(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
12 November 2015 (12.11.2015)

WIPO | PCT

(10) International Publication Number
WO 2015/171931 A4

(51) International Patent Classification:
H03F 3/181 (2006.01) *H03F 3/217* (2006.01)

(21) International Application Number:
PCT/US2015/029747

(22) International Filing Date:
7 May 2015 (07.05.2015)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

61/990,363	8 May 2014 (08.05.2014)	US
62/072,059	29 October 2014 (29.10.2014)	US
62/090,142	10 December 2014 (10.12.2014)	US
14/706,587	7 May 2015 (07.05.2015)	US

(71) Applicant: **CIRRUS LOGIC, INC.** [US/US]; 800 West Sixth Street, Austin, Texas 78701 (US).

(72) Inventors: **KING, Eric J.**; 1050 Trail Head Circle, Dripping Springs, Texas 78620 (US). **MELANSON, John L.**; 90 West 9th Street, #201, Austin, Texas 78703 (US). **MARU, Siddharth**; 3500 Greystone Drive #212, Austin, Texas 78731 (US).

(74) Agents: **PREWITT, Brian K.** et al.; JACKSON WALKER L.L.P., 100 Congress Avenue, Suite 1100, Austin, Texas 78701 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*
— *with amended claims (Art. 19(1))*

Date of publication of the amended claims: 30 December 2015

(54) Title: SYSTEM WITH MULTIPLE SIGNAL LOOPS AND SWITCHED MODE CONVERTER

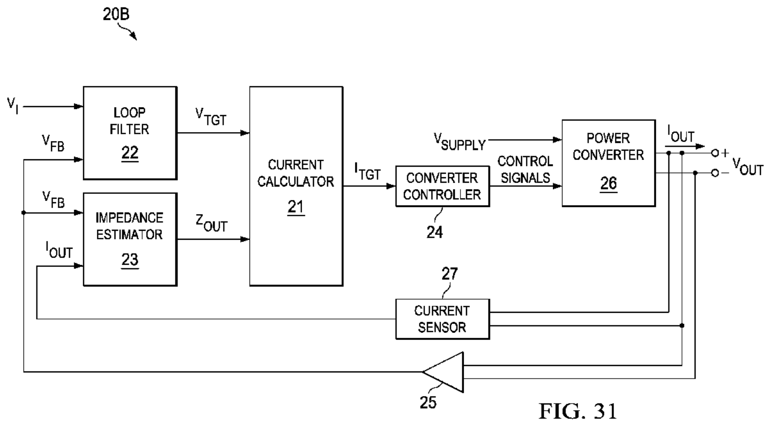

FIG. 31

(57) Abstract: In accordance with embodiments of the present disclosure, a system may include an impedance estimator configured to estimate an impedance of a load and generate a target current based at least on an input voltage and the impedance, a voltage feedback loop responsive to a difference between the input voltage and an output voltage of the load, and a current controller configured to, responsive to the voltage feedback loop, the impedance estimator, and the input voltage, generate an output current to the load.

WO 2015/171931 A4

AMENDED CLAIMS
received by the International Bureau on 16 November 2014 (16.11.2015)

1. A system, comprising:

an impedance estimator configured to estimate an impedance of a load and generate a target current based at least on an input voltage and the impedance;

a voltage feedback loop comprising a delta-sigma modulator, wherein the voltage feedback loop is responsive to a difference between the input voltage and an output voltage of the load; and

a current controller configured to, responsive to the voltage feedback loop, the impedance estimator, and the input voltage, generate an output current to the load to generate an output voltage that is a function of the input voltage.

2. The system of Claim 1, wherein the impedance of the load is estimated based on the output voltage and the output current.

3. (Cancelled)

4. The system of Claim 3, wherein the delta-sigma modulator is a continuous-time delta-sigma modulator.

5. The system of Claim 1, wherein the impedance estimator comprises an adaptive filter responsive to the output current and configured to estimate the impedance of the load in order to adaptively minimize a difference between the output voltage at the load and a target output voltage for the load based on the input voltage.

6. The system of Claim 5, wherein the adaptive filter is a least-mean-squares filter.

7. The system of Claim 1, wherein the input voltage comprises an audio signal and the load comprises an acoustic transducer.

8. The system of Claim 1, wherein the impedance estimator is configured to:

determine impedance of the load as a function of a frequency of the output voltage; and

control the target current to compensate for variance of the impedance as a function of the frequency.

9. The system of Claim 1, wherein the impedance estimator is configured to control the target current to compensate for variance of the impedance over time.

10. A method, comprising:

estimating an impedance of a load and generating a target current based at least on an input voltage and the impedance;

generating, with a voltage feedback loop comprising a delta-sigma modulator, a feedback voltage responsive to a difference between the input voltage and an output voltage of the load; and

responsive to the feedback voltage, estimated impedance of the load, and the input voltage, generating an output current to the load to generate an output voltage that is a function of the input voltage.

11. The method of Claim 10, wherein estimating the impedance of the load comprises estimating the impedance based on the output voltage and the output current.

12. (Cancelled)

13. The method of Claim 12, wherein the delta-sigma modulator is a continuous-time delta-sigma modulator.

14. The method of Claim 10, wherein estimating the impedance of the load comprises filtering responsive to the output current to adaptively minimize a difference between the output voltage at the load and a target output voltage for the load based on the input voltage

15. The method of Claim 14, wherein the adaptive filter is a least-mean-squares filter.

16. The method of Claim 10, wherein the input voltage comprises an audio signal and the load comprises an acoustic transducer.

17. The method of Claim 10, wherein estimating the impedance of the load comprises:

determining the impedance of the load as a function of a frequency of the output voltage; and

controlling the target current to compensate for variance of the impedance as a function of the frequency.

18. The method of Claim 10, wherein the impedance estimator is configured to control the target current to compensate for variance of the impedance over time.