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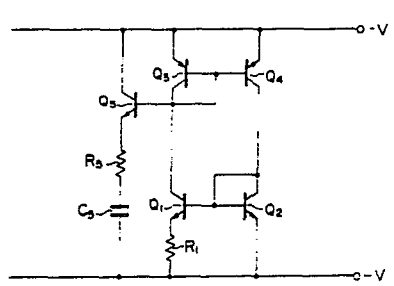
(54) Starter circuit for integrated circuit.

(57) A starter circuit of an integrated circuit according to the present invention includes a first circuit having a pair of transistors (Q_1, Q_2) whose bases are connected together, a second circuit having a pair of transistors (Q_3, Q_4) whose bases are connected together, the first and second circuits being cascade-connected so as to be mutually biased, and a starting transistor (Q_5) for starting the first and second circuits. The starter circuit is characterized by a capacitor (C_5) connected to the starting transistor for forming the starter circuit into a capacitive load.

Fig. I



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STARTER CIRCUIT FOR INTEGRATED CIRCUIT

This invention relates to a starter circuit of an integrated circuit (IC) and, more particularly, to a starter circuit capable of reducing current consumption in an integrated circuit.

In general, an IC device has a circuit arrangement in which two cascade-connected circuits employing a mutual biasing method in a constant-current circuit or constant-voltage circuit are started by a transistor. Circuitry which relies upon mutual biasing referred to here is a circuit arrangement in which the base current of the transistor constituting one circuit is driven by the transistor of the other circuit. The circuitry does not possess transistors in which base current is supplied from positive or negative power supply terminals directly or via a resistor.

With integrated circuitry of this kind, a starter circuit is necessary since the circuits will not operate unless the base current is initially applied to the transistors of either of the two circuits.

In order to facilitate an understanding of such an integrated circuit, a specific example is illustrated in Fig. 3. This circuit includes a pair of transistors Q_1, Q_2 whose bases are connected together to form a first circuit. The emitter of the transistor Q_1 is connected to a -V potential via a resistor R_1, the emitter of the transistor Q_2 is connected directly to -V, and its base and collected are connected together. The circuit also includes a pair of transistors Q_3, Q_4 whose bases are connected together to form a second circuit. The emitters of the transistors Q_3, Q_4 are connected to a +V potential, and the collectors of the transistors Q_3, Q_4 are connected to the collectors of the transistors Q_1, Q_2, respectively. Thus, the first and second circuits are cascade-connected. The first circuit comprising the transistors Q_1, Q_2 is a current mirror circuit, and so is the second circuit comprising the transistors Q_3, Q_4. Accordingly, the circuit of Fig. 3 is a constant-current circuit constituted by the two current mirrors connected in cascade. Further, a starter circuit comprising a series circuit composed of a transistor Q_5 and a resistor R_5 is connected to the cascade-connected circuitry composed of the first and second circuits, and the base of transistor Q_5 is connected to the collectors of the transistors Q_3, Q_1.

In accordance with this circuit configuration, a current flows into the starter circuit composed of transistor Q_5 when the power supply is ON. By virtue of this current, currents also flow into the transistors Q_4, Q_1, after which the transistors Q_3, Q_4 are biased by the transistor Q1 and the transistors Q_1, Q_2 are biased by the transistor Q_4.

With this starter circuit for an integrated circuit, the transistor Q_5 for the starter circuit is required when the power supply which starts the biasing circuitry is turned ON. Once the circuits comprising the transistors Q_1, Q_2 and transistors Q_3, Q_4 start operating, however, the transistor Q_5 no longer performs any useful function. Nevertheless, a constant current flows into the transistor Q_5. This is an impediment to reducing overall current consumption.

However, since there is a limitation upon the high resistance values which can be realized in a manufacturing processing as long as a diffused resistance is used, difficulties are encountered in reducing current consumption. In addition, in order to apply starting stably to a constant-current power supply circuit or constant-voltage circuit, the current of the starter circuit cannot be made very small. For example, in the starter circuit comprising the transistor Q_5 and resistor R_5, a current I_5 which flows into the transistor Q_5 is expressed as follows, where V_{be} represents the base-emitter voltage of the transistor:

$$I_5 = \frac{[+V-(-V)] - V_{be}q_3 - V_{be}q_5}{R_5} \quad \ldots (1)$$

In Eq. (1), q_3, q_5 represent the transistors Q_3, Q_5, respectively.

In a case where ±5 V is used as the power supply, I_5 will be 8.7 µA if the above equation is evaluated at V_{be} = 650 mV, even when 1 MΩ which is near the upper- limit value of a diffused resistor, is employed as the resistor R_5. This is a major disadvantage in an instance where it is desired to make the overall current consumed by the integrated circuit 100 µA. In a case where realizing the value of 1 MΩ with a diffused resistor depends upon the process for manufacturing an ordinary semiconductor integrated circuit, the surface area occupied by the resistor is large and this is an impediment to achieving integration.

If the starter circuit is not provided, the mutual biasing circuitry comprising the transistors Q_1, Q_2, Q_3, Q_4 cannot be started.

An object of the present invention is to provide a starter circuit for an integrated circuit in which the integrated circuit, which employs mutual biasing, can be started, and in which current consumption can be reduced after the integrated circuit is started.

A starter circuit for an integrated circuit according to the present invention is characterized by comprising a first circuit having a pair of transistors (Q_1, Q_2) whose bases are connected together, a second circuit having a pair of transistors (Q_3, Q_4) whose bases are connected together, the first and second circuits being cascade-connected so as to be mutually biased, a starting transistor (Q_5) for starting the first and second circuits, and a capacitor (C_5) connected to the starting transistor for forming the starter circuit into a capacitive load.

In the starter circuit for the integrated circuit according to the present invention, a starting current may flow into the starting transistor when a power supply is ON, thereby starting the mutual biasing circuit constituted by the first and second circuits. Once the starting current flows, however, since the starter circuit forms a capacitive load by means of the capacitors after once the capacitor is charged, the current no longer flows and, hence, current consumption thenceforth can be reduced to almost zero.

Other features and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the figures thereof.

Fig. 1 is a circuit diagram of an integrated circuit illustrating a first embodiment of the present invention;

Fig. 2 is a circuit diagram of an integrated circuit illustrating a second embodiment of the present invention; and

Fig. 3 is a circuit diagram illustrating an example of an integrated circuit in the Discussion of the Related Art.

Embodiments of the present invention will now be described in detail with reference to the drawings.

Fig. 1 is a circuit diagram of an integrated circuit illustrating a first embodiment of the present invention. As shown in Fig. 1, transistors Q_1, Q_2 constituting a first circuit are connected in cascade with transistors Q_3, Q_4 constituting a second circuit, and the circuits are mutually biased. In these aspects, the circuitry is similar to that of Fig. 3. These mutually biased circuits are provided with a transistor Q_5 for starting them when the power supply is turned ON. The transistor Q_5 has a collector connected to +V, and an emitter connected to -V via a serially connected resistor R_5 and capacitor C_5. In other words, what characterizes this circuit arrangement from that of Fig. 3 is that the capacitor C_5 is connected between the resistor R_5 and -V.

In the circuit of this embodiment, a starting current flows through the transistor Q_5, resistor R_5 and capacitor C_5 at start-up when the power supply is turned ON, as a result of which the transistors Q_1, Q_2, Q_3, Q_4 are started. The capacitor C_5 is charged by this starting current so that the potential of its positive terminal rises. When the potential at the positive terminal of capacitor C_5 eventually reaches the base potential of the transistor Q_5, the base-emitter voltage of transistor Q_5 becomes zero and the current ceases flowing. This indicates that current consumption in the starter circuit upon attainment of the steady state at the end of starting is zero. In other words, the foregoing indicates that though the starter circuit comprising the transistor Q_5 and resistor R_5 operates when the integrated circuit is started, the transistor Q_5 is cut out of the circuitry after starting is achieved. Thus, current which is ineffective with regard to functioning of the integrated circuit after starting can be eliminated.

Fig. 2 is a circuit diagram of an integrated circuit illustrating a second embodiment of the present invention. As shown in Fig. 1, the first circuit comprising the transistors Q_1, Q_2 is connected in cascade with the second circuit comprising the transistors Q_3, Q_4, and a circuit for starting this circuitry is provided. In these aspects, the circuitry is similar to that of Fig. 1. In the starter circuit, the emitter of the starting transistor Q_5 is connected via the resistor R_5 to the point at which the collectors of the transistors Q_3, Q_1 are connected together, the collector of the transistor Q_5 is connected to -V, and the capacitor C_5 is connected between the base of transistor Q_5 and -V. In the circuit of this embodiment, a current flows into the transistor Q5 through the resistor R_5 when the power supply is turned ON. This current serves as a starting current which starts the integrated circuit comprising the Q_1, Q_2, Q_3, Q_4. The capacitor C_5 is charged by the biasing current of the transistor Q_5. When voltage at the positive terminal of the capacitor C_5 exceeds a predetermined value, the transistor Q_5 is turned OFF, whereby the starting current is made zero. As a result, needless power consumption can be reduced.

In the circuit of this embodiment, the current charging the capacitor C_5 is solely the base current of the transistor Q_5. Therefore, the capacitance value as seen from the base terminals of the transistors Q_3, Q_4 is h_{fe} times that of the circuit shown in Fig. 1, so that the rise in potential at the positive terminal of capacitor C_5 is slowed in comparison with the circuit of Fig. 1. This makes stabler starting possible.

It should be noted that the resistor R_5 in the integrated circuit of Fig. 1 is merely for the purpose of deciding the charging time of the capacitor C_5. Therefore, unlike the arrangement of Fig. 3, it is unnecessary for the resistor R_5 to have a very high value. As a result, the surface area of the integrated circuit that is occupied by the resistor can be reduced.

In order to start a mutual biasing-type integrated circuit in accordance with the present invention, a capacitor for forming the starter circuit into a capacitive load is connected to a starting transistor. As a result, the integrated circuit can be started by passing a current at the time of start-up, after which the capacitor is charged and the starting transistor turned off as a consequence. From this point onward, therefore, unnecessary current consumption can be made zero.

In addition, since the resistor connected to the starting transistor can be made small, the degree of integration of the integrated circuit can be raised accordingly. Moreover, the reliability of operation of the integrated circuit can be improved.

In a case where a constant-voltage power supply is constructed, it will suffice to assemble the circuit in such a manner that a constant voltage is generated utilizing the constant current obtained from the constant-current circuit of Fig. 1 or Fig. 2.

As many apparently widely different embodiments of the present invention can be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited to the specific embodiments thereof.

Claims

1. A starter circuit of an integrated circuit, comprising:
a first circuit having a pair of transistors whose bases are connected together;
a second circuit having a pair of transistors whose bases are connected together;
said first and second circuits being cascade-connected so as to be mutually biased;
a starting transistor for starting said first and second circuits; and
a capacitor connected to said starting transistor for forming the starter circuit into a capacitive load.

2. An integrated circuit comprising:
a constant-current circuit having two current mirror circuits cascade-connected so as to be mutually biased; and
a starter circuit having a transistor for starting said constant-current circuit;
said starter circuit further having a capacitor charged by a starting current which flows when said constant-current circuit is started, said capacitor making the starting current substantially zero when said capacitor is charged to a predetermined voltage.

Fig. 1

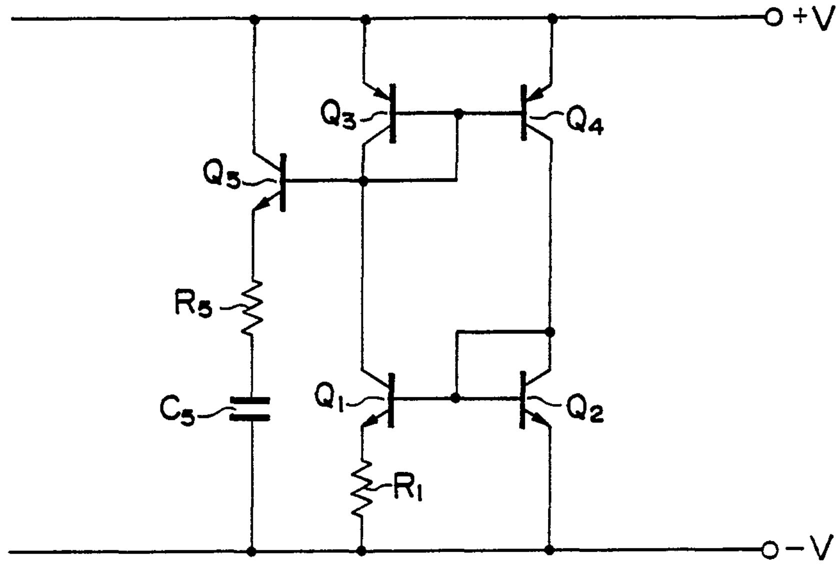


Fig. 2

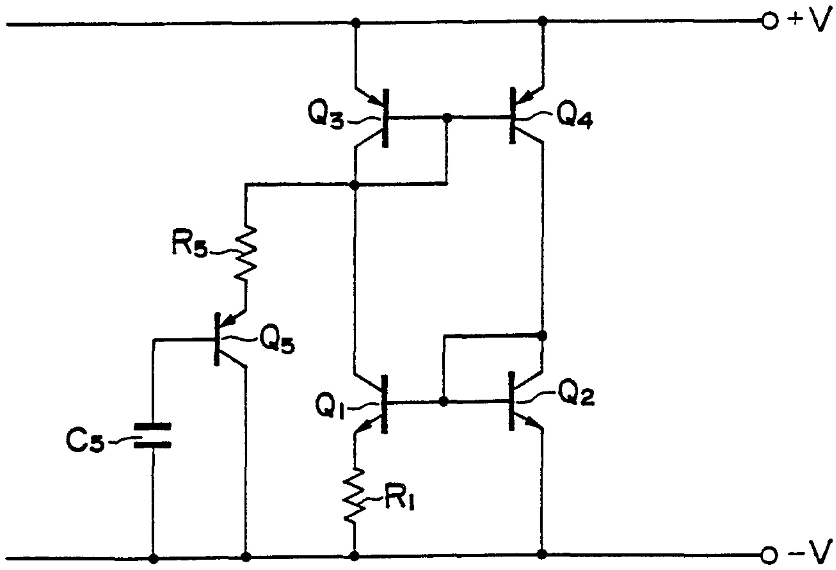
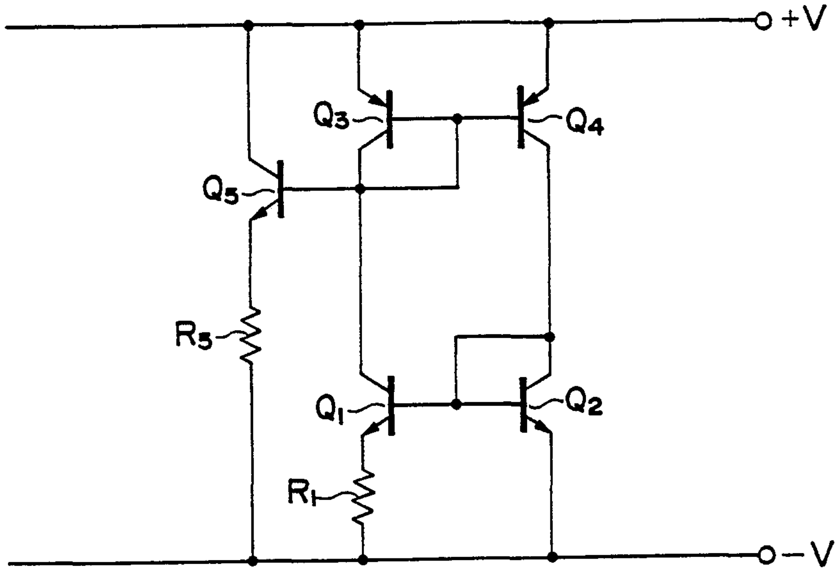


Fig.3



European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 30 1565

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	DE-A-2616363 (PHILIPS) * page 11, lines 6 - 11; figures 1, 2 * ---	1, 2	G05F3/28
A	FR-A-2253237 (PHILIPS) * claim 1; figures 1, 2 * -----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			G05F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	07 MAY 1990	ZAEGEL B.C.

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CATEGORY OF CITED DOCUMENTS

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