VOLTAGE REGULATOR WITH A LOW INPUT IMPEDANCE AND
IMPROVED FEEDBACK GAIN CHARACTERISTICS
Filed Oct. 18, 1968

Fig. 1.

Fig. 2.

Fig. 3.

INVENTOR.
ALASTAIR M. HEASLETT

ATTORNEY
VOLTAGE REGULATOR WITH A LOW INPUT IMPEDANCE AND IMPROVED FEEDBACK GAIN CHARACTERISTICS

Alastair Michael Houslett, Reading, England, assignor to Ampex Corporation, Redwood City, Calif., a corporation of California
Filed Oct. 18, 1968, Ser. No. 768,845
Int. Cl. G05E 1/56
U.S. Cl. 323—22

1

2 Claims

ABSTRACT OF THE DISCLOSURE

A series transistor voltage regulator of the feedback type with a transistor stage of grounded-collector configuration to provide a low impedance input circuit to the regulator, in which the effect of variations in the unregulated input voltage and to provide for the feedback signal amplifier a high impedance load.

This invention relates to voltage regulators.

The object of the invention is to provide an improved series transistor regulator of the feedback type, that is to say, a series regulator wherein a transistor regulating the current through a series load is controlled by the output of an amplifier which amplifies an error signal derived by comparing the actual load voltage (or a selected portion thereof) with a reference voltage.

According to the invention, in a series transistor voltage regulator of the feedback type there is provided a transistor, arranged in a grounded collector configuration such as to provide a low impedance in the input circuit of the regulator to reduce the effect of variations in the unregulated input voltage to the regulator and to provide for the error signal amplifier a high impedance load.

In order to explain the present invention, reference will be made to the drawings, in which:

FIG. 1 illustrates the circuit of a typical conventional series regulator;

FIG. 2 illustrates a circuit embodying the present invention; and

FIG. 3 illustrates a circuit embodying the present invention in a typical practical form.

Referring firstly to FIG. 1, there is shown a simple series regulator (of the feedback type) in which a reference voltage is provided by a Zener diode CR1. A sample of the output voltage is taken from a potentiometer R10 and fed to the base of a transistor Q2. The difference between the sample and the reference is amplified by the transistor Q2 and fed to a main control element, for example, an emitter follower transistor Q1 whose collector/emitter circuit is in series with a load L. Across the input to the emitter follower transistor Q1 is coupled an input resistor R1 whose lower end is connected via the capacitor C1 to ground. The serially connected resistor R1 and capacitor C1 serve as a preregulator.

In the following, "primary regulation" will be defined as the ability of the regulator to reject input voltage changes (either AC or DC) and "secondary regulation" will be defined as the ability of the circuit to compensate for load changes (either AC or DC).

With the circuit shown in FIG. 1, the primary regulation depends on the impedance of the capacitor C1 relative to the impedance of the resistor R1 and the reflected load at the control electrode or base of transistor Q1. At low frequencies, the impedance of the capacitor C1 is high and the DC regulation, which depends on the reflected load at the base of transistor Q1 in parallel with the collected impedance of the transistor Q2, is poor. The secondary regulation at DC, which depends on the gain of transistor Q1, the dynamic impedance of the diode CR1 and the load offered to the collector of transistor Q2 is poor. At AC the secondary regulation suffers since the impedance of the capacitor falls and hence the loop gain falls. In addition, transient load changes are regulated asymmetrically due to the need to recharge the capacitor C1 via the resistor R1 after a sudden load increase. However, to provide proper AC regulation the capacitor C1 must be large and conventional circuits have to compromise between the conflicting requirements of large and small capacitors C1.

FIG. 2 illustrates the circuit of FIG. 1 modified in accordance with the present invention. Here, the capacitor C1 is replaced by a transistor Q3 in a grounded collector configuration. The transistor Q3 presents a dynamically low impedance to signals from the output of the error amplifier and yet provides a high impedance to the output from the error amplifying transistor Q2. The impedance seen by the collector of transistor Q2 is high, being that of a resistor R3 which is buffered and bootstrapped by the transistor Q3. Accordingly the transconductance of the error amplifier is greatly improved resulting in a much higher loop gain.

FIG. 3 illustrates a practical embodiment of the invention. To a pair of input terminals 11, 12 is applied an unregulated voltage in the range 11 volts to 24 volts. Across the input is coupled a diode 13 in series with a resistor R14 both in parallel with a shunt capacitor 15. The junction between the diode 13 and the resistor 14 is connected to the base of a p-n-p transistor 16 whose emitter is coupled to a positive line 17 through a low value resistor 18. The diode 13, the resistor 14, the transistor 16 and the resistor 18 form a simple constant current supply arrangement or preregulator whose output exhibits a "knee" at low forward voltages. This assists the action of a transistor 29 (to be described). The main regulating transistor is formed by a pair of n-p-n transistors 19 and 20, the collectors thereof being fed by the supply line 17, a resistor 21 being provided between the line 17 and the collector of transistor 19 whose emitter is connected to the base of the transistor 20 and also to earth via a resistor 22. The load terminals are shown at 23. Across them is connected a sampling potentiometer 24 whose tap is connected to the base of an error amplifier transistor 25. The collector of the transistor 25 is coupled to the emitter of transistor 29 via a resistor 26, the emitter of the transistor 25 is coupled to earth via a reference Zener diode 27.

The output from the transistor 25 is taken from its collector which feeds the base of the transistor 19 through the resistor 26 which is bootstrapped by the "grounded collector" transistor 29. The collector of the transistor 19 is coupled to ground through a low value resistor 30. The emitter of the transistor 29 is connected to the collector of the transistor 16 and the base of transistor 19. Finally, a further capacitor 31 shunts the load terminals 23, so as to swamp load impedance irregularities at high frequencies (caused by, for example, long lead inductances and stray capacitance in wiring).

I claim:

1. In a voltage regulator of the feedback type having a transistor control element including a control electrode, a preregulator means coupled to receive an unregulated voltage and provide a constant current to the control electrode of the transistor control element, and an error signal amplifier providing at its output an error signal to drive the control element, the improvement comprising a transistor having base, emitter and collector electrodes connected in a grounded collector configuration, the base electrode coupled to receive the error signal
from the output of the error signal amplifier, the emitter electrode coupled to the control electrode of the transistor control element, and a resistor coupled between the emitter electrode of the grounded collector transistor and the output of the error signal amplifier.

2. A regulator as claimed in claim 1 in which the error signal amplifier is a transistor having base, emitter and collector electrodes connected in a grounded emitter configuration, the base electrode of the error signal amplifier coupled to receive a sample of the output voltage provided by the voltage regulator for comparison to a reference voltage provided at its emitter electrode, the base electrode of the grounded collector transistor is directly coupled to the collector electrode of the amplifier, and the resistor is connected between the emitter electrode of the grounded collector transistor and the collector electrode of the transistor amplifier.

References Cited

UNITED STATES PATENTS

<table>
<thead>
<tr>
<th>Patent Number</th>
<th>Date</th>
<th>Inventor</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,897,432</td>
<td>7/1959</td>
<td>Jackson</td>
<td>323—22(T)</td>
</tr>
<tr>
<td>3,069,617</td>
<td>12/1962</td>
<td>Mohler</td>
<td>323—22(T)</td>
</tr>
<tr>
<td>3,109,990</td>
<td>11/1963</td>
<td>Wiley</td>
<td>323—22(T)</td>
</tr>
<tr>
<td>3,374,424</td>
<td>3/1968</td>
<td>Wiechmann</td>
<td>323—22(T)</td>
</tr>
</tbody>
</table>

OTHER REFERENCES


J D MILLER, Primary Examiner
G. GOLDBERG, Assistant Examiner

U.S. Cl. X.R.