

The invention is based on a switch mode power supply according to the preamble of claim 1. A switch mode power supply of this type is known from EP 0 336 725 A2.

5 With such a switch mode power supply the level of the operating voltage generated at the secondary side is stabilised through control of the duty cycle of the switching transistor at the primary side. For this, it is necessary to transmit an item of control information
10 indicating the actual level of the operating voltage from the secondary side to the primary side. With this transmission the electrical separation between the primary side and the secondary side must be maintained, however. Thus it is known to provide additional
15 circuitry means such as, for example, a separate transformer or an optocoupler for the transmission of the item of control information from the secondary side to the primary side.

20 The object of the invention is to attain transmission of the control information from the secondary side to the primary side while maintaining the electrical separation in an electrically simple way and without additional circuit means.

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This object is achieved by the invention disclosed in claim 1. Advantageous further developments of the invention are disclosed in the dependent claims.

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With the invention the transformer which is required in any case for the electrical separation and which

itself transmits power from the primary side to the secondary side is additionally utilised for transmitting an item of control information from the secondary side to the primary side. The transmission of the information occurs during the so-called rest period of the transformer, during which the current through the primary winding is turned off by the power switch. The energy which is transmitted simultaneously with the information or fed back into the transformer is thus kept relatively small. The control voltage on the primary side can be derived from a voltage proportion which is dependent upon the actual value of the reverse charging current and thus upon the level of the operating voltages generated at the secondary side. Preferably the voltage on the primary side is evaluated during the rest period using a time window. The control voltage is then obtained only from the voltage proportion of this time window. It is also possible to derive the control voltage from the steepness or the amplitude of a pulse edge which is also dependent upon the reverse charging current and upon the operating voltage generated at the secondary side. No additional winding at the transformer is required for the transmission of the information. A secondary winding which at the same time serves for the generation of an operating voltage by means of a rectifier circuit can be used for the transmission of the information. This secondary winding then supplies energy to the rectifier circuit during the working period and transmits an item of information for the control to the primary side during the rest period. The energy transmission and the information transmission thus occur via the same

windings, but displaced in time and in opposed directions.

It is thus achieved that a defined proportion of the pulse voltage at the transformer is a measure for the control variable. For the evaluation of this pulse proportion for obtaining the control variable, however, there are various alternatives.

10 In a first solution the pulse voltage at the transformer is gated using a switching pulse during a time window. The switching pulse comes from the processor controlling the switch mode power supply. The processor contains the information on at which time
15 during the working period the voltage proportion containing the control information lies. This voltage proportion is then gated by a time window and rectified for obtaining the control voltage. In a second solution the sampling pulse is obtained from the pulse voltage
20 itself. The individual pulse edges are evaluated by means of differential elements. It is then possible to obtain a pulse marking the beginning of the time window. The desired gating pulse extending throughout the duration of the time window can then be generated from
25 this pulse in a pulse shaper.

Various embodiments of the above solutions are described below with reference to the drawing.

Fig. 1 shows the switch mode power supply in a
30 simplified form with the first solution,

Fig. 2 shows a circuit example according to the second solution and

Fig. 3 shows the path of voltages and currents in Figures 1 and 2.

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In Fig. 1 a positive operating voltage $+U_b$ is present at the terminal 1 obtained through rectification of the mains alternating current. U_b is connected, via the primary winding W_1 of the transformer Tr , to the power transistor T_1 operating as a switch. The transistor T_1 is controlled by the processor P with a voltage 2 which is modulated in its pulse width. Operating voltages U_1 , U_2 , U_3 , U_4 , U_5 are generated by means of a plurality of secondary windings and connected rectifiers. An RCD attenuator 3, also referred to as a "snubber", lies in parallel with the primary winding W_1 and serves for the limitation of pulse peaks and of the edge steepness of the voltage at T_1 .

The transistor T_2 , which is polarised in reverse direction with respect to the diode D_1 and which is controlled at its base by the comparator circuit V , lies in parallel with the diode D_1 , which generates the operating voltage U_5 . The functioning is explained in connection with Fig. 3. From $t_1 - t_2$ the current i_l flows through the primary winding W_1 and the transistor T_1 . From $t_2 - t_3$ the current i_D flows through the diode D_1 for charging the charging capacitor 4. At the time t_3 the transistor T_2 becomes conducting and supplies a so-called reverse charging current i_{T2} from the charging capacitor 4 back into the transformer Tr . The energy

thus transmitted is relatively small. At the time t_4 the transistor T2 is switched off. The voltage U2 arises in the pulse voltage US from $t_4 - t_5$ through the reverse charging current i_{T2} . The amplitude of U2 is dependent upon i_{T2} . In the comparator circuit V the operating voltage U5 is compared with the constant reference voltage Ref. At the Zener diode 5. Dependent upon this comparison the transistor T2 is controlled to be more or less conducting so that also i_{T2} and U2 are dependent upon U5.

The voltage U2 which thus contains an item of control information also appears at the primary winding W2 in the voltage UP which is reversed in phase with respect to US. In the processor P in the pulse shaper 6 the gating pulse UT is obtained from the voltage UB which periodically controls the transistor T1 to be conducting and to be blocked. The gating pulse UT operates the switch 7 in the sense of a time window so that only the proportion U2 out of UP is evaluated. From the voltage U2 which is sampled in a time selective manner, there is obtained at the capacitor 15 by means of the rectifier 8, the control voltage Ur1 which is thus a measure for the actual deviation of U5 from the desired value. In the comparator unit 9 Ur1 is compared with a reference voltage from the voltage source 10. The thus obtained control voltage Ur2 controls the pulse width modulator 11 in such a way that the pulse width of the voltage 2 is controlled in the sense of a stabilisation of the operating voltages U1 - U5. Thus, the criterion for the control voltage Ur2 is the amplitude of a voltage

proportion of US or UP during the time window $t_4 - t_5$. The time window $t_4 - t_5$ amounts to approximately 10 - 20 per cent of the duty cycle of the transistor T1. The gating pulse UT must extend over the time period $t_4 - t_5$.

5 According to Fig. 3 it is made longer, namely from $t_2 - t_5$, because this pulse can be better derived from the circuit. In this case, also the part of UP from $t_2 - t_4$ is switched through by means of the switch 7. However, this negative part is suppressed by the action of the
10 diode 8 so that in the end only the voltage U2 from $t_4 - t_5$ is further transmitted via the diode 8 for forming U_{r1}. The circuit has the following additional advantage: usually an additional shunt resistor is required in parallel to the charging capacitor 4 which is also
15 referred to as "bleeder" and which constitutes a path for discharging the capacitor. With the circuit according to Fig. 1 this shunt resistor can have higher Ohm values so that less power is dropped at it. Depending on the demands the shunt resistor may also be left out
20 completely as a function of the effect of the transistor T2.

Fig. 2 shows another possibility for generating the gating pulse UT. The voltage UP' is obtained from the
25 voltage UP using the differential element 12. Using the differential element 13 the voltage UB' is obtained from the voltage UB at the base of T1. UP' and UB' are added in the adding stage 14 thereby creating the voltage Ud1. The negative pulses UP' at t_1 and t_5 and the positively
30 directed pulses UB' at t_1 and t_5 are added and partially cancel each other whereas the negative voltage in UP' at

t4 remains. Using the diode 16 the voltage Ud2 is obtained from the voltage Ud1, the former having only a negative peak at the time t4. This voltage Ud2 can be used in a pulse shaper or in a monostable circuit for
5 generating the timing pulse UT for the time window from t4 - t5.



Patent Claims

1. A switch mode power supply with a transformer (Tr) with a secondary winding which supplies, via a diode (D1), a charging current (i_D) to a charging capacitor (4) at which an operating voltage (U_5) is present, in which at the primary side a control voltage (U_r) dependent upon the operating voltage (U_5) at the secondary side is obtained for controlling the duty cycle of a switching transistor (T1), and parallel to the diode (D1) there lies a transistor (T2) which after the decay of the charging current (i_D) is controlled to be conducting in dependence upon the operating voltage (U_5) during a fraction of the duty cycle of the switching transistor (T1) and which feeds, through a reverse charging current (i_{T2}) flowing in reverse direction with respect to the charging capacitor (4) back into the transformer (Tr), characterised in that on the primary side the control voltage (U_r) is obtained from the voltage (U_2) induced by the reverse charging current (i_{T2}).

2. A power supply according to claim 1, characterised in that the transistor (T2) is controlled by a comparator circuit (V) in which the operating voltage (U_5) is compared with a reference voltage (Ref.).

3. A power supply according to claim 1, characterised in that a primary winding (W2) is connected via a switch (7), which is actuated by a switching pulse (U_T) during a time window ($t_4 - t_5$), to a rectifier (8) supplying the control voltage (U_{r1}).



4. A power supply according to claim 2, characterised
in that the switching pulse (UT) is derived from a
processor (P) controlling the switch mode power supply
5 and has a defined temporal position within the operating
period.

5. A power supply according to claim 2, characterised
in that the switching pulse (UT) is derived from a pulse
10 edge of the voltage at the primary winding or a secondary
winding of the transformer (Tr) (Fig. 2).

6. A power supply according to claim 1, characterised
in that the fraction amounts to approximately 10 - 20 per
15 cent.