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(72) Inventors:
• **Cerchi, Marco**
27050 Cornale (IT)
• **Fiocchi, Carlo**
27011 Belgioioso (PV) (IT)

(71) Applicant: **austriamicrosystems AG**
8141 Unterpremstätten (AT)

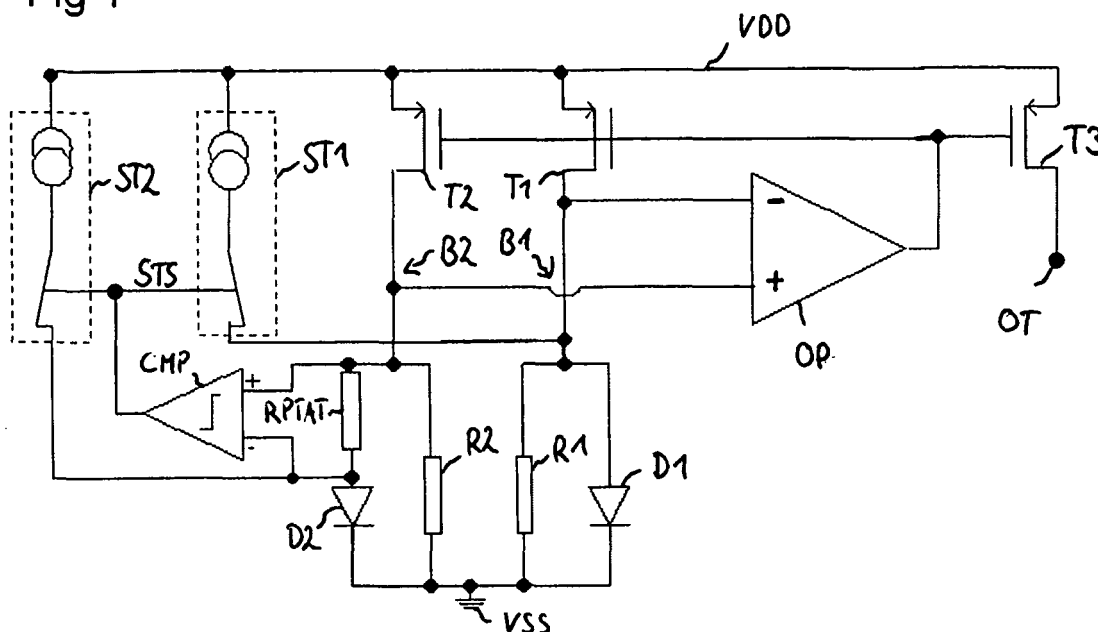
(74) Representative: **Epping - Hermann - Fischer**
Patentanwalts-gesellschaft mbH
Ridlerstrasse 55
80339 München (DE)

(54) **Band gap reference circuit and method for operating a band gap reference circuit**

(57) A band gap reference circuit comprises a first and a second branch (B1, B2) with a pair of matched transistors (T1, T2) and a pair of mismatched diode elements (D1, D2). A reference resistive element (RPTAT) is connected in series to one of the diode elements (D2). Resistive elements (R1, R2) are connected in parallel, respectively, to the pair of diode elements (D1, D2). A control amplifier (OP) comprised by the circuit is coupled to the first and the second branch (B1, B2) on its input

side and commonly coupled to respective control terminals of the pair of matched transistors (T1, T2) and an output transistor (T3) on its output side. A comparator device (CMP) is configured to provide a startup signal (STS) depending on a voltage drop across the reference resistive element (RPTAT). A switchable startup current device (ST1) is configured to provide a startup current to the other one of the diode elements (D1) depending on the startup signal (STS).

Fig 1



Description

[0001] Band gap reference circuit and method for operating a band gap reference circuit

[0002] The invention relates to a band gap reference circuit with a fractional approach and a method for operating such a band gap reference circuit.

[0003] Band gap reference circuits usually comprise a pair of mismatched diodes, wherein one of the diodes is connected in series to a reference resistor in order to generate a proportional-to-absolute temperature, PTAT, current. Voltages resulting from the diodes can be sensed and used to generate a defined output voltage or output current, respectively.

[0004] In some applications, the sensed voltages are used to control a pair of matched transistors which provide current to the diode pair. The output voltage or output current are controlled by the same control signal used for the matched transistors.

[0005] In some further applications, a respective resistor is connected in parallel to the diode and the series connection of the diode and the reference resistor, respectively. Such band gap reference circuits can also be called fractional band gap circuits because an output voltage of the band gap reference circuit can be arbitrarily chosen by injecting the current from the matched transistors into a respective resistor of an appropriate value.

[0006] The above-mentioned band gap reference circuits work properly if the diode pair is operated in a conducting state or biased state, which implies a certain amount of current flowing through the diodes. To reach this operating state from a startup of the band gap reference circuit as fast as possible, an additional startup current can be provided to the diode without a series resistor. However, if the startup current is still provided after the operating state is reached, the output voltage or output current, respectively, will become too large, for example. In other words, an overshoot will be generated in the output signal.

[0007] To keep such overshoots small, the startup current can be switched off after a predetermined time which may be found from a mathematical simulation of the band gap reference circuit. However, due to process variations and/or simulation imprecision, the time after which a startup current is switched off may be too long or too short.

[0008] In particular for the fractional band gap approach, also an amount of startup current provided should be taken care of. For example, if the startup current is too small, the diode will not be biased by this current but rather flow through the parallel resistor. Additionally, it has to be taken care of that the current provided by the matched transistors is large enough to bias the diodes after the startup current is switched off.

[0009] To avoid such behavior of the band gap reference circuit, a larger startup current can be provided for the predefined time. However, this will again result in a large overshoot which lasts as long as the startup current is provided.

[0010] It is an object of the invention to provide a band gap reference circuit and a method for operating a band gap reference circuit which enable both a fast startup and an efficient operation.

5 **[0011]** This object is achieved with the subject matter of the independent patent claims. Embodiments and developments of the invention are the subject matter of the dependent claims.

10 **[0012]** In one embodiment, a band gap reference circuit comprises a first and a second branch with a pair of matched transistors and a pair of mismatched diode elements, the pair including a first and a second diode element. A first resistive element is connected in parallel to the first diode element. A reference resistive element is connected in series to the second diode element, wherein a second resistive element is connected in parallel to that series connection. An output transistor is coupled between a first supply terminal and an output terminal.

20 **[0013]** A control amplifier is coupled to the first and the second branch on its input side and commonly coupled to respective control terminals of the pair of matched transistors and of the output transistor on its output side. The band gap reference circuit further comprises a first switchable startup current device being configured to provide a startup current to the first diode element depending on a startup signal. A comparator device is configured to provide the startup signal depending on a voltage drop across the reference resistive element.

30 **[0014]** During a startup phase, the first startup current device is controlled to provide a startup current for bringing the band gap reference circuit to an operating state. A voltage drop across the reference resistive element can only be sensed if a current is flowing through this element. As the reference resistive element is connected in series to the second diode element, this means that also a current is at least flowing through the second diode element. Hence, the second diode element is biased, at least partially, in this state. As the current through the reference resistive element and the second diode element is provided by one of the matched transistors, control by the control amplifier is in or near the operating state. Hence, depending on the voltage drop sensed by the comparator device, the first startup current device can be switched off. In other words, the first startup current device is then controlled such that no startup current is provided to the first diode element by means of a respective state of the startup signal. As a consequence, overshooting of an output signal at the output terminal can be minimized or avoided completely.

50 **[0015]** It should be noted that in the embodiment of the band gap reference circuit described, control of the startup current device is independent as well from a size of the startup current provided as from a time needed to reach the operating state during the startup phase.

55 **[0016]** During operation of the band gap reference circuit, an output signal is provided at the output terminal which can be an output current or an output voltage. In

particular, a load can be connected to the output terminal which preferably is matched to the resistive elements in the first and the second branch. In this case, a desired fractional bandgap voltage is provided at the output terminal. If no load is connected to the output terminal, a current with precisely defined temperature coefficient is available at the output terminal.

[0017] In one embodiment, the first branch comprises a first transistor connected in series to the parallel connection of the first resistive element and the first diode element, wherein the first branch is connected between the first and the second supply terminal. The second branch comprises a second transistor connected in series to the parallel connection of the second resistive element and the series connection of the reference resistive element and the second diode element, wherein the second branch is connected in parallel to the first branch.

[0018] As the pair of first and second transistor are matched to each other, they basically provide the same amount of current when being controlled with the same control signal. Mismatching of first and second diode element can, for example, be achieved by providing different junction areas. For example, the first diode element can be called smaller because it has a higher voltage drop than the second diode element for the same amount of current.

[0019] In some embodiments, at least one of the first and the second diode element comprises a diode connected transistor, wherein the control terminal of the transistor is connected to one of the other transistor terminals, respectively.

[0020] In one embodiment, the band gap reference circuit further comprises a second switchable startup current device which is configured to provide a startup current to the second diode element depending on the startup signal. Preferably, the startup current is provided to the second diode element such that it only flows through the diode element but not through the series connected reference resistive element. Providing of startup currents to both of the diode elements can improve the matching of the currents through them also during the startup phase and makes a band gap difference voltage sensed by the control amplifier nearer to the operating state. This can further reduce a possible initial overshooting of the output signal.

[0021] In one embodiment, the comparator device is configured to compare the voltage drop across the reference resistive element with a threshold value. The threshold value should be chosen any non-negative value such that the startup current devices are switched off when the second diode element is conducting and the respective current causes the voltage drop across the reference resistive element. For example, the threshold value can be chosen a small positive value in order to provide some safety margins which, for example, take into account and compensate an offset in the comparator device.

[0022] In one embodiment, the comparator device

comprises a differential amplifier whose inputs are connected to respective terminals of the reference resistive element. Hence, the voltage potentials at the terminals of the reference resistive element can be compared to each other. In a special embodiment, the threshold value of the comparator device is set by corresponding dimensioning of input transistors of the differential amplifier. For example, the differential amplifier can be provided with an offset.

[0023] In one embodiment, the band gap reference circuit further comprises a further transistor having a control terminal connected to the respective control terminals of the first and the second transistor and the output transistor. The further transistor is configured to control a tail current of the differential amplifier. For example, the further transistor provides a scaled version of the currents in the first and the second branch, wherein the scaled current is mirrored to the differential amplifier as a tail current. Hence, if the control amplifier is not in its operating state, neither current in the branches nor a tail current in the differential amplifier can flow. Therefore, it is implicitly made impossible to switch off the startup current before the control amplifier is in the operating state.

[0024] In a further embodiment, an input stage of the differential amplifier is matched to an input stage of the control amplifier. This additionally can ensure that the comparator device does not switch off the startup current devices before the input dynamic range of the control amplifier is securely reached.

[0025] In a further embodiment, the band gap reference circuit comprises a third switchable startup current device which is configured to provide a startup current to an output branch of the differential amplifier depending on the startup signal. This makes it possible to force the comparator output, namely the startup signal, to be at a desired logic state as long as no tail current and no suitable dynamic range is given at the input stage of the differential amplifier. This further can improve any noise margin during the startup phase.

[0026] The startup devices used in the embodiments described above can be realized in various manners. For example, the startup devices comprise a switch being coupled to the first supply terminal. In another embodiment, the startup devices comprise a series connection of a switch and a resistor, the series connection being coupled to the first supply terminal. In still another embodiment, the startup devices comprise a series connection of a switch, a diode connected transistor and a resistor, the series connection being coupled to the first supply terminal. The switches of the startup devices should be normally closed such that the startup current is securely provided during the startup phase. In other words, the startup devices or the switches, respectively, should be actively switched off.

[0027] In an embodiment of a method for operating a band gap reference circuit, the circuit comprises a first and a second branch which comprise a pair of matched transistors and a pair of mismatched diode elements. A

first resistive element is connected in parallel to a first diode element of the pair of diode elements, wherein a reference resistive element is connected in series to a second diode element of the pair of diode elements. A second resistive element is connected in parallel to the series connection of the reference resistive element and the second diode element. An output transistor is coupled between a supply terminal and an output terminal. A control amplifier comprised by the circuit is coupled to first and the second branch on its input side and commonly coupled to respective control terminals of the pair of matched transistors and the output transistor on its output side. In this embodiment, the method comprises providing a first startup current to the first diode element, sensing a voltage drop across the reference resistive element, and stopping of the providing of the first startup current if the voltage drop exceeds a predetermined threshold value.

[0028] The described method makes it possible to bring a band gap reference circuit to an operating state in a fast manner and without overshooting of an output signal because the startup current is only provided until the control amplifier controls the pair of transistors to provide enough current to bring the band gap reference circuit to the operating state. The method is independent of process variations and needs no predefined timing.

[0029] In one embodiment, the method further comprises the providing of a second startup current to the second diode element and the stopping of the providing of the second startup current if the voltage drops exceeds a predetermined threshold value.

[0030] The text below explains the invention in detail using exemplary embodiments with reference to the drawings. In the drawings, like reference numerals designate corresponding similar parts or elements. In the drawings,

FIG. 1 shows a first embodiment of a band gap reference circuit,

FIGs. 2A and 2B show embodiments of startup current devices, and

FIG. 3 shows a second embodiment of a band gap reference circuit.

[0031] FIG. 1 shows an embodiment of a band gap reference circuit comprising a first and a second branch B1, B2 with a pair of matched transistors T1, T2 and a pair of mismatched diode elements D1, D2. The branches B1, B2 are connected between a first supply terminal VDD and a second supply terminal VSS. For example, a supply voltage is provided at the first supply terminal VDD and a reference or ground potential is provided at the second supply terminal VSS. The first branch B1 comprises a series connection of a first one of the pair of matched transistors and a parallel connection of a first resistive element R1 and a first one of the pair of mis-

matched diode elements. In the second branch B2, a second one of the matched transistors T2 is connected in series to a parallel connection of a second resistive element R2 and a series connection of a reference resistive element RPTAT and a second one of the mismatched diode elements D2.

[0032] In particular, the second diode element D2 is connected downstream of the reference resistive element RPTAT such that a current flowing from the second transistor T2 first flows through the reference resistive element RPTAT and afterwards through the second diode element D2. In other words, the cathode terminals of the first and the second diode element D1, D2 are commonly connected to the second supply terminal VSS.

[0033] The circuit further comprises a control amplifier OP which, for example, is an operational amplifier. An inverting input is coupled to the connection between the first transistor T1 and the parallel connection of the first diode element D1 and the first resistive element R1. Similarly, the non-inverting input of the control amplifier OP is connected to the connection between the second transistor T2 and the parallel connection comprising the second resistive element R2 and the series connection of the second diode element D2 and the reference resistive element RPTAT. In other words, inputs of the control amplifier OP are coupled to the first and the second branch B1, B2. An output of the control amplifier OP is commonly connected to the control terminals of the first and the second transistor T1, T2 and of an output transistor T3 which is coupled between the first supply terminal VDD and an output terminal OT.

[0034] A first startup current device ST1 is coupled between the first supply terminal VDD and the anode terminal of the first diode element D1. Similarly, a second startup current device ST2 is coupled to the anode terminal of the second diode element D2. First and second startup current devices ST1, ST2 are switchable with respect to a startup signal STS. In another embodiment, the second startup current device ST2 can also be left out such that only the first startup current device ST1 is provided.

[0035] A comparator device CMP is connected to terminals of the reference resistive element RPTAT on its input side. On its output side, the comparator device CMP is connected to respective switches of the first and the second startup current device ST1, ST2 for providing the startup signal STS.

[0036] During a startup phase, the first and the second transistor T1, T2 do not provide enough current to securely bring the diode elements D1, D2 into a conductive state or, in other words, bias the diode elements D1, D2, at least in the beginning of the startup phase. Hence, no substantial voltage difference at the inputs of the control amplifier OP will result in the beginning such that no sufficient control signal will be provided to the control terminals of the transistors T1, T2, T3. To bring the first and the second diode element D1, D2 to a conductive state, a first startup current is provided to the first diode element

D1 by the first startup current device ST1 and a second startup current is provided to the second diode element D2 by the second startup current device ST2.

[0037] The startup currents result in respective voltage drops across the diode elements D1, D2 which can be sensed at the inputs of the control amplifier OP. As a consequence, the control amplifier OP will cause respective current flows through the first and the second transistors T1, T2. If the current from the second transistor T2 is large enough that a voltage across the second resistive element R2 is greater than the voltage drop across the second diode element D2 caused by the startup current, a positive voltage drop will result over the reference resistive element RPTAT. If this state is reached, enough current is provided by the pair of transistors T1, T2 for the diode elements D1, D2 to be operated or biased, respectively, without the startup currents. Hence, the startup current devices ST1, ST2 can be switched off if a voltage drop across the reference resistive element RPTAT can be sensed by the comparator device CMP being at least equal to zero or positive.

[0038] It should be noted that the voltage drop across the reference resistive element RPTAT may become negative at the beginning of the startup phase due to the startup current. Preferably, the comparator device CMP is configured such that the startup current devices ST1, ST2 are switched off only if the sensed voltage drop exceeds a small positive value, giving some security margin. In other words, the comparator device CMP compares the voltage drop with a threshold value being equal to zero or being greater than zero.

[0039] Accordingly, when the voltage drop across the reference resistive element RPTAT becomes positive, this means that the current from the second transistor T2 is able to sustain across the parallel connected resistive element R2 a voltage equal to the forward bias voltage of the second diode element D2. Thus, if the startup current is even immediately cut off at this time, the diode elements D1, D2 can be biased by the currents provided by the transistors T1, T2 controlled by the control amplifier OP. As a consequence, after switching off the startup currents, the difference between the forward bias voltages of the first and the second diode elements can provide a desired settling of the band gap reference circuit at a given target value.

[0040] With the proposed circuit, it is not necessary to rely upon delays to switch off the startup currents. In this way, the settling time towards a reference value is reduced compared to a conventional band gap reference circuit. Furthermore, it is not necessary to bring the currents provided by the first and the second transistor T1, T2 higher than the steady state ones to ensure that the band gap reference circuit will properly settle. Hence, no overshoot takes place which would be needed to be filtered out by a filter element connected to the output terminal.

[0041] The startup current devices ST1, ST2 in FIG. 1 are drawn as current sources connected in series with a

switch. However, various embodiments of startup current devices can be used to provide respective startup currents.

[0042] FIG. 2A shows a first alternative embodiment of a startup current device comprising a series connection of a diode connected transistor TST, a resistor RST and a switch SST. The diode connected transistor TST therefore has its input terminal connected to its control terminal.

[0043] The switch SST of the startup current device preferably is normally closed such that during the startup phase, the startup current can be provided without the need of a special control signal for the switch SST. Accordingly, if the desired voltage drop across the reference resistive element RPTAT is sensed, the switch is actively opened.

[0044] FIG. 2B shows another alternative startup current device being similar to the one of FIG. 2A. However, no diode connected transistor is provided but only a series connection of the resistor RST and a switch SST.

[0045] FIG. 3 shows another embodiment of a band gap reference circuit. Branches B1, B2 with respective elements, a control amplifier OP and the output transistor T3 show the same arrangement and fulfill the same function as in FIG. 1 and will therefore not be described in detail again. First and second startup current device ST1, ST2 are drawn symbolically.

[0046] The comparator device CMP comprises a differential amplifier with an input stage incorporating transistors T7, T8. The differential amplifier further comprises a current mirror load incorporating transistors T9, T10. A tail current is provided for the differential amplifier by a current mirror incorporating transistors T5, T6, the current mirror being coupled to a further transistor T4 whose control terminal is connected to the control terminals of the first, the second and the output transistor T1, T2, T3. The source terminal of the further transistor T4 is commonly connected to the first supply terminal VDD with the source terminals of the transistors T1, T2, T3.

[0047] A third startup current device ST3 is connected to the output branch of the differential amplifier. In particular, the third startup current device ST3 is connected to the connection of input transistor T7 and load transistor T9. Furthermore, this connection of transistors T7, T9 forms the output of the comparator device CMP for providing the startup signal STS and also the third startup current device ST3 is connected to that output of the comparator device CMP.

[0048] Preferably, the input stage T7, T8 of the differential amplifier is matched to an input stage of the control amplifier OP, not shown here for reasons of a better overview. In this case, differential amplifier and control amplifier OP show comparable dynamic behavior.

[0049] Operation of the differential amplifier depends on a current provided by the transistor T6 which is in control of transistors T4 and T5. Therefore, in the beginning of the startup phase, as no or little current is coming from transistor T4 and the dynamic range of the control

amplifier is not right, the differential amplifier cannot switch its output. Therefore, the differential amplifier is locked. If the circuit comes near its steady state or operating state, the differential amplifier is enabled to safely switch off the startup current devices.

[0050] However, the third startup current device can ensure that the startup signal has a desired logic state as long as no tail current and no suitable dynamic range is given at the input state T7, T8 of the differential amplifier. If the tail current of transistor T6 becomes large enough, changing the logic state of the startup signal STS becomes possible.

[0051] In the embodiment of FIG. 3, the output current of transistor T3 is mirrored to the tail current of the differential amplifier by means of an NMOS current mirror T5, T6. However, the NMOS current mirror could also be replaced by a respective PMOS current mirror, wherein the position of the current mirror is to be changed accordingly.

[0052] Furthermore, in the embodiments of the band gap reference circuits of FIGs. 1 and 3, field-effect transistors are used for the circuit. However, it is also possible to replace these elements by respective bipolar transistors accordingly. Furthermore, the band gap reference circuits can be implemented in BiCMOS technology.

[0053] In the embodiments of the band gap reference circuit described above, a first and a second startup current device ST1, ST2 are used to provide a startup current both to the first and to the second diode element D1, D2. However, in various embodiments, the second startup current device ST2 can also be left out. Nevertheless, also in this case, sensing of the voltage drop across the reference resistive element RPTAT can be used to detect that enough current is provided by the pair of matched transistors T1, T2 to achieve the steady state or operating state of the circuit. However, usage of the two startup current devices ST1, ST2 may further reduce an initial overshoot of the output signal.

[0054] Furthermore, in the embodiments of the band gap reference circuit described above, a load can be connected to the output terminal OT which preferably is matched to the resistive elements R1, R2 in the first and the second branch B1, B2. In this case, a desired fractional bandgap voltage is provided at the output terminal OT. If no load is connected to the output terminal OT, a current with precisely defined temperature coefficient is available at the output terminal OT.

Reference list

[0055]

B1, B2	branch
D1, D2	diode element
ST1, ST2, ST3	startup current device

T1, ..., T10	transistor
OP	control amplifier
5 CMP	comparator device
R1, R2	resistive element
RPTAT	reference resistive element
10 OT	output terminal
VDD, VSS	supply terminal
15 SST	switch
RST	resistor
TST	transistor
20 STS	startup signal

Claims

1. Bandgap reference circuit, comprising

- a first branch (B1) comprising a first transistor (T1) connected in series to a parallel connection of a first resistive element (R1) and a first diode element (D1), the first branch (B1) being connected between a first and a second supply terminal (VDD, VSS);
- a second branch (B2) comprising a second transistor (T2) connected in series to a parallel connection of a second resistive element (R2) and a series connection of a reference resistive element (RPTAT) and a second diode element (D2), the second branch (B2) being connected in parallel to the first branch (B1), the first and the second transistor (T1, T2) being matched to each other and the first and the second diode element (D1, D2) being mismatched to each other;
- an output transistor (T3) coupled between the first supply terminal (VDD) and an output terminal (OT);
- a control amplifier (OP) having an inverting input coupled to the first branch (B1), a non-inverting input coupled to the second branch (B2) and an output commonly coupled to respective control terminals of the first and the second transistor (T1, T2) and the output transistor (T3);
- a first switchable startup current device (ST1) being configured to provide a startup current to the first diode element (D1) depending on a startup signal (STS); and
- a comparator device (CMP) being configured

to provide the startup signal (STS) depending on a voltage drop across the reference resistive element (RPTAT).

2. Bandgap reference circuit according to claim 1, further comprising a second switchable startup current device (ST2) being configured to provide a startup current to the second diode element (D2) depending on the startup signal (STS). 5
3. Bandgap reference circuit according to claim 1 or 2, wherein the comparator device (CMP) is configured to compare the voltage drop across the reference resistive element (RPTAT) with a threshold value. 10
4. Bandgap reference circuit according to one of claims 1 to 3, wherein the comparator device (CMP) comprises a differential amplifier whose inputs are connected to respective terminals of the reference resistive element (RPTAT). 15
5. Bandgap reference circuit according to claim 3 and 4, wherein the threshold value of the comparator device (CMP) is set by corresponding dimensioning of input transistors (T7, T8) of the differential amplifier. 20
6. Bandgap reference circuit according to claim 4 or 5, further comprising a further transistor (T4) having a control terminal connected to the respective control terminals of the first and the second transistor (T1, T2) and the output transistor (T3), the further transistor (T4) being configured to control a tail current of the differential amplifier. 25
7. Bandgap reference circuit according to one of claims 4 to 6, wherein an input stage of the differential amplifier is matched to an input stage of the control amplifier (OP). 30
8. Bandgap reference circuit according to one of claims 4 to 7, further comprising a third switchable startup current device (ST3) being configured to provide a startup current to an output branch of the differential amplifier depending on the startup signal (STS). 35
9. Bandgap reference circuit according to one of claims 1 to 8, wherein at least one of the first and the second diode element (D1, D2) comprises a diode-connected transistor. 40
10. Bandgap reference circuit according to one of claims 1 to 9, wherein the startup device comprises a switch, or a series connection of a switch (SST) and a resistor (RST), or a series connection of a switch (SST), a diode-connected transistor (TST) and a resistor (RST), each coupled to the first supply terminal (VDD). 45

11. Method for operating a bandgap reference circuit, the circuit comprising a first and a second branch (B1, B2) which comprise a pair of matched transistors (T1, T2) and a pair of mismatched diode elements (D1, D2), wherein a first resistive element (R1) is connected in parallel to a first diode element (D1) of the pair of diode elements, wherein a reference resistive element (RPTAT) is connected in series to a second diode element (D2) of the pair of diode elements, wherein a second resistive element (R2) is connected in parallel to the series connection of the reference resistive element (RPTAT) and the second diode element (D2), wherein an output transistor (T3) is coupled between a supply terminal (VDD) and an output terminal (OT), and wherein a control amplifier (OP) comprised by the circuit is coupled to the first and the second branch (B1, B2) on its input side and commonly coupled to respective control terminals of the pair of matched transistors (T1, T2) and the output transistor (T3) on its output side, 50
the method comprising

- providing a first startup current to the first diode element (D1);
- sensing a voltage drop across the reference resistive element (RPTAT); and
- stopping of the providing of the first startup current if the voltage drop exceeds a predetermined threshold value.

12. Method according to claim 11, further comprising

- providing a second startup current to the second diode element (D2); and
- stopping of the providing of the second startup current if the voltage drop exceeds the predetermined threshold value.

Fig 1

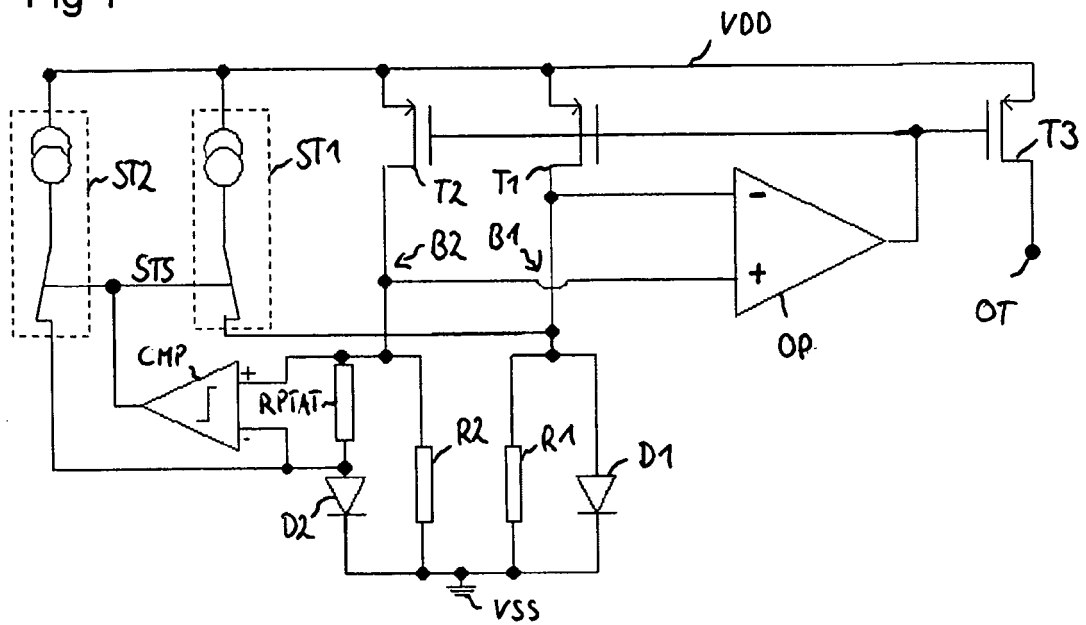


Fig 2A

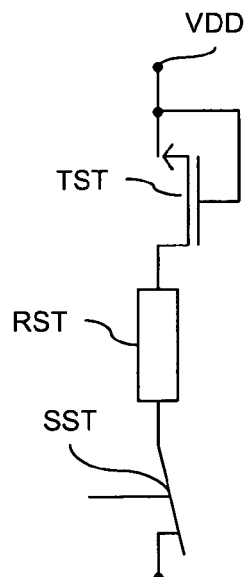


Fig 2B

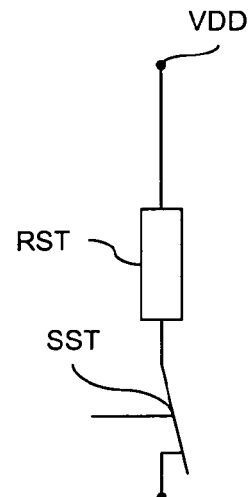
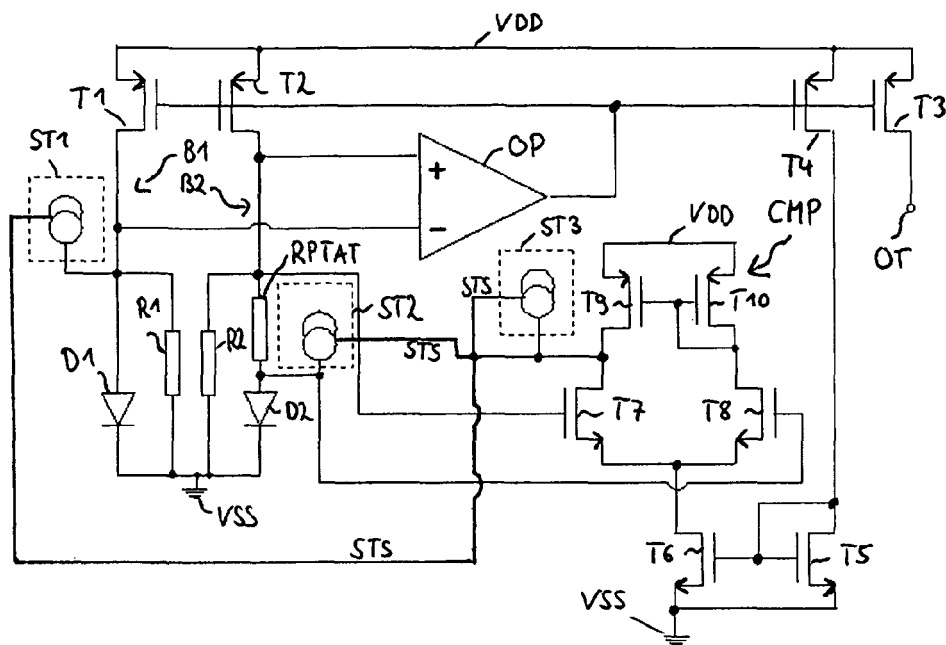


Fig 3





EUROPEAN SEARCH REPORT

Application Number
EP 09 00 5238

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	GB 2 442 494 A (WOLFSON MICROELECTRONICS PLC [GB]) 9 April 2008 (2008-04-09) * the whole document *	1-12	INV. G05F3/30
A	US 2008/007244 A1 (DRAXELMAYR DIETER [AT]) 10 January 2008 (2008-01-10) * abstract; figure 1 *		
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A	US 2008/157746 A1 (CHEN MU-JUNG [TW]) 3 July 2008 (2008-07-03) * abstract; figure 7 *		
			TECHNICAL FIELDS SEARCHED (IPC)
			G05F
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		17 August 2009	Arias Pérez, Jagoba
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EPO FORM 1503 03.02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 09 00 5238

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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