The United States of America



Has received an application for a patent for a new and useful invention. The title and description of the invention are enclosed. The requirements of law have been complied with, and it has been determined that a patent on the invention shall be granted under the law.

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Grants to the person(s) having title to this patent the right to exclude others from making, using, offering for sale, or selling the invention throughout the United States of *America or importing the invention into the United States of America, and if the inven*tion is a process, of the right to exclude others from using, offering for sale or selling throughout the United States of America, or importing into the United States of America, products made by that process, for the term set forth in 35 U.S.C. 154(a)(2) or (c)(1), subject to the payment of maintenance fees as provided by 35 U.S.C. 41(b). See the Maintenance Fee Notice on the inside of the cover.

Michelle K. Lee

Director of the United States Patent and Trademark Office



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Wehmeier

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(54) SINE-COSINE MODULATOR

(75) Inventor: Stefan Wehmeier, Recklinghausen (DE)

(73) Assignee: Conta Pronat GmbH, Recklingshausen

(DE)

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See application file for complete search history.

(56) References Cited

U.S. PATENT DOCUMENTS

FOREIGN PATENT DOCUMENTS

EP 2391002 A1 11/2011 JP 2001127562 A 5/2001

OTHER PUBLICATIONS

Jun Yu et al.: "A Dual-Feedforward Carrier Modulated Second-Order Class-D Amplifier with Improved THD", IEEE Transactions on Circuits and Systems II: Epress Briefs, IEEE, US, vol. 59, No. 1, Jan. 1, 2012, pp. 35-39, XP011397557, ISSN: 1549-7747, DOI: 10.1109/TCSII.2011.2173973, Figure 3.

* cited by examiner

Primary Examiner — Arnold Kinkead
(74) Attorney, Agent, or Firm — Michael Soderman

(57) ABSTRACT

The invention relates to a self-oscillating pulse-width modulation amplifier in the form of a sine-cosine modulator (10) comprising at least two comparators (13, 14), two integrators (11, 12), a power switching stage (15), and negative feedback coupling with a low-frequency signal input and output. To achieve a maximum modulation factor, there are provisions with the aid of the comparators (13, 14) and integrators (11, 12) for the generation of sine- and cosine-square-wave voltages and sine- and co-sine-triangle-wave voltages that drive the power switching stage (15) in part, wherein the output of the power switching stage (15) combined with an LC lowpass filter (16) forms the low-frequency signal output. This brings about a situation in which a stable natural frequency exists and the modulation factor can be increased to nearly 100%. At the same time, a very low level of distortion is achieved and no distortion components higher than K3 arise, so there is a significant improvement vis-a-vis the known pulse-width modulation amplifiers.

9 Claims, 16 Drawing Sheets



