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REPLY TO ATTN OF: GP

TO: USI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U. S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code USI, the attached NASA-owned U. S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U. S. Patent No. : 3,566,158

Government or Corporate Employee : Westinghouse Electric Corp Lima, Ohio 45802

Supplementary Corporate Source (if applicable) :

NASA Patent Case No. : LEW-10233

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:
Yes ☒ No ☐
Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of Column No. 1 of the Specification, following the words ". . . with respect to an invention of . . . "

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Enclosure
Copy of Patent cited above

FACILITY FORM 602

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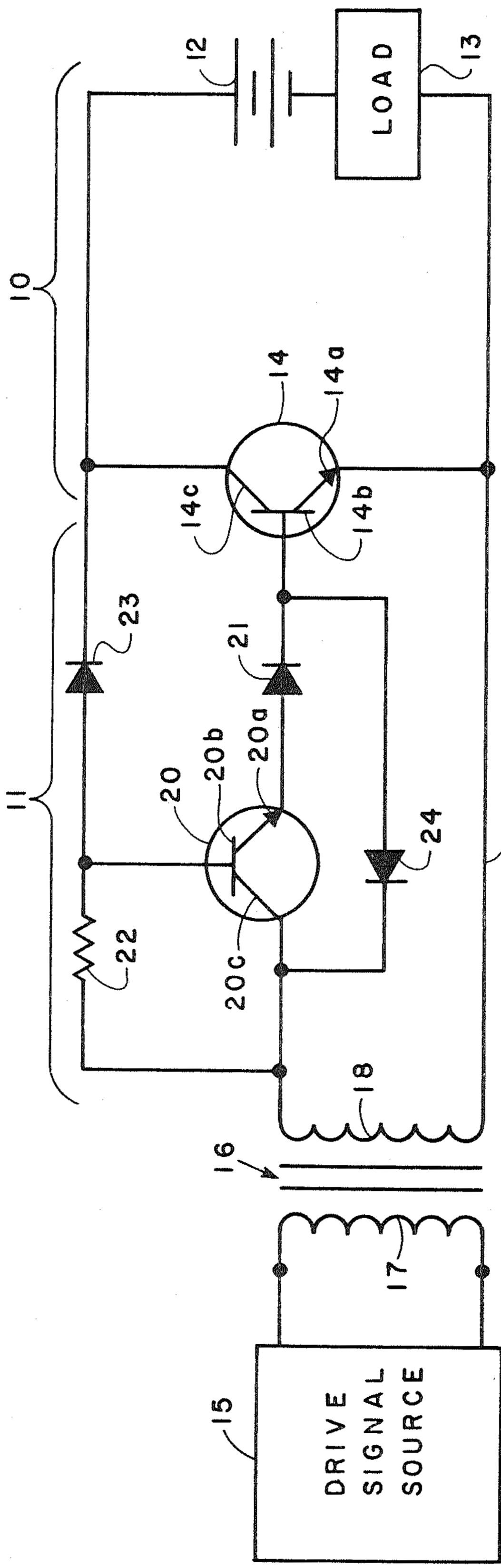

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United States Patent

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[54] **TRANSISTOR DRIVE REGULATOR**
6 Claims, 1 Drawing Fig.

[52] U.S. Cl. 307/253, 307/300
[51] Int. Cl. H03k 17/04
[50] Field of Search 307/254, 280, 300, 253

[56] **References Cited**

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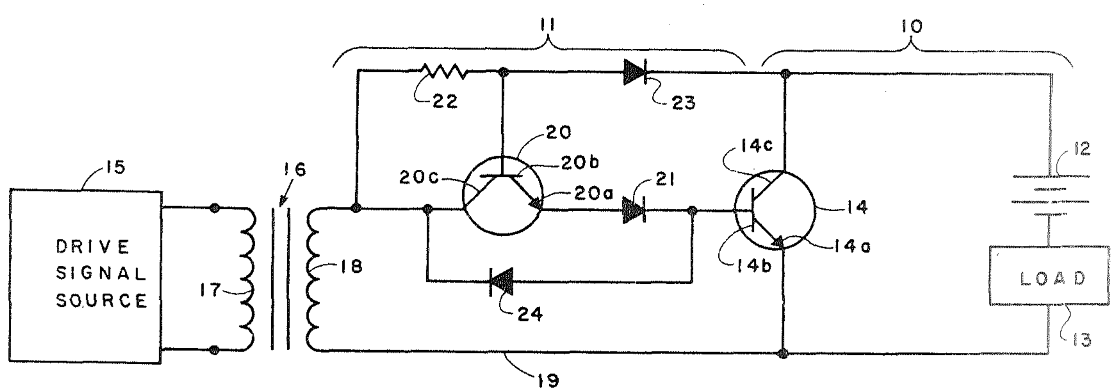
ABSTRACT: A drive circuit for a semiconductor switch has a variable conducting means connected between a drive signal source and the switch. The variable conducting means is connected in controlled relationship to the driving source through a voltage dropping means and drive current diverting means bypasses some drive current around the variable conducting means. Means for decreasing the turnoff time of the switch is also provided.



TRANSISTOR DRIVE REGULATOR

ORIGIN OF THE INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85—568 (72 Stat. 435, 42 U.S.C. 2457).

BACKGROUND OF THE INVENTION

This invention relates to electrical power circuits and is directed more particularly to semiconductor switching circuits as exemplified by DC to AC inverter circuits.

The major requirement for fulfill inverter circuit is that the switching times of the power switching semiconductors coincide as nearly as possible with the switching times of the driving voltage being supplied thereto. To fulfill this requirement the power transistors in inverter circuits must be driven with a high current base drive during turn-on, be strongly reverse biased at turnoff, and be operated slightly below saturation to minimize turnoff delay time. Furthermore, in order to maintain reasonable efficiency at low power output levels, it is necessary for the power dissipation in the driver circuit to be directly proportional to the output current of the inverter.

In some inverter circuits of the prior art, a resistance or other voltage dropping element was connected between the base electrode of each power transistor and its associated drive signal source. Such a circuit configuration fulfills substantially all the requirements for transistor inverter circuits set forth above except that dissipation in the drive circuit is not proportional to the power output current. In order to overcome the lack of direct proportionality between the power output current and the power dissipation of the drive circuit, the prior art in some cases added a positive feedback winding to the drive transformer interposed between the driving source and the power transistor. This scheme is not fully satisfactory, however, because the voltage on the feedback winding adds to the drive voltage. As a result of this additional voltage, the drive transformer may saturate under high output load current conditions causing undesirable distortion of the output wave form. This is particularly true where the drive signal is a variable pulse width voltage.

OBJECTS OF THE INVENTION

Accordingly, it is an object of the invention to provide a high efficiency semiconductor switching circuit having high input signal drive to a switching element which advantageously operates below saturation during its conducting period.

It is another object of the invention to provide a semiconductor switching circuit in which the drive voltage applied to the drive transformer is determined solely by the drive signal source.

Still another object of the invention is to provide a circuit of the above type in which the drive transformer may be of minimum size and yet will not saturate under high output load current conditions.

It is a further object of the invention to provide a semiconductor switching circuit having a drive regulator circuit which maintains power dissipation in the drive circuit at a magnitude directly proportional to the output load current of the inverter without the need for a feedback winding on the drive transformer.

Other objects and advantages of the invention will become apparent from the following description and drawings in which the single FIG. is a schematic diagram of a switching circuit constructed in accordance with the invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring now to the schematic diagram, it will be seen that a switching circuit embodying the invention may include in

general a power switching circuit **10** and a drive circuit **11**. The power switching circuit **10** may include, by way of example, a DC source **12**, a load **13** to be energized, and an NPN type transistor **14** having emitter, base, and collector electrodes **14*a***, **14*b***, and **14*c***, respectively. The DC source **12** and the load **13** are serially connected between the collector electrode **14*c*** and the emitter electrode **14*a*** of transistor **14**, as shown. Each time that the transistor **14** conducts substantially the full voltage of the DC source **12** is applied across the load **13**. Consequently, by operating the transistor **14** in a switching mode, voltage pulses of rectangular wave shape are applied to the load **13**.

In order to operate the transistor **14** in a switching mode, drive signal such as a square wave or quasi wave voltage, is supplied to the drive circuit **11** from a drive signal source **15** via a drive transformer **16** having a primary winding **17** and a secondary winding **18**. The primary winding **17** is connected to the drive signal source to receive a drive signal therefrom. The lower end of the secondary winding **18** of the drive transformer **16**, as viewed in the schematic, is connected to the emitter electrode **14*a*** of transistor **14** by means of a load **19** while the upper end is connected to a collector electrode **20*c*** of an NPN type transistor **20**. An emitter electrode **20*a*** of the transistor **20** is connected to the base electrode **14*b*** of transistor **14** through a voltage dropping means such as diode **21**. The diode **21** drops some of the drive voltage applied to the base electrode **14*b*** of the transistor **14** and thereby determines the conduction of and the voltage drop across transistor **14** when it is turned on. It will be understood that additional diodes may be connected in series with diode **21** if desired.

As indicated previously, for a switching circuit to operate with high efficiency at low output load current magnitudes, it is necessary that power dissipation in the driving circuit be directly proportional to the load current. Accordingly, the conduction of transistor **20** must be varied to appropriately regulate the drive current. To this end, a voltage dropping means such as resistor **22** is connected between the upper end of the secondary winding **18** of the drive transformer **16** and a base electrode **20*b*** of the transistor **20** to serve as bias means for that transistor. A diode **23** which may be termed a drive current diverting means is connected between the base electrode **20*b*** of transistor **20** and the collector electrode **14*c*** of the transistor **14** serves to direct some drive current away from the base electrode **14*b*** of the transistor **14** as the voltage across that transistor drops when it turns on. This diversion of base current advantageously serves to prevent the transistor **14** from saturating so that it can be rapidly turned off.

For the purpose of further decreasing turnoff time of the transistor **14** at the end of its conducting period, a diode **24** is connected between the base electrode **14*b*** of the transistor **14** and the collector electrode **20*c*** of transistor **20** which, as shown in the schematic, is electrically common with the upper end of the secondary winding **18** of the drive transformer **16**. The diode **24** establishes a path whereby a strong reverse bias is applied to the transistor **14** when the polarity of voltage on the secondary winding **18** is such as to render the transistor **14** nonconducting.

Assuming now that the drive signal source has just reversed polarity and that the upper end of the secondary winding **18** of the drive transformer **16** is positive with respect to its lower end, a positive potential will be applied to the base electrode **20*b*** of the transistor **20** through the resistor **22**. This forward biases the transistor **20** to such an extent that it could pass several times the magnitude of drive current available from the secondary winding **18**. This high conduction capability of the transistor **20** causes rapid turn-on of the transistor **14** because all available drive current from the drive current source is directed to the transistor **14**. With the transistor **20** conducting, current flows from the upper end of the secondary winding **18** through the collector-emitter path of the transistor **20**, the diode **21**, the base-emitter path of the transistor **14** and then through the lead **19** to the lower end of the secondary winding **18** causing transistor **14** to conduct.

When the transistor **14** switches from a nonconducting condition to a conducting state as just described, the voltage between the collector electrode **14c** and the emitter electrode **14a** drops to a low level so that substantially all of the voltage of the DC source **12** appears across the load **13**. As the conduction of the transistor **14** increases and the voltage across it decreases, some drive current is diverted away from the collector-emitter path of the transistor **20** flowing from the collector **20c** through the base electrode **20b**, and then through the diode **23** which serves as a drive current diverting means. From the diode the diverted current flows through the collector emitter path of the transistor **14**. By this diversion of a portion of the drive current away from the base electrode **14b** of the transistor **14**, the transistor is prevented from saturating so that it will turn off rapidly when the voltage on the secondary winding **18** reverses.

When the voltage of the drive signal source reverses polarity causing the upper end of the secondary winding **18** to become more negative than the lower end, the transistor **20** ceases conducting because of the negative bias applied to its base electrode **20b** through the resistor **22**. This terminates the drive current being supplied to the base electrode **14b** of the transistor **14** so that transistor **14** will begin to turnoff. The turnoff time is advantageously shortened by the diode **24** which enables a strong reverse bias to be applied to the transistor **14**. When the drive signal source again switches, the on-off conduction cycle of the transistor **14** will be repeated.

It will be understood that the foregoing circuitry may be changed or modified without departing from the spirit and scope of the invention as set forth in the claims appended hereto. For example, PNP type transistors may be substituted for the NPN types utilized in the circuitry of the invention.

We claim:

1. In a drive circuit for regulating the drive current being supplied from a drive signal source to a current switching device having first and second power electrodes and a control electrode, a DC source and a load being serially connected between said first and second electrodes, in combination:
   - variable conducting means connected between said drive signal source and said control electrode of said switching device to regulate said drive current;
   - bias means connected operatively to said variable conducting means and in signal receiving relationship to said drive signal source to render said variable conducting means conducting when said drive signal is of a first polarity;
   - drive current diverting means connected between said variable conducting means and said second power electrode of said switching device to direct a portion of said drive current through said power electrodes of said switching device whereby said switching device is prevented from saturating;
   - a transformer having a primary winding connected to said drive signal source and a secondary winding connected to said drive circuit;
   - voltage dropping means connected between said variable conducting means and said control electrode of said switching element; and
   - a unidirectional current conducting device connecting between said secondary winding of said transformer and said control electrode of said switching device, said unidirectional current conducting device being poled to allow current flow in a direction away from said control electrode of said switching means.

2. The drive circuit set forth in claim **1** wherein said variable conducting means is a transistor having a collector electrode connected to one end of said secondary winding of said transformer an emitter electrode connected to said control electrode of said switching device and a base electrode connected to said bias means, said bias means comprising a resistor connected between said collector electrode and said base electrode of said transistor, the other end of said secondary winding being connected to said first electrode of said current switching device.

3. The circuit of claim **2** wherein said drive current diverting means comprises a unidirectional conducting means connected between said base electrode of said transitor and said second power electrode of said switching device, said unidirectional conducting means being poled to allow current to flow away from said base electrode.

4. The circuit set forth in claim **2** wherein said drive current diverting means comprises a diode connected between said base electrode of said transistor and said second power electrode of said switching device, said diode being poled to pass current from said base electrode to said second power electrode of said switching device.

5. The circuit set forth in claim **4** and including at least a second diode connected between said emitter electrode of said transistor and said control electrode of said switching device, said second diode being poled to pass current in a direction toward said control electrode.

6. The circuit set forth in claim **5** and including a third diode connected between said collector electrode of said transistor and said control electrode of said switching device, said third diode being poled to pass current in a direction away from said control electrode.