UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/620,770	06/12/2017	AKHILESH KESAVANUNNITHAN	TI-77951	4032

23494 7590 06/23/2020
TEXAS INSTRUMENTS INCORPORATED
P O BOX 655474, MS 3999
DALLAS, TX 75265

EXAMINER	
NGUYEN, LINH V	

ART UNIT	PAPER NUMBER
2845	

NOTIFICATION DATE	DELIVERY MODE
06/23/2020	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

uspto@ti.com

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Ex parte AKHILESH KESAVANUNNITHAN,
SHARAT CHANDRA RUDRASAMUDRAM,
HENRY MANOJ D'SOUZA, and VIVEK VARIER

Appeal 2019-004612
Application 15/620,770
Technology Center 2800

Before MICHAEL P. COLAIANNI, JULIA HEANEY, and
MICHAEL G. McMANUS, *Administrative Patent Judges*.

McMANUS, *Administrative Patent Judge*.

DECISION ON APPEAL

Pursuant to 35 U.S.C. § 134(a), Appellant[1] seeks review of the Examiner's decision to reject claims 1–20. We have jurisdiction under 35 U.S.C. § 6(b).

We AFFIRM IN PART.

---

[1] We use the word "Appellant" to refer to "applicant" as defined in 37 C.F.R. § 1.42. Appellant identifies Texas Instruments Incorporated as the real party in interest. Appeal Brief (filed Jan. 24, 2019, hereinafter "Appeal Br.") 1.

CLAIMED SUBJECT MATTER

The present application generally relates to analog to digital converters ("ADCs"). Specification (filed June 12, 2017, hereinafter "Spec.") ¶ 9. ADCs are used to convert an analog signal into a digital signal. *Id.* The Specification teaches that, "[w]hen an ADC samples an analog signal, the characteristics of the ADC may introduce integral non-linearity (INL)." *Id.* ¶ 10. Non-linearity is an undesirable deviation between an input value and a measured output level. *Id.* The Specification further teaches that "[n]on-linearity causes unwanted harmonics in the output of an ADC. The unwanted harmonics cause spikes (e.g., images) in the frequency of the output (e.g., the digital signal), thereby degrading the output of the ADC." *Id.*

The Specification describes a method intended to alleviate the problems of conventional techniques by "determining INL in a fast, efficient manner that accounts for phase distortion and that is independent of ADC architecture (e.g., it can be used on any kind of ADC without customization)." *Id.* ¶ 11.

The Specification teaches that "[t]he phase of the harmonics [of the ADC output] is distorted with reference to the fundamental harmonic." *Id.* 13. The Specification further teaches that "examples disclosed herein correct the distortion by multiplying the output by a correction factor . . . [to generate] a more accurate representation of the INL of the ADC." *Id.*

Claim 1 is illustrative of the subject matter on appeal and is reproduced below with certain limitations bolded for emphasis:

1. An apparatus comprising:

> a signal interface to receive an output of an analog-to-digital converter (ADC), the output corresponding to a

> periodic signal transmitted to the ADC;
>
> a signal transformer **to determine at least harmonic amplitude and phase attributes** corresponding to the output; and;
>
> an integral non-linearity (INL) term calculator **to determine INL of the ADC based on a characteristic of the periodic signal and the harmonic attributes**.

Appeal Br. (Claims App. 1) (emphasis added).

REFERENCES

The Examiner relies upon the following prior art:

Name	Reference	Date
Lang	US 2009/0273499 A1	Nov. 5, 2009
Naka	US 2017/0053655 A1	Feb. 23, 2017

REJECTIONS

The Examiner maintains the following rejections:

1. Claims 1–4, 6–14, and 16–20 are rejected under 35 U.S.C. § 102(a)(1) as anticipated by Lang. Final Action (mailed June 28, 2018, hereinafter "Final Act.") 7–13.
2. Claims 5 and 15 are rejected under 35 U.S.C. § 103 as unpatentable over Lang in view of Naka. *Id.* at 13–14.

DISCUSSION

Rejection 1. The Examiner rejects claims 1–4, 6–14, and 16–20 as anticipated by Lang. *Id.* at 7–13. In support of the rejection, the Examiner finds, inter alia, that Lang teaches an error detection circuit that may be configured to perform a fast Fourier transform "to determine at least harmonic amplitude and phase attribute." Final Act. 7. The Examiner further finds that Lang teaches determination of "harmonic attributes as frequency and its amplitudes wherein phase is an inherent characteristic of amplitude." *Id.*

Appellant argues that the rejection is in error on several bases. Appeal Br. 7–21. Appellant argues independent claims 1, 11, and 20 collectively. *Id.* at 7–8. Appellant additionally argues certain dependent claims separately. *Id.* at 15–21.

Claims 1, 11, and 20

First, Appellant argues that Lang does not teach to determine "at least harmonic amplitude and phase attributes corresponding to the output" as required by claims 1, 11, and 20. Appeal Br. 8–13.

Appellant argues that while Lang "teaches a frequency analysis that 'identifies harmonics'. . . there is no further teaching or suggestion for further detecting or identifying 'harmonic amplitude and phase attributes corresponding to the output.'" *Id.* at 9. Thus, Appellant concludes that Lang does not teach to determine phase attributes corresponding to the ADC output.

Appellant further contends that Lang does not inherently teach to determine the harmonic phase attributes corresponding to the output. *Id.* at 10–13. Appellant asserts that phase and amplitude are unrelated, thus, phase is not an inherent characteristic of amplitude. *Id.* at 10–12.

In the Answer, the Examiner directs us to a portion of the Specification that teaches exemplary systems that "calculate a transform (e.g., a Fourier transform, fast Fourier transform, discrete Fourier transform, etc.) of the ADC output to obtain the amplitude and phase of individual harmonics." Answer 5 (citing Spec. ¶ 12); *see also* Spec. ¶ 24. The Examiner further directs us to a portion of Lang that teaches a "Fourier transform may be applied using a Fast Fourier Transform (FFT) implementation or a Discrete Fourier Transform (DFT) method." Lang ¶ 15 (emphasis omitted). Lang further teaches that "[t]he frequency analysis identifies harmonics." *Id.* (emphasis omitted). The Examiner determines that Lang's teaching to use a Fourier transform inherently teaches to determine the harmonic phase attributes. Answer 6–7.

This finding is supported. The Specification teaches that a Fourier transform will yield the amplitude and phase of individual harmonics. Spec. ¶ 12; *see also Hospira, Inc. v. Fresenius Kabi USA, LLC*, 946 F.3d 1322, 1329–30 (Fed. Cir. 2020) (explaining that "the work of the inventor or the patentee can be used as the evidence of inherency"). Further, we find Appellant's assertion that "'phase' and 'amplitude' are unrelated" (Appeal Br. 12) to be unpersuasive. Phase relates to the amplitude of a waveform at a given point in time.

As persons of scientific competence in the fields in which they work, examiners are responsible for making findings, informed by their scientific knowledge, as to the meaning of prior art references to persons of ordinary skill in the art. Absent legal error or contrary factual evidence, those findings can establish a prima facie case of unpatentability. *In re Berg*, 320 F.3d 1310, 1315 (Fed. Cir. 2003). Here, the Examiner determines that the Fourier transform of Lang would inherently disclose a device that determines the harmonic phase attributes corresponding to the output. Appellant has not shown error in this finding.

Second, Appellant argues that Lang does not teach to determine INL of the ADC based on a characteristic of the periodic signal and the harmonic attributes as required by claims 1, 11, and 20. Appeal Br. 13–15.

In the Final Action, the Examiner finds that Paragraphs 14–16 of Lang teach "the compensation 30 is to compute a compensated valued for non-linearity error[ ] to determine INL of the ADC (20) based on a characteristic of the periodic signal (14, 18) and the harmonic attribute (paragraph 0014-0016)." Final Act. 7–8 (regarding claim 1); *see also id.* at 10 (regarding claim 11); *see also id.* at 12–13 (regarding claim 20). This is more fully described in the Response to Arguments section of the Final Action where the Examiner explains as follows:

> Fig. 1 and paragraph 0014-0016 discloses the error detection circuit 28 to identify the non-linearity errors from the linear correction circuitry 24 and generates frequency error and its magnitudes to a compensation circuit 30 to identify a compensation values that remove the non-linearity errors identified by frequency components generate by the error detection circuit 28. Wherein the detection circuitry 28 implement a Fast Fourier Transformer (FFT) to identify the frequency components in the digital values received from linear correction circuit 24; and the frequency analysis by the circuit 28 identifies harmonics; compensation circuit 30 received the amplitude and identify frequency components from error detection circuit 28 and compute a least mean square minimization of the frequency components to generate a compensation values for linear correction circuitry 24. Thus Fig. 1 Lang clearly teaches an integral non-linearity (INL) term calculator 30 to determine INL (compensated value values for linearity correction 24) of the ADC 20 **based on a characteristic of the period signal (digital output of A/D 20 is based on characteristic period signal 14) and the harmonic attributes (frequency components identified by error detection circuit are attributes of harmonic)**.

Id. at 3–4 (emphasis altered).

Appellant argues that Paragraph 14 of Lang teaches that error detection circuit 28 analyzes the output of linearity detection circuit 24 to identify nonlinearity errors in the corrected digital output but fails to teach what to do after identifying the nonlinear errors. Appeal Br. 14–15. Appellant further argues that Paragraph 15 of Lang similarly fails to teach what to do with the identified harmonics and what aspects of the harmonics are determined or identified. *Id.* at 15. Appellant additionally argues that Paragraph 16 of Lang teaches only "that the 'amplitude and identify of the frequency components may be provided to the compensation circuit 30 that is coupled to the digital signal analyzer.'" *Id.* (citing Lang ¶ 16). Appellant concludes that Lang fails to teach to determine the INL of the ADC based on a characteristic of the periodic signal *and the harmonic attributes*. *Id.*

As discussed above, Lang teaches to use a Fourier transform to identify harmonics. Lang ¶ 15. Subsequently, compensation circuit 30 receives the amplitude and identify of the frequency components from error detection circuit 28. Lang ¶ 16; Final Act. 4. "The compensation circuit 30 is configured to minimize the frequency components identified in the compensated digital values other than the resonant frequency." Lang ¶ 16. Thus, as found by the Examiner, Lang teaches to determine INL of the output of ADC 20 based on characteristics of the periodic signal 14 (including frequency) and frequency components identified by error detection circuit as harmonic.

In view of the foregoing, Appellant has not shown error in the rejection of independent claims 1, 11, and 20.

Claims 2 and 3

Appellant relies on the arguments presented above with regard to its appeal of the rejection of claims 2 and 3. As we have not found such arguments to be persuasive, we determine that Appellant has not shown error with regard to the rejection of claims 2 and 3.

Claims 4 and 14

Appellant seeks review of the rejection of claims 4 and 14. Appeal Br. 16, 18–19. Claim 4 depends from claim 3 which, in turn, depends from claim 1. *Id.* (Claims App. 1). Claim 4 further requires that "the INL term calculator determines the INL based on a harmonic phase to correct for Fourier transform phase distortion." *Id.* Claim 14 is a method claim depending from claims 13 and 11 which is similar in scope to claim 4. *Id.* (Claims App. 3).

Appellant asserts that "[t]here is simply no teaching or suggestion in Lang for 'wherein the INL term calculator determines the INL based on a harmonic phase to correct for Fourier transform phase distortion.'" *Id.* at 16 (emphasis omitted).

The Examiner finds that "[r]egarding claim 4, the apparatus of claim 3, Fig. 1 further discloses wherein the INL term calculator (30) determines the INL (non-linearity compensated) based on a harmonic phase (output of 28 to 30) to correct for Fourier transform phase distortion (paragraph 0014)."

The Specification teaches the following regarding phase distortion in conventional techniques:

> Another **conventional technique** includes extracting INL from a **fast Fourier transform (FFT)**. However, such a technique will not capture the effects of high frequency components in the INL. Accordingly **approximating the INL and correction factor for phase distortion caused by the FFT is not accounted for**, leading to an inaccurate INL determination.

Spec. ¶ 11 (emphasis added). The Specification additionally teaches a method of correcting for Fourier transform phase distortion as follows:

> [T]he example INL term calculator 206 calculates an INL term corresponding to the example ADC 102 using Chebyshev polynomials. For example, the INL calculator 206 based on $\sum_{n=2}^{\infty} A_n T_n(n\omega t + \varphi_n) \cos(\varphi_n - n\varphi_1)$, where (i) ω and A_n correspond to the period/frequency and amplitude of the generated sinusoid, (ii) $T_n(n\omega t + \varphi_n)$ are the Chebyshev polynomials of $\cos(n\omega t + \varphi_n)$ for 2^N values between -1 and 1 where N corresponds to the resolution of the example ADC 102 and (iii) $\cos(\varphi_n - n\varphi_1)$ **utilizes the phase of the nth harmonic and the phase of the fundamental harmonic to correct for the Fourier transform phase distortion**.

Spec. ¶ 34 (emphasis added).

In the Answer, the Examiner finds that Lang teaches or suggests a phase attribute inherent "for the same reason of Fourier Transform as applied to claim 1 above, associated with the identified harmonics in ¶ [0015], ¶ [0014] similarly [teaches] or suggest[s] 'harmonics' (¶ 0015) associated with the non- linearity errors in ¶ [0014] in the corrected digital output (corrected output of 24)." Answer 8. This is inadequate.

As discussed above, one may conclude that Lang teaches the use of a fast Fourier transform that inherently determines phase attributes and "a characteristic of the periodic signal and the harmonic attributes." *See* Lang ¶¶ 14–16. The Examiner has not shown, however, that the fast Fourier transform inherently requires the use of phase information to correct for the Fourier transform phase distortion.

Claims 6 and 16

Appellant seeks review of the rejection of claims 6 and 16. Appeal Br. 16–17, 19–20. Claim 6 depends from claim 1 and additionally requires "a signal generator to: enable the periodic signal from[2] being input into the ADC; and after the INL is determined, disable the periodic signal from being input into the ADC." *Id.* (Claims App. 2). Claim 16 depends from claim 11 and is similar in scope to claim 6.

The Examiner relies, in part, on Figure 1 of Lang as teaching the elements of these claims. Final Act. 8–9. Figure 1 of Lang is reproduced below.

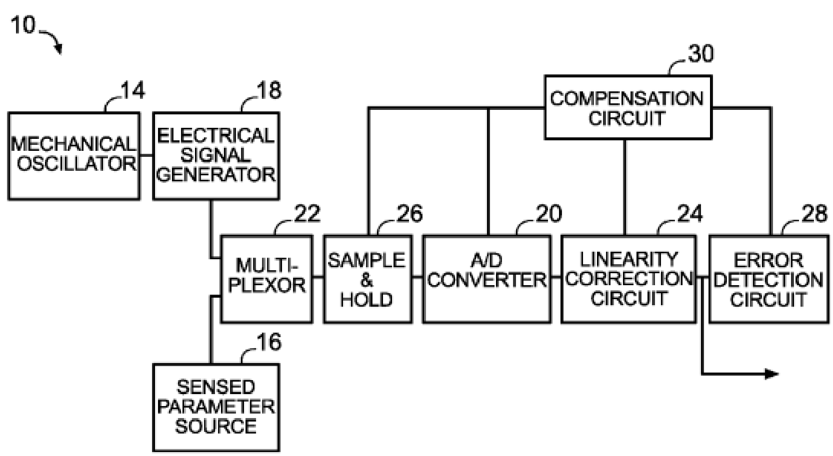

Figure 1 "is a block diagram of a system that generates compensation values that correct non-linearity errors in the digital output of a minimum transistor circuit." Lang ¶ 7. In rejecting claim 6, the Examiner finds that Lang

[2] We do not presently consider whether the claim terms "enable . . . from" as used in claim 6 and "enabling . . . from" as used in claim 16 comply with the requirements of 35 U.S.C. § 112(b) regarding indefiniteness.

teaches "signal generator (22) is to: enable the periodic signal (18) from being input into the ADC (20); and after the INL (28, 30) is determined, disable the periodic signal." Final Act. 8. Lang, however, does not teach a "signal generator (22)." Lang, Figure 1; *id.* ¶¶ 10, 11. Rather, it teaches electrical signal generator 18 and multiplexor 22. Lang ¶¶ 10, 11.

In its principal brief, Appellant asserts that the "Examiner identifies multiplexor 22 as being the signal generator that performs the above limitation . . . . [The] Examiner's determination, however, is not supported by paragraph [0011]." Appeal Br. 16. Appellant makes a similar argument with regard to claim 16. *See id.* at 19–20.

In the Answer, the Examiner clarifies that

> Figs. 1 and 2 of Lang [teach] **a signal generator (14, 18)** to: 'enable (22) the periodic signal (14, 18) from being [i]nput (see step 204 in Fig. 2) into the ADC 20['] and 'after (step 230 after step 226 in Fig. 2) the INL is determined (see step 226 in Fig. 2), disable (see step 230 which is switching to reference parameter source 16 in Fig. 1); for disable (switching the input to ADC to sense parameter source 16) from the periodic signal (Oscillation 14, 18) from being input into the ADC (20).'

Answer 10 (emphasis added); *see id.* at 16 (regarding claim 16). Thus, the Examiner relies upon the signal generator of Lang as teaching the "signal generator" of claim 6.

In its Reply Brief, Appellant's "traverse Examiner's new determination as . . . electrical signal generator 18 is an analog signal generator." Reply Br. 12 (citing Lang ¶ 9, ll. 4–5). Appellant however, does not explain why an analog signal generator may not satisfy the "signal generator" limitation of claim 6.

Accordingly, Appellant has not shown error in regard to the rejection of claims 6 and 16.

Claims 7–13 and 17–19

Appellant does not present separate argument for claims 7–13 or 17–19. Appeal Br. 17–18, 20–21. In support of its appeal of the rejection of claims 7–10, Appellant relies on its arguments relating to claim 1. *Id.* at 17–18. In support of its appeal of the rejection of claims 12, 13, and 17–19, Appellant relies on its arguments relating to claim 11. *Id.* at 18, 20–21.

As we have not found such arguments to be persuasive, we determine that Appellant has not shown error in regard to the rejection of claims 7–13 and 17–19.

Rejection 2. The Examiner rejects claims 5 and 15 as obvious over Lang in view of Naka. Claim 5 is generally similar in scope to claim 1 but additionally requires "wherein the INL term calculator determines the INL using Chebyshev polynomials." Appeal Br. (Claims App. 1–2). Claim 15 is generally similar to claim 11 but additionally requires "determining, using Chebyshev polynomials, the INL of the ADC based on a characteristic of the periodic signal and the harmonic attribute." *Id.* (Claims App. 2–3).

The Examiner acknowledges that Lang does not teach an INL calculator using Chebyshev polynomials. Final Act. 13. The Examiner finds, however, that Naka teaches the use of Chebyshev polynomials. *Id.* The Examiner determines that one of ordinary skill in the art would have had reason to "incorporate the calculation for linearity using Chebyshev polynomials of Naka into calculation for linearity of Lang; since Lang and

Naka [pertain to] common subject matter of calculation for linearity and Chebyshev polynomials calculation for linearity is well known and conventional in the art as suggested by Naka." *Id.* at 14. The Examiner further determines that use of Chebyshev polynomials would permit one to "more effectively calculate the power spectrum." *Id.*; *see also* Answer 21–23.

Appellant argues that the Examiner has not shown an adequate reason to combine the teachings of Lang and Naka. Appeal Br. 21–26. Appellant contends that "Naka teaches its use of Chebyshev polynomials is often used for modeling of a short-term spectral envelope in speech and audio coding, which is completely unrelated to Lang's system and method for improving linearity of electronic circuits with mechanical oscillators in which the output of an A/D converter is monitored for nonlinearity errors." *Id.* at 25. Appellant further argues that a person of ordinary skill in the art would not have had reason "to combine Lang with Naka as they [disclose] different solutions to different problems in different technologies." *Id.*

The thrust of Appellant's argument is that Naka teaches the use of Chebyshev polynomials in a technological environment that differs from Lang. This, however, is not directly responsive to the Examiner's determination. The Examiner determines that Lang and Naka both concern "linearity compensation." Answer 21. The Examiner further determines that one of skill in the art would have had reason to "incorporate the calculation for linearity using Chebyshev polynomials suggested by Naka into calculation for linearity (linear calculation by 30) of Lang . . . [to] more effectively calculate the power spectrum by using Chebyshev polynomials." Appellant has not shown error in this reasoning. *Id.*

CONCLUSION

The Examiner's rejections of claims 1–3, 5–13, and 15–20 are affirmed. The Examiner's rejection of claims 4 and 14 is reversed.

In summary:

Claims Rejected	35 U.S.C. §	Reference(s)/Basis	Affirmed	Reversed
1–4, 6–14, and 16–20	102(a)(1)	Lang	1–3, 6–13, 16–20	4, 14
5, 15	103	Chow	5, 15	
Overall Outcome			1–3, 5–13, 15–20	4, 14

AFFIRMED IN PART