

POWER SWITCH CONTROL CIRCUIT,
E.G. FOR TELEVISION APPARATUS

This invention relates to a power switching circuit such as for deflection scanning in television.

5 Generally, a T.V. horizontal scanning circuit applies a pulse signal from a horizontal oscillation circuit to the base or control electrode of a horizontal power transistor that operates as a switch. The collector of the horizontal power transistor is connected
10 in series with the primary winding of a flyback transformer. The turning on and off of the horizontal power transistor in response to the pulse signal from the horizontal oscillation circuit causes a scanning current flow in a horizontal deflection winding.

15 According to the present invention, a switching apparatus for switching an output current, such as a deflection current for horizontal scanning in television apparatus, comprises a power transistor switch for switching said output current in said inductive load;
20 a source of an input signal at an input rate; a control circuit for operating said switch at said input rate, said control circuit comprising: a source of reverse biasing voltage; a control switch coupled to said source of reverse biasing voltage and to the base of said power transistor switch; and an inductance coupled to said
25 control switch. The control switch is responsive to said input signal for coupling said reverse biasing voltage to said power transistor switch during a first interval of a given period of said input signal to turn off said power transistor switch, said reverse biasing voltage being
30 applied to said inductance to generate inductive current therein during said first interval. The control switch decouples said reverse biasing voltage from said power transistor switch and enables said inductive current to
35 flow in said inductance in the same direction after said reverse biasing voltage is decoupled and into the base of said power transistor switch that turns on said power transistor switch after said first interval during a second interval of said given period.

In the accompanying drawings:

FIGURE 1 illustrates a deflection circuit embodying the invention and also the invention of application No. 8904389 divided herefrom:

5 FIGURES 2a-2c illustrate waveforms useful in explaining the normal operation of the circuit of FIGURE 1; and

 FIGURES 3a-3c illustrate waveforms useful in explaining the start-up operation of the circuit of FIGURE 10 1.

 In a deflection circuit 200, illustrated in the FIGURE 1, that may be used in a double frequency scanning format television system, a filtered DC voltage V_B at a terminal 48 is supplied by a power supply 45 that is 15 separate from circuit 200 and that may be of the switched mode type. Terminal 48 is coupled through primary winding 53a of a horizontal output or flyback transformer 53 to a terminal 90 of horizontal deflection circuit 200. A horizontal deflection winding 81 is coupled to horizontal 20 deflection generator 86 for generating scanning current i_y in deflection winding 81. Generator 86 comprises a linearity inductor 83 in series with a trace capacitor 62 and in series with a parallel arrangement of a retrace capacitor 80, and a trace switch 87. Trace switch 87 25 includes the parallel arrangement of a horizontal output power transistor 88 having a control electrode and a damper diode 89.

 A high voltage winding 53c of flyback transformer 53 is coupled to a conventional high voltage 30 circuit 63 for developing an ultor accelerating potential.

 A synchronized horizontal oscillator and predriver circuit 85, that is energized by a voltage V_{HO}

of power supply 45, provides through a capacitor C_0 a switching control signal voltage V_{84b} , that appears as a square wave superimposed on a negative direct current voltage, to the control base electrode of a transistor switch 84. The period of voltage V_{84b} is $H/2$, where $H/2$ represents one line scan interval in a $2f_H$ deflection system. Note that H is the conventional horizontal period of e.g. 63.5 microseconds in NTSC systems.

When voltage V_{84b} forward-biases the base-emitter junction of transistor switch 84, in accordance with a first level of the superimposed square wave, transistor switch 84 is conductive. Conversely, when voltage V_{84b} back-biases the base-emitter junction, in accordance with the other, or second, level of the superimposed square wave, transistor switch 84 is non-conductive. The emitter electrode of transistor switch 84 is coupled to a negative pull-down voltage source V_{NEG} . The collector electrode of transistor switch 84 is coupled through a current limiting resistor 91 to the base electrode of horizontal output power transistor 88. A terminal 46 of a secondary winding 53b of flyback transformer 53 is coupled through a current limiting resistor 92 to a terminal 82b of an inductor 82. A terminal 47, the other end terminal of inductor 82, is coupled at the junction between resistor 91 and the collector electrode of transistor switch 84.

In normal operation, deflection switch 87 is conductive during the trace interval. When deflection switch 87 is conductive, it isolates transformer 53 from deflection winding 81. An upramping primary current i_2 in primary winding 53a increases the energy stored in flyback transformer 53 during the trace interval. This stored energy replenishes losses in deflection generator 86 and energizes high voltage circuit 63, when switch 87 is made non-conductive during the retrace interval. Deflection winding 81 forms with transformer 53, and with retrace capacitor 80 a retrace resonant circuit. The energy stored in transformer 53 and deflection winding 81, during

the trace interval, is transferred into retrace capacitor 80 to produce a retrace voltage V_R across capacitor 80, during the retrace interval, that is illustrated in FIGURE 2c.

5 The voltage across primary winding 53a is coupled by transformer action to secondary winding 53b for developing a voltage V_S at terminal 46. During the trace interval, voltage V_S is positive. During the retrace interval, voltage V_S is negative. Negative voltage V_S occurs when retrace voltage V_R at terminal 90 is more positive than voltage V_B at terminal 48.

10 - Positive voltage V_S , across secondary winding 53b, causes the flow of an upramping current i_s in inductor 82, as illustrated in FIGURE 2a, from time t_{re} , at the end of retrace, to time t_0' , at the end of trace.

15 During a first portion of trace, transistor switch 84 of FIGURE 1 is conductive, in accordance with the occurrence of the first level of the waveform of voltage V_{84b} . Therefore, voltage V_{84c} at terminal 47 of inductor 82 is negative and substantially equal to voltage V_{NEG} . During the first portion of trace, from time t_{re} to time t_1 of FIGURE 2a, power transistor 88 of FIGURE 1 is non-conductive because voltage V_{84c} , that is coupled to its base electrode, is negative. Negative voltage V_{84c} causes the rate of increase of current i_s of FIGURE 2a to be higher during the interval $t_{re}-t_1$. Simultaneously, deflection current i_y of FIGURE 1 flows through damper diode 89.

25 Prior to the center of the trace interval, voltage V_{84b} at the base electrode of transistor switch 84 becomes more negative when the transition from the first to the second level of the superimposed square wave occurs, causing transistor switch 84 to be non-conductive. When transistor switch 84 is non-conductive, current i_s flows entirely to the base electrode of power transistor 88 in the form of base electrode current i_b , thus causing the conduction, or turn-on, of power transistor 88. Afterward, during the rest of trace, current i_b , or i_s , as

illustrated in FIGURE 2b or 2a, respectively, between times t_1 and t_0' , continues to ramp up because of positive voltage V_S of FIGURE 1 at terminal 46 of secondary winding 53b. Upramping current i_b of FIGURE 2b provides the base electrode drive for sustaining the corresponding upramping current in the collector electrode of power transistor 88 of FIGURE 1.

Near the end of trace interval, voltage V_{84b} at the base electrode of transistor 84 becomes more positive, causing transistor switch 84 to become conductive. Conduction of transistor switch 84 couples voltage $V_{NEG'}$ that is generated by power supply 45, to terminal 47 for producing voltage V_{84c} that is negative. Negative voltage V_{84c} at terminal 47 produces a negative base electrode current i_b in power transistor 88, having a peak of -4A as illustrated in FIGURE 2b, resulting in a fast turn-off of power transistor 88 to thereby initiate the retrace interval. Thus, current i_b rapidly sweeps out the charge from the base electrode, to render power transistor 88 non-conductive. When switch 84 is conductive, it shunts current i_s away from the base electrode of power transistor 88. Retrace voltage V_R across capacitor 80 is developed when power transistor 88 becomes non-conductive. Voltage V_{84c} has a negative average direct current voltage component. Resistor 92 limits the direct current component of current i_s that is caused by voltage V_{84c} .

Prior to the beginning time of a start-up interval, none of transformer 53, winding 81 and capacitors 62 and 80 is energized. Assume, illustratively, that prior to the beginning of the start-up interval, voltages V_{H0} and V_{NEG} of power supply 45 are at their respective normal operating levels, that voltage V_{84b} has the normal operating waveform, and voltage V_B is turned on at the beginning of the start-up interval. At the beginning of start-up, there is no voltage V_S available across flyback transformer winding

53b for generating positive current i_b to switch on power transistor 88 at the initiation of start-up.

During the start-up interval, current i_s is generated in inductor 82 by the switching operation of transistor switch 84 that couples voltage V_{NEG} to terminal 47. During the start-up interval, when transistor switch 84 is conductive, voltage V_{84c} is negative, in accordance with the occurrence of the first level of the square wave voltage V_{84b} . The voltage at terminal 82b is more positive than that at terminal 84c because terminal 82b is coupled to ground potential through winding 53b. Furthermore, at start-up, no voltage is being developed across winding 53b. Therefore, inductive current i_s in inductor 82 flows into junction terminal 47 in an upramping manner during start-up when transistor 84 is conductive. Upramping current i_s stores inductive energy in inductor 82.

FIGURES 3a-3c illustrate waveforms obtained when voltage V_B of power supply 45 is zero, so as to simulate the beginning of the start-up operation. The other voltages of power supply 45 are at the normal levels, respectively. Similar numerals and symbols in FIGURES 1, 2a-2c and 3a-3c indicate similar items or functions.

As illustrated in FIGURE 3a, between times t_0 and t_1 , the interval when transistor 84 is conductive, current i_s is upramping. When transistor switch 84 of FIGURE 1 becomes non-conductive, in accordance with the occurrence of the second level of the square wave voltage V_{84b} , current i_s that results from the stored magnetic energy in inductor 82 is a downramping current that is diverted to the base electrode of power transistor 88 to form positive base electrode current i_b , as illustrated in FIGURE 3b between times t_1 and t_0' . Positive base electrode current i_b of FIGURE 3b causes power transistor 88 of FIGURE 1 to be conductive by developing a positive base voltage V_{bs} of FIGURES 1 and 3c between times t_1 and t_0' . When voltage V_B begins to be developed, after the initiation of start-up, alternating periods of conduction

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and non-conduction of power transistor 88 of FIGURE 1 initiate normal deflection circuit switching operation, thereby generating deflection rate voltage V_s . After voltage V_s is generated, the normal switching drive to horizontal output transistor 88, illustrated in Figure 2b, can take place.

It should be understood that an arrangement similar to that of deflection circuit 200 of FIGURE 1, in which deflection winding 81 is replaced by an inductor, may be used as part of a switching power supply that generates output voltages from an arrangement similar to high voltage circuit 63. The operating frequency of the switching power supply power transistor may be the deflection frequency or a multiple thereof when the power supply is provided in television apparatus.



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CLAIMS:

1. Switching apparatus for switching an output current comprising:
an inductive load;
a power transistor switch for switching said output current in said inductive load;
a source of an input signal at an input rate;
a control circuit for operating said switch at said input rate, said control circuit comprising:
a source of reverse biasing voltage;
a control switch coupled to said source of reverse biasing voltage and to the base of said power transistor switch;
an inductance coupled to said control switch, said control switch being responsive to said input signal for coupling said reverse biasing voltage to said power transistor switch during a first interval of a given period of said input signal to turn off said power transistor switch, said reverse biasing voltage being applied to said inductance to generate inductive current therein during said first interval, wherein said control switch decouples said reverse biasing voltage from said power transistor switch and enables said inductive current to flow in said inductance in the same direction after said reverse biasing voltage is decoupled and into the base of said power transistor switch that turns on said power transistor switch after said first interval during a second interval of said given period.

2. Apparatus according to Claim 1, in which said load comprises:
a resonant circuit coupled to said power transistor switch for generating an output current that is switched at said input rate by said power transistor switch and for generating a voltage at said input rate;
and



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means responsive to said voltage and coupled to said base electrode of said power transistor switch for generating in said base electrode current that causes said switch to be conductive at said input rate and that has a magnitude that, in each period of said input signal, is progressively increasing as long as said power transistor switch is conductive.

3. Apparatus as recited in Claim 2, wherein said current generating means comprises a transformer coupled to said power transistor switch for generating at a first terminal thereof a first voltage at said input rate that is at a first polarity when said power transistor switch is conductive.

4. Apparatus as recited in Claim 2, wherein said resonant circuit includes an inductance, said inductance generating a switch current that flows in a first direction in said power transistor switch during a portion of each period of said input signal, wherein said switch current is of a progressively increasing magnitude during substantially the entire interval that occurs when said switch conducts said switch current in said first direction.

5. Apparatus as recited in any preceding claim being a television apparatus wherein said load comprises a deflection winding and a retrace capacitance of a horizontal deflection circuit.
