

"AMPLIFIER ARRANGEMENT"

The invention relates to an amplifier arrangement. A known amplifier arrangement comprises an input and an output, a first and a second transistor of the same conductivity type, whose base electrodes are interconnected, the emitter electrode of the first transistor being connected to the input, the emitter of the second transistor being connected to a first common point via a first resistor, the collector of the first transistor being connected to a quiescent-current source, and the collector of the second transistor being connected to the output and, via a second resistor, to a power-supply terminal.

Such a known amplifier arrangement is inter alia employed in SOAR protection circuits in integrated power amplifiers as is known inter alia from "Neues aus der Technik", No. 3, 1977, article number 406, page 4.

In this circuit arrangement a voltage which is a measure of the current, voltage and/or power load of an output transistor in the power amplifier is applied to the input. The amplifier circuit is then proportioned so that at the critical point, i.e. the point at which the protection circuit should be actuated, the voltage across the first resistor is equal to the voltage on said input. At this point the combination of the first and the second transistor, the first transistor in this known circuit being arranged as a diode; operates as a current mirror through the first resistor a current equal to the current supplied by the quiescent current source will flow and produce a voltage across said resistor, to which a circuit can respond which limits the drive of the protected output transistor.

Especially in an integrated circuit with p-type substrate, which is generally employed in practice, the first and the second transistor, when they are pnp-transistors, will be of the lateral

type, so that they will have a comparatively low current gain factor, which is moreover subject to a substantial spread owing to process variations. As a result of this, the collector current of the second transistor at said actuating point will not be equal to the collector current of the first transistor and will be greatly dependent on process variations, so that the point at which the protection circuit is actuated is subject to a substantial spread. It is highly undesirable, because in order to obtain a maximum output power of an integrated circuit the protection circuit of the output transistor should not be actuated until an extreme value is reached.

It is the object of the invention to provide an amplifier arrangement in which for a voltage on the input at which the voltage across the first resistor is equal to the voltage on said input, the voltage on the output depends on the current gain factor of the first and the second transistor to a minimal extent.

According to the present invention there is provided an amplifier arrangement comprising an input, an output, a first and a second transistor of the same conductivity type, whose base electrodes are interconnected, the emitter electrode of the first transistor being connected to the input, the emitter of the second transistor being connected to a first common point via a first resistor, the collector of the first transistor being connected to a quiescent-current source, the collector of the second transistor being connected to the output and, via a second resistor, to a power-supply terminal, and a base drive circuit having an input, which is connected to the collector electrode of the first transistor, a voltage follower output, which is connected to the base electrodes of the first and the second transistor, for driving said base electrodes in such a way that the current in the first transistor is equal to the quiescent current from said quiescent-current source, and a base-current diverting output, on which at least a part of the base currents of the first and the second transistor appears, said base-current diverting output being connected to a tapping on the second resistor at such a location that the voltage across the

second resistor depends on the current gain factors of the first and the second transistor to a minimal extent when the voltage on the input, which is connected to the emitter of the first transistor, has such a value that said voltage on the input corresponds to the
 5 voltage across the first resistor.

Owing to the drive at a tapping of the second resistor a variation of the current gain factor of the two transistors, which variation results in a variation in the collector current of the second transistor, produces an opposite variation of the current
 10 applied to the tapping of the second resistor, which in the case of a correct location of said tapping, which may for example be determined experimentally, leads to a substantially full compensation at the said actuation point.

The present invention will now be described, by way of example,
 15 with reference to the single figure of the accompanying drawing which shows an embodiment of the amplifier arrangement in accordance with the present invention. In this drawing transistor T_p is the power transistor to be protected. The collector lead of the transistor T_p includes a resistor 5 for measuring the collector
 20 current of the transistor T_p , which resistor is generally selected to have a very small value and may for example be constituted by the resistance of a connecting track or a connection point. Between the collector and the emitter of transistor T_p a voltage divider with the resistors 6 and 7 is included for measuring the
 25 collector-emitter voltage of the transistor T_p . The junction point of the resistors 6 and 7 is connected to input A of the protection circuit and by a suitable choice of the values of resistors 5, 6 and 7 the voltage V_A on point A can be an optimum function of the current through, and the voltage across, the transistor T_p to be protected
 30 for current, voltage and power limitation. The protection circuit comprises an amplifier, comprising pnp-transistors T_1 and T_2 whose base electrodes are interconnected. The emitter electrode of transistor T_1 is connected to input A, whilst the emitter of transistor T_2 is connected to the power supply terminal $+V_B$ via a resistor 1. The
 35 collector of transistor T_1 is connected to a quiescent-current source

4 with a current I_0 , whilst the collector of transistor T_2 is connected to an output B and, via resistors 2 and 3, to a negative supply voltage terminal $-V_s$. The base electrodes of the transistors T_1 and T_2 are connected to the emitter electrode of a transistor T_3 , whose base electrode is connected to the collector electrode of transistor T_1 and whose collector electrode is connected to the junction point between resistors 2 and 3. Transistor T_3 drives transistor T_1 in such a way that it carries the current I_0 supplied by the current source 4. Output B leads to the base of transistor T_4 , which is arranged as a differential pair with a transistor T_5 . The base electrode of the transistor T_5 is connected to a point C at reference voltage V_{ref} . The collector electrode of the transistor T_4 is connected to the base electrode of the transistor T_p to be protected.

Resistor 1 is dimensioned so that when the voltage V_A reaches a value at which transistor T_p is to be protected, transistors T_1 and T_2 both carry the current I_0 supplied by the current source 4 (ignoring the base current loss). Resistors 2 and 3 are then dimensioned so that the voltage V_B on point B is then equal to the reference voltage V_{ref} . At the point where the protection circuit is actuated the current, which is supplied to transistors T_4 and T_5 by the common emitter current source 8, is transferred from transistor T_5 to transistor T_4 and which current via the collector of transistor T_4 is diverted from the base electrode of the transistor T_p to be protected, whose drive is limited at said protection point.

The current gain factor β of the lateral pnp-transistors T_1 , T_2 and T_3 exhibits a spread in respect of process variations and moreover is greatly dependent on the value of the bias current I_0 , which may exhibit a spread as a result of process variations. In practice this may give rise to a variation of the β between for example 3 and 30 in integrated circuits whose integration process is suitable for comparatively large currents, which may lead to a deviation in the collector current of transistor T_2 relative to the current I_0 of maximum $\pm 15\%$, which in its turn leads to an equal error in the voltage V_B , i.e. the value of the voltage V_A for which the drive of transistor T_p is limited. For the protection of

transistors in integrated power amplifiers this is an impermissible variation and in practice means that transistor T_p is limited to a dissipation which is 15% smaller than the optimum value.

This problem can be mitigated by feeding the drive of transistors T_1 and T_2 via transistor T_3 , or alternatively a transistor arrangement comprising a plurality of transistors, and the collector current of the transistor T_3 , or the output current of such a combination, to a tapping between resistors 2 and 3, so that said collector current produces an extra voltage on point B. A decrease of the current gain factor of the transistors T_1 and T_2 causes a decrease of the collector current of the transistor T_2 and at the same time an increase of the collector currents of the transistor T_3 , so that by a suitable choice of the ratio of the values of the resistors 2 and 3 the effect of a variation in β on the voltage V_B is largely cancelled.



Claims

1. An amplifier arrangement comprising an input, an output, a first and a second transistor of the same conductivity type, whose base electrodes are interconnected, the emitter electrode of the first transistor being connected to the input, the emitter
5 of the second transistor being connected to a first common point via a first resistor, the collector of the first transistor being connected to a quiescent-current source, the collector of the second transistor being connected to the output and, via a second resistor, to a power-supply terminal, and a base drive circuit
10 having an input, which is connected to the collector electrode of the first transistor, a voltage follower output, which is connected to the base electrodes of the first and the second transistor, for driving said base electrodes in such a way that the current in the first transistor is equal to the quiescent
15 current from said quiescent-current source, and a base current diverting output, on which at least a part of the base currents of the first and the second transistor appears, said base-current diverting output being connected to a tapping on the second resistor at such a location that the voltage across the second resistor
20 depends on the current gain factors of the first and the second transistor to a minimal extent when the voltage on the input, which is connected to the emitter of the first transistor, has such a value that said voltage on the input corresponds to the voltage across the first resistor.
- 25 2. An amplifier arrangement constructed and arranged to operate substantially as hereinbefore described with reference to the accompanying drawing.

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