

- [54] VOLTAGE REGULATOR HAVING A
CONSTANT CURRENT CONTROLLED,
CONSTANT VOLTAGE REFERENCE
DEVICE**

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[75] Inventor: **Michael John Gay**, Scottsdale, Ariz.

[73] Assignee: **Motorola, Inc.**, Franklin Park, Ill.

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abandoned.
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322/22 Z; 323/38
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- [58] Field of Search 323/22 T, 22 Z, 34, 36,
323/38, 4, 9, 16; 307/299 B, 297, 296

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Primary Examiner—Gerald Goldberg

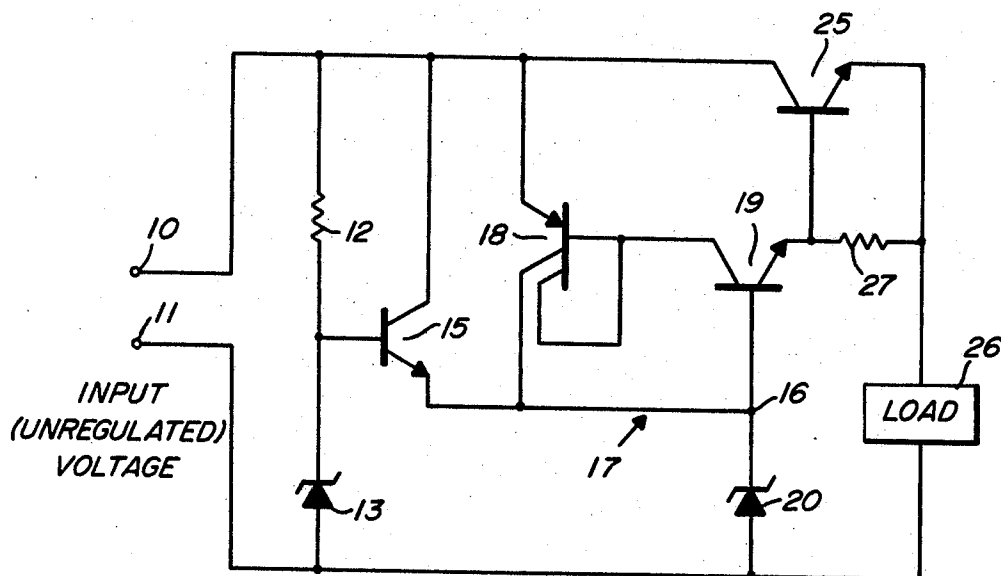
Attorney, Agent, or Firm—Vincent J. Rauner; Maurice J. Jones Jr.; Michael D. Bingham

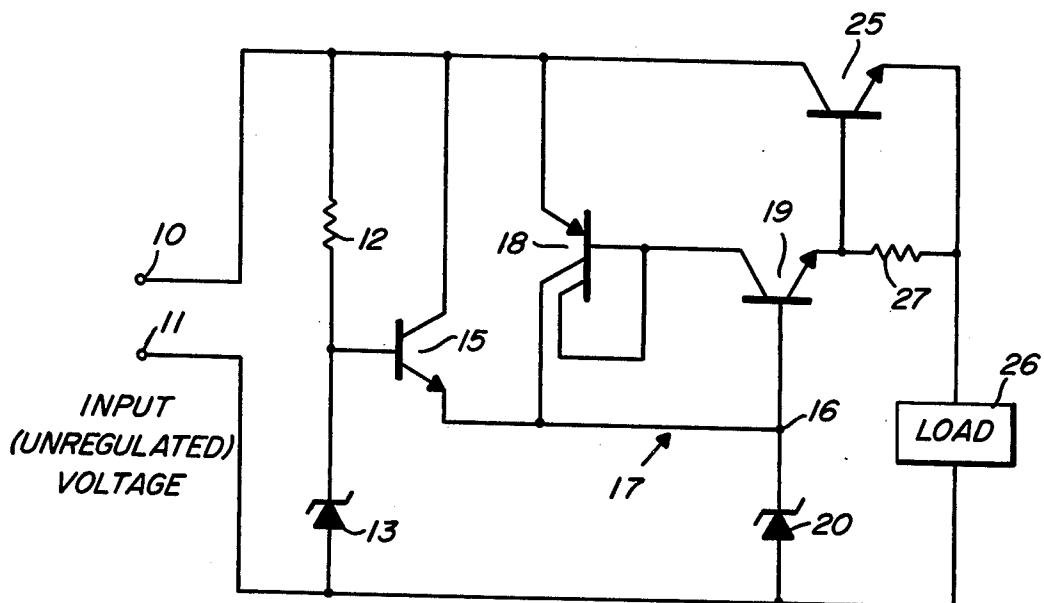
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ABSTRACT

A feedback loop, including a low beta transistor and a second transistor with the bases connected to the collectors to form a loop, is utilized to provide a flow of current to a zener diode to maintain a reference voltage thereacross. The feedback loop is so arranged that said current is substantially constant in normal operation and is virtually independent of the supply voltage applied to the circuit.

13 Claims, 1 Drawing Figure





VOLTAGE REGULATOR HAVING A CONSTANT CURRENT CONTROLLED, CONSTANT VOLTAGE REFERENCE DEVICE

This is a continuation of application Ser. No. 308,221, filed Nov. 20, 1972, now abandoned.

BACKGROUND OF THE INVENTION

The present invention pertains to voltage regulators adapted to receive an unregulated voltage input and produce a regulated voltage output irrespective of impedance changes in load output. Voltage regulators are utilized throughout the electronic industry and are well known in a great variety of configurations with varying complexities. In many high volume commercial applications it is imperative that the voltage regulator be constructed as simply and inexpensively as possible so that the structure in which it is utilized can be competitively priced. In a great many of these circuits zener diodes are utilized to provide a reference voltage. However, it is well known that a zener diode must be biased above a certain minimum current to remove certain forms of noise signal. In general this current is sufficiently high to cause significant voltage drop across parasitic series resistances associated with the diode so that if the current varies substantially with the unregulated voltage applied to the circuit, or the load, the regulation is seriously impaired.

SUMMARY OF THE INVENTION

The present invention pertains to an improved voltage regulator utilizing a reference device, such as a zener diode, and a feedback loop including a low beta semiconductor device which provides substantially constant current to the reference device during normal operation to maintain a reference voltage thereacross. The feedback loop is so arranged that the current to the zener diode is virtually independent of the supply voltage applied to the circuit.

It is an object of the present invention to provide an improved voltage regulator.

It is a further object of the present invention to provide an improved voltage regulator incorporating a feedback loop for providing current to a zener diode to maintain a reference voltage across the zener diode.

It is a further object of the present invention to provide an improved voltage regulator incorporating a zener diode and a feedback loop providing to the zener diode a bias current which is reasonably well controlled and is substantially independent of the unregulated input voltage and the load current, so that said bias current can be set above the level needed to ensure low noise without incurring poor regulation.

These and other objects of this invention will become apparent to those skilled in the art upon consideration of the accompanying specification, claims and drawing.

BRIEF DESCRIPTION OF THE DRAWING

The single FIGURE is a schematic diagram of an embodiment of the improved voltage regulator.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the FIGURE, the numerals 10 and 11 designate a pair of input terminals adapted to be connected to an unregulated voltage with the terminal 10 being positive in the present embodiment and the terminal 11 being a common. One end of a resistor 12 is

connected to the terminal 10 and the other end is connected to one end of a reference device, which in the present embodiment is the cathode of a zener diode 13, the other end or anode of which is connected to the common terminal 11. The cathode of the zener diode 13 is also connected to the base of an NPN type transistor, the collector of which is connected to the terminal 10. The emitter of the transistor 15 is connected to a junction 16 forming a portion of a feedback loop generally designated 17. The feedback loop 17 includes a low beta semiconductor device, which in this embodiment is a lateral construction type PNP transistor with a split collector ring, designated 18, and also includes an NPN type transistor 19. Part of the collector of the transistor 18 is connected to the base of the transistor 18 (which connection may be formed internally when the device is constructed if desired) and part of the collector is connected through the junction 16 to the base of the transistor 19. The collector of the transistor 19 is connected to the base of the transistor 18 to form a feedback loop. The junction 16 is also connected to one side of a reference device, which in this embodiment is the cathode of a zener diode 20, the opposite side or anode being connected to the common 11.

The emitter of the transistor 18 is connected to the terminal 10. The emitter of the transistor 19 is connected to the base of an NPN type transistor 25. The transistor 25 is connected as a series pass transistor with the collector connected to the terminal 10 and the emitter connected to one side of a load 26, the other side of which is connected to the common 11. A resistor 27 is connected between the emitter of the transistor 19 the side of the load 26 connected to the emitter of transistor 25. While specific types of components a semiconductor devices have been disclosed for exemplar purposes, it should be understood that a variety of components and devices might be utilized by those skilled in the art.

In the operation of the above described circuit, when a sufficiently high voltage is applied between the terminals 10 and 11 the transistor 15 begins to conduct supplying base current to the transistor 19, which also begins to conduct. Conduction of the transistor 19 provides a base current path for the transistor 18 which, upon conduction, conducts current from the terminal 10 to the base of the transistor 19. The current through the transistor 18 adds to the current through the transistor 15 and, assuming that the gain of the feedback loop 17 is greater than unity, current in the loop 17 will regeneratively increase. Emitter current from the transistor 19 flows through the resistor 27 and the load 26 to the common 11. The current supplied by transistor 19 would increase until the voltage developed across the load, together with that across the resistor 27, and that across the base emitter junction of transistor 19, became sufficient to cause the zener diode 20 to enter conduction, thereby reducing the loop gain of the circuit to below unity and preventing further regeneration. It is intended, however, that before the current supplied by transistor 19 reaches this level the voltage across resistor 27 will reach such a level as to cause transistor 25 to enter conduction. Once this occurs further increases in load current are substantially supplied by transistor 25 so that transistor 19 passes a substantially constant current defined by the base emitter voltage of transistor 25 and the resistor 27. Since this current is supplied to the base of the transistor 18 it causes

a substantially constant current to be supplied by transistor 18 to the junction 16 of the zener diode and the base of transistor 19. The base current required by transistor 19 is readily made insignificant so that the current supplied by transistor 18 is virtually all passed by the zener diode 20. The current passed by the zener diode is thus determined by the base emitter voltage of transistor 25 the value of resistor 27 and the current gain of transistor 18. In order that this current be well defined the current gain of transistor 18 must be well controlled. This control is most easily achieved by setting the gain to a low value, for example by using the well known twin collector lateral PNP construction connected as in the circuit diagram shown. It is also preferable that transistor 18 have a low current gain inasmuch as this allows the use of a lower value resistor, 27, for a given zener diode bias current and, thereby, ensures that the relatively constant current, defined by the base emitter voltage of transistor 25 applied across this resistor, substantially exceeds the highly load-dependent base current of said transistor.

It should be noted that the zener diode 13, resistor 12 and transistor 15 serve only to provide a starter circuit to supply the initial base current to transistor 19. The zener diode 13 is chosen to have a zener breakdown voltage equal to or somewhat lower than that of zener diode 20. Thus, at some point before full voltage is established across the zener diode 20 the transistor 15 will cease conduction due to an insufficiency of base emitter voltage and thereafter this part of the circuit has no further effect on the operation.

Thus, a relatively simple voltage regulator has been described which provides an output voltage with a high degree of isolation from fluctuations in the input voltage and which utilizes a substantially constant control current to maintain a reference voltage therein which current and, therefore, the reference voltage, are virtually independent of the supply voltage.

While I have shown and described a specific embodiment of this invention, further modifications and improvements will occur to those skilled in the art. I desire it to be understood, therefore, that this invention is not limited to the particular form shown and I intend in the appended claims to cover all modifications which do not depart from the spirit and scope of this invention.

I claim:

1. A voltage regulator circuit responsive to an unregulated voltage developed between first and second conductors to provide a regulated voltage between a third conductor and the second conductor, the voltage regulator circuit including:

a first reference device having a first electrode connected to the second conductor and a second electrode;

first electron control means having a control electrode connected to the second electrode of said first reference device, a first electrode and a second electrode;

second electron control means having a first electrode connected to the first conductor, a control electrode directly connected to said second electrode of said first electron control means, a second electrode connected directly to said second electrode of said first reference device, and a third electrode connected directly to said second electrode of said first electron control means; and

circuit means connecting said first electrode of said first electron control means to the third conductor.

2. The voltage regulator circuit of claim 1 wherein said circuit means includes:

third electron control means having a control electrode connected to said first electrode of said first electron control means, a first electrode connected directly to the third conductor, and a second electrode connected directly to said first conductor; and

first resistive means connected directly between said control electrode of said third electron control means and said third conductor.

3. A voltage regulator circuit responsive to an unregulated voltage developed between first and second conductors to provide a regulated voltage between a third conductor and the second conductor, the voltage regulator circuit including:

a first reference device having a first electrode connected to the second conductor and a second electrode;

first electron control means having a control electrode connected to the second electrode of said first reference device, a first electrode and a second electrode;

second electron control means having a first electrode connected to the first conductor, a control electrode connected to said second electrode of said first electron control means, and a second electrode connected to said second electrode of said first reference device;

circuit means connecting said first electrode of said first electron control means to the third conductor; and

a starting circuit having fourth electron control means having a first electrode connected to said second electrode of said second electron control means, a second electrode connected to the first conductor, a control electrode, a second reference device having a first electrode connected to said second conductor, a second electrode connected to said control electrode of said fourth electron control means, second resistive means connected between said first conductor and said control electrode of said fourth electron control means.

4. The voltage regulator circuit of claim 3 wherein each of said electron control means include bipolar transistors having emitter, base and collector electrodes respectively forming said first, control and second electrodes and each of said reference devices includes a zener diode.

5. The voltage regulator circuit of claim 4 wherein said bipolar transistor included by said second electron control means has a low beta.

6. The voltage regulator circuit of claim 5 wherein said bipolar transistor means included by said second electron control means has two collector electrodes, one of which is connected to the base thereof.

7. A voltage regulator circuit providing a regulated voltage between first and second terminals in response to an unregulated voltage applied between first and third terminals including in combination:

first zener diode means having a first electrode connected to the first terminal and a second electrode; first resistive means connecting the second electrode of said first zener diode means to the third terminal;

5

first transistor means having a base electrode connected to the second electrode of said first zener diode means, a second electrode connected to the third terminal and a first electrode at which a starting current is developed;

second transistor means having a first electrode connected to the third terminal, a second electrode connected to the first electrode of the first transistor means, and a base electrode;

third transistor means having a first electrode, a base electrode connected to said second electrode of said second transistor means, a second electrode connected to said base electrode of said second transistor means; second zener diode means having a first electrode connected to said base of said third transistor means and a second electrode connected to the first terminal; and

circuit means connecting said first electrode of said third transistor means to the second terminal.

8. The voltage regulator circuit of claim 7 wherein said circuit means includes:

pass transistor means having a base electrode connected to said first electrode of said third transistor means, a first electrode connected to the second terminal, and a second electrode connected to the third terminal.

9. The voltage regulator circuit of claim 8 further including second resistive means connected between the second terminal and said base electrode of said pass transistor means.

10. In a voltage regulator circuit for use in an integrated circuit which provides a regulated voltage between first and second conductors in response to an unregulated voltage between first and third conductors comprising first reference means having a first electrode connected to the first conductor and a second electrode, and first electron control means having a control electrode connected to the second electrode of the first reference means, a first electrode coupled to

6

the second conductor and a second electrode, wherein the improvement comprises:

second electron control means having a low beta and a control electrode connected to the second electrode of the first electron control means, a first electrode connected to the third conductor and a second electrode connected to the second electrode of the first reference means and to the control electrode of the first reference means and to the control electrode of the first electron control means;

third electron control means having a first electrode connected to the second conductor, a control electrode connected to a first electrode of the first electron control means and a second electrode connected to the third conductor; and

first resistive means connected between said control electrode of said third electron control means and the second conductor.

11. The combination of claim 10 further including a starting circuit having:

fourth electron control means with a first electrode connected to the second electrode of the first reference means and a second electrode connected to the third conductor and a control electrode coupled to the third conductor; and

second reference means having a first electrode connected to said control electrode of said fourth electron control means and a second electrode connected to the first conductor.

12. The combination of claim 11 further including second resistive means connected between said control electrode of said fourth electron control means and the third conductor.

13. The combination of claim 12 wherein said electron control means are semiconductor transistors and said reference means are zener diodes.

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