

Description

The invention relates to a self-oscillating power-supply circuit for supplying a load with input voltages of different values, comprising a transformer with a primary winding and a secondary winding, which primary winding in series with the main-current path of a switching transistor is arranged between two terminals to which the input voltage is to be applied, the switching transistor being turned off by means of a control transistor depending on a current proportional to the input voltage, and which secondary winding in series with a diode is arranged in parallel with the load, a positive feedback loop comprising capacitor in series with a first resistor being arranged between one end of the secondary winding and the base of the switching transistor.

Such a power-supply circuit may be used for charging batteries and powering electronic equipment. In particular, such a power-supply circuit may be employed in an electric shaver, in which the circuit supplies the charging current for the batteries and the current for the d.c. motor if the batteries are exhausted and the shaver is powered directly from the mains.

A power-supply circuit of the type defined in the opening paragraph is disclosed in European Patent Specification 30026. If the input voltage is applied to this circuit a small current is fed to the base of the switching transistor via a starting resistor and drives this transistor partly into conduction. This results in a small primary current in the primary of the transformer. This current induces a voltage in the secondary winding, as a result of which a larger current is applied to the base of the switching transistor via the positive feedback between the secondary winding and the base of the switching transistor. In this way the switching transistor is rapidly driven into full conduction. During the so-called "forward" interval the primary current increases as a linear function of time. In the known circuit a resistor is arranged in the emitter line of the switching transistor, which resistor is connected in parallel with the base-emitter junction of the control transistor. For a specific value of the primary current the control transistor is then turned on and the switching transistor is consequently turned off. During the so-called "flyback" interval the energy stored in the transformer produces a secondary current in the secondary winding. This current constitutes the charging current for the batteries or directly powers the relevant apparatus. The secondary current decreases as a linear function of time until the switching transistor is turned on again.

In this way the power-supply circuit forms a self-oscillating power supply which supplies a constant average output current at a specific input voltage and a constant output voltage. However, this output current depends on the input voltage. For example, if the input voltage is higher, the primary current increases at a faster rate during

the forward interval, so that the level at which the switching transistor is turned off is reached more rapidly. Since the flyback interval is substantially constant, this leads to a higher oscillating frequency and hence to a larger average output current.

In addition, an increasing input voltage leads as a result of the positive feedback between the secondary winding and the base of the switching transistor to an increasing base current of this transistor. Increasing input voltages therefore drive the switching transistor further towards saturation, so that after the primary current has reached the turn-off level the switching transistor is turned off with an increasing delay. As a result of this, the primary current becomes increasingly higher at increasing input voltages, which also results in an increasing average output current.

However, the output current of the power-supply circuit should remain within a specific range in order to preclude damage to the batteries and/or the apparatus as a result of an excessive current at high input voltages and in order to enable an adequate charging current for the batteries and/or power-supply current for the apparatus to be obtained at low input voltages.

To enable the power-supply circuit to be used with different mains voltages in various countries without adaptation of switching over, the known circuit employs mains-voltage compensation, by means of which it is achieved that the values of the primary current for which the switching transistor is turned off are reduced as the input voltage increases. This is effected for example, by applying a current which is proportional to the input voltage to the resistor in the emitter line of the switching transistor, so that the control transistor is turned on for values of the primary current which decrease as the input voltage increases.

The invention aims at precluding the above effect of the turn-off delay increasing as the input voltages in such a self-oscillating power supply increase. Tests have revealed that of the two effects of increasing input voltages, namely an increasing switching frequency and an increasing turn-off delay, the latter is the principal cause of the increase in output current as the input voltage increases. Moreover, it has been found that by eliminating the increase in turn-off delay compensation for the increase in switching frequency may even be dispensed with.

Therefore, it is the object of the invention to provide a self-oscillating power-supply circuit which in a simple manner provides compensation for increases in turn-off delay as a result of input-voltage increases to enable the circuit to be used over a larger range of input voltages.

In accordance with the invention a self-oscillating power supply circuit of the type defined in the opening paragraph is characterized in that the positive feedback loop further comprises a second resistor in series with the capacitor and the first resistor, a zener diode is arranged between a point on the connection between the

first resistor and the second resistor and that end of the main current path of the switching transistor which is remote from the primary winding, which capacitor provides d.c. isolation between the said point and the secondary winding. At a specific input voltage the zener diode is turned on, so that for higher input voltages the what would otherwise be increase in base current is drained to the emitter of the switching transistor via the zener diode. As a result of this, the switching transistor is always saturated to substantially the same extent. Thus, the turn-off delay does not increase when the input voltage increases, so that the output current becomes less dependent on the input voltage.

It is remarked that DE—A 33 00 285 discloses a self-oscillating power-supply in which a zener diode is used for improved stabilisation of the switching frequency. In contrast to the power-supply according to the present invention the zener diode in the known circuit is employed to charge the capacitor in the positive feedback loop from a constant voltage supply during the flyback interval. Thereby the dependence of the duration of the flyback interval from the input voltage is removed. However, the known circuit does not reduce the dependency of the turn-off delay from the input voltage.

The base-current compensation in the power-supply circuit in accordance with the invention may be combined in a suitable manner with compensation for increases in switching frequency of the switching transistor as a result of input voltage increases. The power-supply circuit is then characterized further in that the circuit comprises compensation means coupled to a control electrode of the control transistor for supplying therefore a signal for turning off the switching transistor at decreasing values of the current through the primary winding at increasing values of the input voltage.

In accordance with a further embodiment said compensation means may comprise a third resistor which is in series with the main current path of the switching transistor and is connected to the negative input-voltage terminal, which third resistor is coupled to the control electrode of the control transistor via the collector-emitter path of a transistor whose base is connected to the collector, the emitter, and the positive input-voltage terminal by a fourth resistor, a fifth resistor, and a sixth resistor, respectively, which control electrode is connected to the negative input-voltage terminal by a seventh resistor. Another embodiment may be characterized in that the compensation means comprise a third resistor which is, in series with the main current path of the switching transistor and is connected to the negative input-voltage terminal, which third resistor is coupled to the control electrode of the control transistor via the collector-emitter path of a transistor whose base is connected to the collector and the emitter by a fourth resistor and a fifth resistor, respectively, a second capacitor being arranged in parallel with the

fourth resistor. With respect to the compensation means yet another embodiment may be characterized in that the junction point between the secondary winding and the diode is connected to the negative input-voltage terminal by the series arrangement of a third resistor and a second capacitor, the junction point of said third resistor and said second capacitor being coupled to the control electrode of the control transistor.

Embodiments of the invention will now be described in more detail, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 shows a power-supply circuit in accordance with a first embodiment of the invention,

Fig. 2 shows a power-supply circuit in accordance with a second embodiment of the invention,

Fig. 3 shows a power-supply circuit in accordance with a third embodiment of the invention,

Fig. 4 shows some characteristic curves relative to the circuits shown in Fig. 1 and Fig. 3,

Fig. 5 shows a power-supply circuit in accordance with a fourth embodiment of the invention,

Fig. 6 shows a power-supply circuit in accordance with a fifth embodiment of the invention, and

Fig. 7 shows some characteristic curves to illustrate the operation of the circuit shown in Fig. 6.

Fig. 1 shows a self-oscillating power-supply circuit in accordance with a first embodiment of the invention. Only those parts of the circuit are shown which are relevant to the operation of the circuit in accordance with the invention. The control circuit for turning off the power-supply circuit when the batteries are full is not shown. The circuit comprises two input terminals 1 and 2, to which the mains voltage, which may be an alternating voltage or a direct voltage, is applied. This voltage is supplied to a rectifier bridge 3. The rectified voltage is smoothed by means of a filter 4, which in the present example comprises two capacitors C_3 , C_4 and a coil L_1 . The smoothed voltage is applied to the primary winding n_1 of a transformer having a core 6. A zener diode Z_2 in series with diode D_2 is arranged in parallel with the primary winding n_1 to preclude voltage transients when the current through the primary is switched off. The collector-emitter path of a switching transistor T_1 is connected in series with the primary winding n_1 , which switching transistor has its base connected to the positive input-voltage terminal by means of a resistor R_1 having a high resistance. The resistor R_1 is a starting resistor for starting the circuit when the mains voltage is applied. It is to be noted that the circuit can also be started in ways other than by means of the resistor R_1 . The series arrangement of a load 10 and a resistor R_2 connects the emitter of the switching transistor T_1 to the negative input-voltage terminal. In the present example the load 10 comprises two nickel-cadmium batteries 11 and 12, with which a d.c. motor M can be connected in parallel by means of a switch s_1 . In that case the switch S_2 simultaneously connects a

resistor R_3 in parallel with the resistor R_2 . The base-emitter junction of a control transistor T_2 is arranged in parallel with the resistor R_2 , which control transistor has its collector connected to the base of the switching transistor T_1 . The secondary winding n_2 in series with a diode D_1 is arranged in parallel with the load 10. A series arrangement of a resistor R_4 , a capacitor C_1 and a resistor R_5 is connected between the junction point of the secondary winding n_2 and the diode D_1 , and the base of the switching transistor T_1 . The cathode of a zener diode Z_1 is connected to the junction point of the resistor R_5 and the capacitor C_1 and the anode of this zener diode is connected to the emitter of the switching transistor T_1 . It is to be noted that the resistor R_4 and the capacitor C_1 may be inter-changed.

The circuit operates as follows. It is assumed that the switches S_1 and S_2 are open and the circuit consequently supplies the charging current for the batteries 11 and 12. When the mains voltage is applied to the input terminals 1 and 2 a very small current will follow into the base of the transistor T_1 via the large starting resistor R_1 . This produces a small collector current, which also flows through the primary winding n_1 of the transformer 6. In the secondary winding n_2 this results in an increase of the voltage on the end which is connected to the diode D_1 . By means of the positive feedback loop, which comprises the resistor R_4 and R_5 and the capacitor C_1 , and which is arranged between that end of the secondary winding n_2 which is positive during the forward interval and the base of the transistor T_1 , a larger base current is applied to the transistor T_1 , which current drives this transistor further into conduction. The positive feedback then ensures that the transistor T_1 is rapidly saturated. During the forward interval the primary current increases as a linear function of time. At a level of the primary current which is determined by the resistance of the resistor R_2 the control transistor T_2 is turned on, so that the switching transistor T_1 is turned off. It is to be noted that the control transistor T_2 can also be turned on depending on the value of the primary current in a manner other than by means of a resistor R_2 . As the primary current becomes zero because the transistor T_1 is turned off, the polarity of the voltage across the secondary winding n_2 is reversed. The end of the winding n_2 which is connected to the diode D_1 then becomes negative, so that the diode D_1 is turned on. The energy stored in the transformer 6 during the forward interval is then delivered to the batteries 11 and 12 in the form of a charging current via the diode D_1 in the flyback interval. This current decreases to zero as a linear function of time, after which the switching transistor T_1 is turned on again.

During the forward interval the maximum voltage on that end of the secondary winding n_2 which is connected to the diode D_1 is dictated by the input voltage and the transformation ratio of the transformer 6. For comparatively low input voltages the zener diode Z_1 does not conduct. The

base current of the switching transistor T_1 is then determined by the voltage difference between the positive end of the winding n_2 and the base of the switching transistor T_1 and by the resistance of the resistors R_4 and R_5 . When the input voltage increases the voltage on the junction point between the capacitor C_1 and the resistor R_5 increases as a result of the increasing base current, so that the zener diode Z_1 is turned on at a specific input voltage. The base current is then determined by the difference between the zener voltage and the base-emitter voltage of the transistor T_1 and by the resistance value of the resistor R_5 . As the input voltage increases further, the what would otherwise be further increase in base current is drained to the emitter of transistor T_1 via the zener diode Z_1 . The base current of the transistor T_1 therefore remains constant, so that the switching transistor T_1 is not further saturated at increasing input voltages. This ensures that the turn-off delay cannot increase at increasing input voltages. Thus, the output current of the circuit remains within the range in which it cannot damage the batteries 11 and 12 and the electronic circuitry.

Apart from the base-current compensation the zener diode Z_1 has another advantage. During the forward interval that end of the capacitor C_1 which is connected to the secondary winding n_2 is positive relative to the end which is connected to the base of the transistor T_1 . At the beginning of the flyback interval the polarity of the voltage across the secondary winding n_2 is reversed and the voltage on that end of the winding n_2 which is connected to the diode D_1 becomes negative. The voltage on the base of the transistor T_1 would then also become negative via the capacitor C_1 , as a result of which starting would take more time during the next forward interval. This is avoided in that during the flyback interval the zener diode Z_1 clamps the junction point between the capacitor C_1 and R_5 at a voltage which is one diode voltage lower than the battery voltage.

If the switches S_1 and S_2 are closed, the circuit directly supplies the direct current for the d.c. motor M. As the resistor R_3 is arranged in parallel with the resistor R_2 , the control transistor T_2 is turned on and the switching transistor T_1 is consequently turned off at larger primary currents. In this situation the circuit supplies a larger output current. Otherwise, the circuit operates in the same way.

Fig. 2 shows a power-supply circuit in accordance with a second embodiment of the invention. Identical parts bear the same reference numerals as in Fig. 1. The present embodiment differs from that shown in Fig. 1 in that the load 10 is not arranged in the emitter line of the switching transistor T_1 but is arranged separately from this line. The emitter of the transistor T_1 is connected to the negative input-voltage terminal via the resistor R_2 . By means of a switch S_2 a resistor R_3 can be arranged in parallel with the resistor R_2 . The batteries 11 and 12 are connected in parallel with the series arrangement of the secondary

winding n_2 and the diode D_1 . By means of a switch S_1 , which is actuated simultaneously with the switch S_2 , a d.c. motor M can be connected in parallel with the batteries 11 and 12. Again a positive-feedback loop comprising the resistors R_4 and R_5 and the capacitor C_1 is arranged between that end of the winding n_2 which is positive during the forward interval and the base of the transistor T_1 . The zener diode Z_1 is arranged between the junction point of the resistor R_5 and the capacitor C_1 and the emitter of the transistor T_1 and thus provides base-current compensation. The circuit operates in a similar way to that shown in Fig. 1, except that during the flyback interval the zener diode Z_1 does not clamp the base of the transistor T_1 at a voltage which is one diode voltage lower than the battery voltage.

It has been found that the dependence of the output current on the input voltage can be reduced by means of the base-current compensation to such an extent that the output current remains within the desired range for correct operation of the circuit. In addition to the base-current compensation, a power-supply circuit in accordance with the invention may provide compensation for an increase in the switching frequency of the switching transistor T_1 when the input voltage increases. Fig. 3 shows a power-supply circuit with such compensation, which yields an output current with very good overall mains — voltage compensation. Identical parts bear the same reference numerals as in Fig. 1. A base-emitter-voltage multiplier is arranged in the base line of the control transistor T_2 and comprises a transistor T_3 , which has a resistor R_8 arranged between its base and its emitter and a resistor R_7 between its base and its collector. The base of the transistor T_3 is connected to the positive input-voltage terminal by means of a resistor R_6 having a high resistance. Further, a resistor R_9 is arranged between the emitter of the transistor T_3 and the negative input-voltage terminal. The voltage division by means of the resistors R_8 , R_6 and R_9 results in an input-voltage-dependent voltage across the resistor R_8 and hence across the base-emitter junction of the transistor T_3 .

The voltage across the entire multiplier is a fraction higher than the voltage across the base emitter junction of the transistor T_3 , which fraction is defined by the ratio between the resistance values of the resistors R_7 and R_6 . The voltage across the resistor R_2 at which the control transistor T_2 is driven into conduction is equal to the sum of the voltages which appear across the base-emitter junction of the transistor T_2 and the multiplier T_3 , R_6 and R_7 when the transistors T_2 and T_3 are conductive, minus the input-voltage-dependent bias of the multiplier T_3 , R_6 and R_7 . The level at which the primary current is switched off therefore decreases as the input voltage increases. This compensates for the effect of the increasing output current resulting from the increase in the switching frequency of the switching transistor T_1 in response to increasing input

voltages. Otherwise, the circuit operates in the same way as that shown in Fig. 1.

In Fig. 4 the output current I_0 is plotted as a function of the mains voltage for equally dimensioned circuit, as shown in Fig. 1 and Fig. 3. The characteristics I and II respectively represent the load current and the motor current for the circuit of Fig. 1 and the characteristics III and IV respectively represent the load current and the motor current for the circuit shown in Fig. 3. From the characteristics I and II it is evident that when the base-current compensation becomes operative, in the present case at an input voltage of approximately 120 to 130 V, the output current varies less strongly in the range of input voltages above this voltage than in the range of input voltages below this voltage. The characteristics III and IV show that the base-current compensation in conjunction with switching-frequency compensation leads to an even smaller variation of the output current as a function of the input voltage.

Fig. 5 shows a circuit in accordance with an embodiment of the invention, derived from the circuit shown in Fig. 3. Identical parts bear the same reference numerals as in Fig. 3. The circuit differs from that shown in Fig. 3 in that the base of the transistor T_3 is no longer connected to the positive-input voltage terminal via a resistor R_6 and in that the resistor R_6 is no longer arranged across the base-emitter junction of the transistor T_2 . However, now a capacitor C_6 is arranged across resistor R_7 . As explained already, the voltage across the resistor R_2 increases less rapidly at comparatively low input voltages than at comparatively high input voltages. This means that the frequency of the voltage across this resistor increases as the input voltage increases. The capacitor C_6 across the resistor R_7 constitutes a high impedance for comparatively low frequencies and it constitutes a short-circuit for comparatively high frequencies. As a result of this, the voltage across the multiplier T_3 , R_6 , R_7 decreases as the input voltage increases, so that the control transistor T_2 is turned on at a decreasing level of the primary current and, consequently, the switching transistor T_1 is turned off at a decreasing level. This results in compensation for the increasing switching frequency in addition to the base current compensation.

Fig. 6 shows a power-supply circuit in an embodiment in which switching-frequency compensation in conjunction with the base-current compensation provides satisfactory mains-voltage compensation. Identical parts bear the same reference numerals as in Fig. 1. The present embodiment does not comprise the resistor R_2 for measuring the primary current in the emitter line of the switching transistor T_1 . A series arrangement of a resistor R_{10} and a capacitor C_7 is arranged between the junction point of the secondary winding n_2 and the diode D_1 and the negative input-voltage terminal. A voltage divider comprising resistors R_{11} and R_{12} is arranged across the capacitor C_7 and has a tapping connected to the base of the control transistor T_2 . A

capacitor C_8 can be connected in parallel with the capacitor C_7 by means of a switch S_2 , which is actuated simultaneously with the switch S_1 . The operation of the circuit is explained with reference to Fig. 7, which shows the variation of the primary current and the voltage across the capacitor C_7 as a function of time during the forward interval for two different mains voltages. For the first mains voltage V_1 the primary current during the forward interval increases in accordance with the characteristic I in the Figure. As the primary current increases, the voltage across the secondary, causes the capacitor C_7 to be charged. The voltage across the capacitor C_7 varies in conformity with the characteristic II. The primary current is switched off at the instant t_1 at which the voltage across the capacitor C_7 has reached the level at which the control transistor T_2 is turned on via the voltage divider R_{11} , R_{12} and consequently the transistor T_1 is turned off. For the second mains voltage V_2 , which is approximately twice as high as the voltage V_1 , the primary current during the forward interval increases twice as fast, as indicated by the characteristic III. Therefore, the secondary voltage is doubled, so that the capacitor C_7 is also charged at a faster rate, as is apparent from the characteristic IV. However, since the charging of the capacitor C_7 is a non-linear process, the voltage across the capacitor C_7 will reach the level at which the primary current is turned off in less than half the time required in the case of the input voltage V_1 . In the present example, this time $t_2 = 0.4 t_1$. The maximum value of the primary current at the input voltage V_2 is therefore smaller than in the case of the input voltage V_1 . As the time during which the switching transistor T_2 is conductive decreases more than linearly at increasing input voltage, the maximum value of the primary current decreases as the input voltage increases. This compensates for the effect of the increasing switching frequency on the output current. It is to be noted that the voltage level across the capacitor C_7 at which the primary current is turned off can be adjusted by means of a resistor arranged in the emitter line of the control transistor T_2 .

Claims

1. A self-oscillating power-supply circuit for supplying a load with input voltages with different values, comprising a transformer with a primary winding and a secondary winding, which primary winding in series with the main-current path of a switching transistor (T_1) is arranged between two terminals to which the input voltage is to be applied, the switching transistor being turned off by means of a control transistor (T_2) depending on a current proportional to the input voltage, and which secondary winding in series with a diode (D_1) is arranged in parallel with the load, a positive feedback loop comprising a capacitor (C_1) in series with a first resistor (R_5) being arranged between one end of the secondary winding and the base of the switching

transistor, characterized in that the positive feedback loop further comprises a second resistor (R_4) in series with the capacitor (C_1) and the first resistor, a zener diode (Z_1) is arranged between a point on the connection between the first resistor (R_5) and the second resistor (R_4) and that end of the main current path of the switching transistor which is remote from the primary winding and the capacitor provides d.c. isolation between the said point and the secondary winding.

2. A self-oscillating power-supply circuit as claimed in Claim 1, characterized in that the circuit comprises compensation means coupled to a control electrode of the control transistor for supplying thereto a signal for turning-off the switching transistor at decreasing values of the current through the primary winding at increasing values of the input voltage.

3. A self-oscillating power-supply circuit as claimed in Claim 2, characterized in that the means comprise a third resistor (R_2) which is in series with the main-current path of the switching transistor and is connected to the one input-voltage terminal, which third resistor is coupled to the control electrode of the control transistor (T_2) via the collector-emitter path of a transistor (T_3) whose base is connected to the collector, the emitter, and the other input-voltage terminal by a fourth resistor (R_7), a fifth resistor (R_8), and a sixth resistor (R_9), respectively, which control electrode is connected to the one input-voltage terminal by a seventh resistor (R_6).

4. A self-oscillating power-supply circuit as claimed in Claim 2, characterized in that the means comprise a third resistor (R_2) which is in series with the main current path of the switching transistor and is connected to the one input-voltage terminal, which third resistor is coupled to the control electrode of the control transistor via the collector-emitter path of a transistor (T_3) whose base is connected to the collector and the emitter by a fourth resistor (R_7) and a fifth resistor (R_8), respectively, a second capacitor (C_6) being arranged in parallel with the fourth resistor.

5. A self-oscillating power-supply circuit as claimed in Claim 2, characterized in that the said one end of the secondary winding is connected to the one input-voltage terminal by the series arrangement of a eighth resistor (R_{10}) and a third capacitor (C_7), the junction point of said eighth resistor and said third capacitor being coupled to the control electrode of the control transistor (Fig. 6).

6. A self-oscillating power-supply circuit as claimed in Claim 5, characterized in that the control electrode of the control transistor is connected to the tapping of a voltage divider arranged in parallel with the second capacitor.

7. A self-oscillating power-supply circuit as claimed in any one of the preceding Claims, characterized in that the load is arranged in series with the main current path of the switching transistor.

capacitor C_8 can be connected in parallel with the capacitor C_7 by means of a switch S_2 , which is actuated simultaneously with the switch S_1 . The operation of the circuit is explained with reference to Fig. 7, which shows the variation of the primary current and the voltage across the capacitor C_7 as a function of time during the forward interval for two different mains voltages. For the first mains voltage V_1 , the primary current during the forward interval increases in accordance with the characteristic I in the Figure. As the primary current increases, the voltage across the secondary, causes the capacitor C_7 to be charged. The voltage across the capacitor C_7 varies in conformity with the characteristic II. The primary current is switched off at the instant t_1 at which the voltage across the capacitor C_7 has reached the level at which the control transistor T_2 is turned on via the voltage divider R_{11} , R_{12} and consequently the transistor T_1 is turned off. For the second mains voltage V_2 , which is approximately twice as high as the voltage V_1 , the primary current during the forward interval increases twice as fast, as indicated by the characteristic III. Therefore, the secondary voltage is doubled, so that the capacitor C_7 is also charged at a faster rate, as is apparent from the characteristic IV. However, since the charging of the capacitor C_7 is a non-linear process, the voltage across the capacitor C_7 will reach the level at which the primary current is turned off in less than half the time required in the case of the input voltage V_1 . In the present example, this time $t_2 = 0.4 t_1$. The maximum value of the primary current at the input voltage V_2 is therefore smaller than in the case of the input voltage V_1 . As the time during which the switching transistor T_2 is conductive decreases more than linearly at increasing input voltage, the maximum value of the primary current decreases as the input voltage increases. This compensates for the effect of the increasing switching frequency on the output current. It is to be noted that the voltage level across the capacitor C_7 at which the primary current is turned off can be adjusted by means of a resistor arranged in the emitter line of the control transistor T_2 .

Claims

1. A self-oscillating power-supply circuit for supplying a load with input voltages with different values, comprising a transformer with a primary winding and a secondary winding, which primary winding in series with the main-current path of a switching transistor (T_1) is arranged between two terminals to which the input voltage is to be applied, the switching transistor being turned off by means of a control transistor (T_2) depending on a current proportional to the input voltage, and which secondary winding in series with a diode (D_1) is arranged in parallel with the load, a positive feedback loop comprising a capacitor (C_1) in series with a first resistor (R_5) being arranged between one end of the secondary winding and the base of the switching

transistor, characterized in that the positive feedback loop further comprises a second resistor (R_4) in series with the capacitor (C_1) and the first resistor, a zener diode (Z_1) is arranged between a point on the connection between the first resistor (R_5) and the second resistor (R_4) and that end of the main current path of the switching transistor which is remote from the primary winding and the capacitor provides d.c. isolation between the said point and the secondary winding.

2. A self-oscillating power-supply circuit as claimed in Claim 1, characterized in that the circuit comprises compensation means coupled to a control electrode of the control transistor for supplying thereto a signal for turning-off the switching transistor at decreasing values of the current through the primary winding at increasing values of the input voltage.

3. A self-oscillating power-supply circuit as claimed in Claim 2, characterized in that the means comprise a third resistor (R_2) which is in series with the main-current path of the switching transistor and is connected to the one input-voltage terminal, which third resistor is coupled to the control electrode of the control transistor (T_2) via the collector-emitter path of a transistor (T_3) whose base is connected to the collector, the emitter, and the other input-voltage terminal by a fourth resistor (R_7), a fifth resistor (R_6), and a sixth resistor (R_9), respectively, which control electrode is connected to the one input-voltage terminal by a seventh resistor (R_8).

4. A self-oscillating power-supply circuit as claimed in Claim 2, characterized in that the means comprise a third resistor (R_2) which is in series with the main current path of the switching transistor and is connected to the one input-voltage terminal, which third resistor is coupled to the control electrode of the control transistor via the collector-emitter path of a transistor (T_3) whose base is connected to the collector and the emitter by a fourth resistor (R_7) and a fifth resistor (R_6), respectively, a second capacitor (C_2) being arranged in parallel with the fourth resistor.

5. A self-oscillating power-supply circuit as claimed in Claim 2, characterized in that the said one end of the secondary winding is connected to the one input-voltage terminal by the series arrangement of a eighth resistor (R_{10}) and a third capacitor (C_7), the junction point of said eighth resistor and said third capacitor being coupled to the control electrode of the control transistor (Fig. 6).

6. A self-oscillating power-supply circuit as claimed in Claim 5, characterized in that the control electrode of the control transistor is connected to the tapping of a voltage divider arranged in parallel with the second capacitor.

7. A self-oscillating power-supply circuit as claimed in any one of the preceding Claims, characterized in that the load is arranged in series with the main current path of the switching transistor.



Patentansprüche

1. Selbstschwingende Versorgungsschaltung zum Speisen einer Belastung aus Eingangsspannungen mit verschiedenen Werten, die einen Transformator mit einer Primär- und einer Sekundärwicklung enthält, dessen Primärwicklung mit dem Hauptstromweg eines Schalttransistors (T_1) zwischen zwei Klemmen zum Zuführen der Eingangsspannung in Reihe geschaltet ist, wobei der Schalttransistor abhängig von einem der Eingangsspannung proportionalen Strom mit Hilfe eines Steuertransistors (T_2) abgeschaltet wird, und die Sekundärwicklung mit einer Diode (D_1) parallel zur Belastung in Reihe geschaltet ist, wobei zwischen einem Ende der Sekundärwicklung und der Basis der Schalttransistors eine positive Rückkopplung angeordnet ist, die die Reihenschaltung eines Kondensators (C_1) und eines ersten Widerstandes (R_5) enthält, dadurch gekennzeichnet, daß in Reihe mit dem Kondensator (C_1) und dem ersten Widerstand die positive Rückkopplung weiter mit einem zweiten Widerstand (R_4) versehen und zwischen dem Verbindungspunkt des ersten (R_5) und des zweiten Widerstandes (R_4) und dem von der Primärwicklung abgewandten Ende des Hauptstromwegs des Schalttransistors eine Zenerdiode (Z_1) angeordnet ist, wobei der Verbindungspunkt durch den Kondensator gleichstrommäßig von der Sekundärwicklung entkoppelt ist.

2. Selbstschwingende Versorgungsschaltung nach Anspruch 1, dadurch gekennzeichnet, daß die Schaltung ein an eine Steuerelektrode des Steuertransistors angeschlossenes Ausgleichmittel enthält, um bei abfallenden Werten des Stroms durch die Primärwicklung bei ansteigenden Werten der Eingangsspannung ein Signal zum Abschalten des Schalttransistors zu liefern.

3. Selbstschwingende Versorgungsschaltung nach Anspruch 2, dadurch gekennzeichnet, daß das Mittel einen dritten Widerstand (R_2) enthält, der in Reihe mit dem Hauptstromweg des Schalttransistors mit der einen Klemme der Eingangsspannung verbunden ist, wobei der dritte Widerstand über den Kollektor-Emitterweg eines Transistors (T_3), dessen Basis durch einen vierten (R_7), einen fünften (R_6) bzw. einen sechsten Widerstand (R_9) an den Kollektor, den Emitter und die andere Klemme der Eingangsspannung angeschlossen ist, mit der Steuerelektrode des Steuertransistors (T_2) verbunden ist, wobei die Steuerelektrode mittels eines siebten Widerstandes (R_8) an die eine Klemme der Eingangsspannung angeschlossen ist.

4. Selbstschwingende Versorgungsschaltung nach Anspruch 2, dadurch gekennzeichnet, daß das Mittel einen dritten Widerstand (R_2) enthält, der in Reihe mit dem Hauptstromweg des Schalttransistors geschaltet und an die eine Klemme der Eingangsspannung angeschlossen ist, wobei dieser dritte Widerstand mit der Steuerelektrode des Steuertransistors über den Kollektor-Emitterweg eines Transistors (T_3) verbunden ist, dessen Basis an den Kollektor und den Emitter über einen

vierten Widerstand (R_7) bzw. einen fünften Widerstand (R_6) angeschlossen ist, wobei ein zweiter Kondensator (C_6) parallel zum vierten Widerstand angeordnet ist.

5. Selbstschwingende Versorgungsschaltung nach Anspruch 2, dadurch gekennzeichnet, daß das eine Ende der Sekundärwicklung an die eine Klemme der Eingangsspannung durch die Reihenschaltung eines achten Widerstandes (R_{10}) und eines dritten Kondensators (C_7) angeschlossen ist, wobei der Verbindungspunkt des achten Widerstandes und des dritten Kondensators mit der Steuerelektrode des Steuertransistors verbunden ist (Fig. 6).

6. Selbstschwingende Versorgungsschaltung nach Anspruch 5, dadurch gekennzeichnet, daß die Steuerelektrode des Steuertransistors mit dem Abzweig eines Spannungsteilers verbunden ist, der parallel zum zweiten Kondensator angeordnet ist.

7. Selbstschwingende Versorgungsschaltung nach einem der vorangehenden Ansprüche, dadurch gekennzeichnet, daß die Belastung in Reihe mit dem Hauptstromweg des Schalttransistors angeordnet ist.

Revendications

1. Circuit d'alimentation auto-oscillant pour alimenter une charge de tensions d'entrée de valeurs différentes, comportant un transformateur muni d'un enroulement primaire et d'un enroulement secondaire, enroulement primaire qui, en série avec le trajet de courant principal d'un transistor de commutation (T_1), est disposé entre deux bornes servant à recevoir la tension d'entrée, le transistor de commutation étant bloqué par un transistor de commande (T_2) en fonction d'un courant proportionnel à la tension d'entrée, et enroulement secondaire qui, en série avec une diode (D_1), est disposé en parallèle avec la charge, une boucle de réaction positive comportant un condensateur (C_1) en série avec une première résistance (R_5) étant disposée entre l'une des extrémités de l'enroulement secondaire et la base du transistor de commutation, caractérisé en ce que la boucle de réaction positive comporte en outre une deuxième résistance montée en série avec le condensateur (C_1) et la première résistance, et en ce qu'une diode Zener (Z_1) disposée entre, d'une part, un point dans la liaison entre la première (R_5) et la deuxième (R_4) résistance et, d'autre part, l'extrémité du trajet de courant principal du transistor de commutation située à l'opposé de l'enroulement primaire, ledit condensateur assurant la séparation en courant continu entre ledit point et l'enroulement secondaire.

2. Circuit d'alimentation auto-oscillant selon la revendication 1, caractérisé en ce qu'il comporte des moyens de compensation couplés à une électrode de commande du transistor de commande pour appliquer à celui-ci un signal pour bloquer le transistor de commutation à des valeurs décroissantes du courant à travers l'en-



roulement primaire, dues à des valeurs croissantes de la tension d'entrée.

3. Circuit d'alimentation auto-oscillant selon la revendication 2, caractérisé en ce que les moyens comportent une troisième résistance (R_2) disposée en série avec le trajet de courant principal du transistor de commutation et reliée à une première borne de tension d'entrée, troisième résistance qui est couplée à l'électrode de commande du transistor de commande (T_2) à travers le trajet de collecteur-émetteur d'un transistor (T_3) dont la base est reliée au collecteur, à l'émetteur et à l'autre borne de tension d'entrée respectivement par des quatrième (R_7), cinquième (R_8) et sixième (R_9) résistances, électrode de commande qui, par une septième résistance (R_6) est reliée à la première borne de tension d'entrée.

4. Circuit d'alimentation auto-oscillant selon la revendication 2, caractérisé en ce que les moyens comportent une troisième résistance (R_2) disposée en série avec le trajet de courant principal du transistor de commutation et reliée à la première borne de tension d'entrée, troisième résistance qui est couplée à l'électrode de commande du transistor de commande à travers le trajet de

collecteur-émetteur d'un transistor (T_3) dont la base est reliée au collecteur et à l'émetteur respectivement par une quatrième (R_7) et une cinquième (R_8) résistance, un deuxième condensateur (C_6) étant disposé en parallèle avec la quatrième résistance.

5. Circuit d'alimentation auto-oscillant selon la revendication 2, caractérisé en ce que ladite extrémité de l'enroulement secondaire est reliée à la première borne de tension d'entrée par le montage série d'une huitième résistance (R_{10}) et d'un troisième condensateur (C_7), le point commun à ladite huitième résistance et audit troisième condensateur étant couplé à l'électrode de commande du transistor de commande (Figure 6).

6. Circuit d'alimentation auto-oscillant selon la revendication 5, caractérisé en ce que l'électrode de commande du transistor de commande est reliée à la prise d'un diviseur de tension disposé en parallèle avec le deuxième condensateur.

7. Circuit d'alimentation auto-oscillant selon l'une quelconque des revendications précédentes, caractérisé en ce que la charge est disposée en série avec le trajet de courant principal du transistor de commutation.

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