality of secondary windings (Ls1, Ls2) and rectifiers (GL1, GL2) connected thereto for generating operating voltages (V1, V2).
4. A circuit according to claim 1, characterised in that the value of the inductance (La) is less than the inductance of the primary winding (Lp) of the transformer (Tr).