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Fernandez et al.

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(54) **METHOD AND APPARATUS FOR PRODUCING A LINEARIZED AMPLIFIED CONTINUOUS WAVE (CW) SIGNAL**

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(51) **Int. Cl.**
H03M 1/00 (2006.01)

(52) **U.S. Cl.** **341/142**; 341/144

(58) **Field of Classification Search** 341/142, 341/144

See application file for complete search history.

(56) **References Cited**

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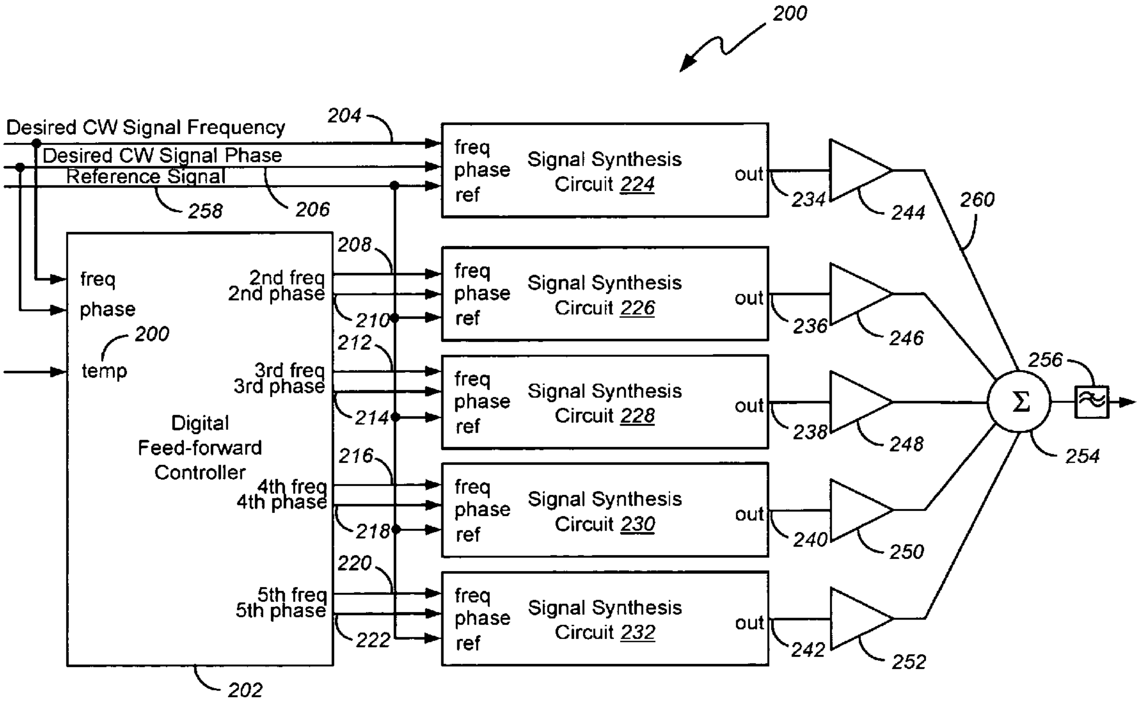
* cited by examiner

Primary Examiner—Khai M Nguyen

(57) **ABSTRACT**

In one embodiment, at least one parameter set for at least one harmonic of a continuous wave (CW) signal is digitally generated in response to a parameter set for the CW signal. In response to the parameter set for the CW signal, the CW signal is synthesized; and in response to the at least one parameter set for the at least one harmonic of the CW signal, at least one nulling tone is synthesized. The CW signal and the at least one nulling tone are amplified; and the amplified CW signal and the at least one amplified nulling tone are summed to produce a linearized amplified CW signal. Other embodiments are also described.

20 Claims, 9 Drawing Sheets



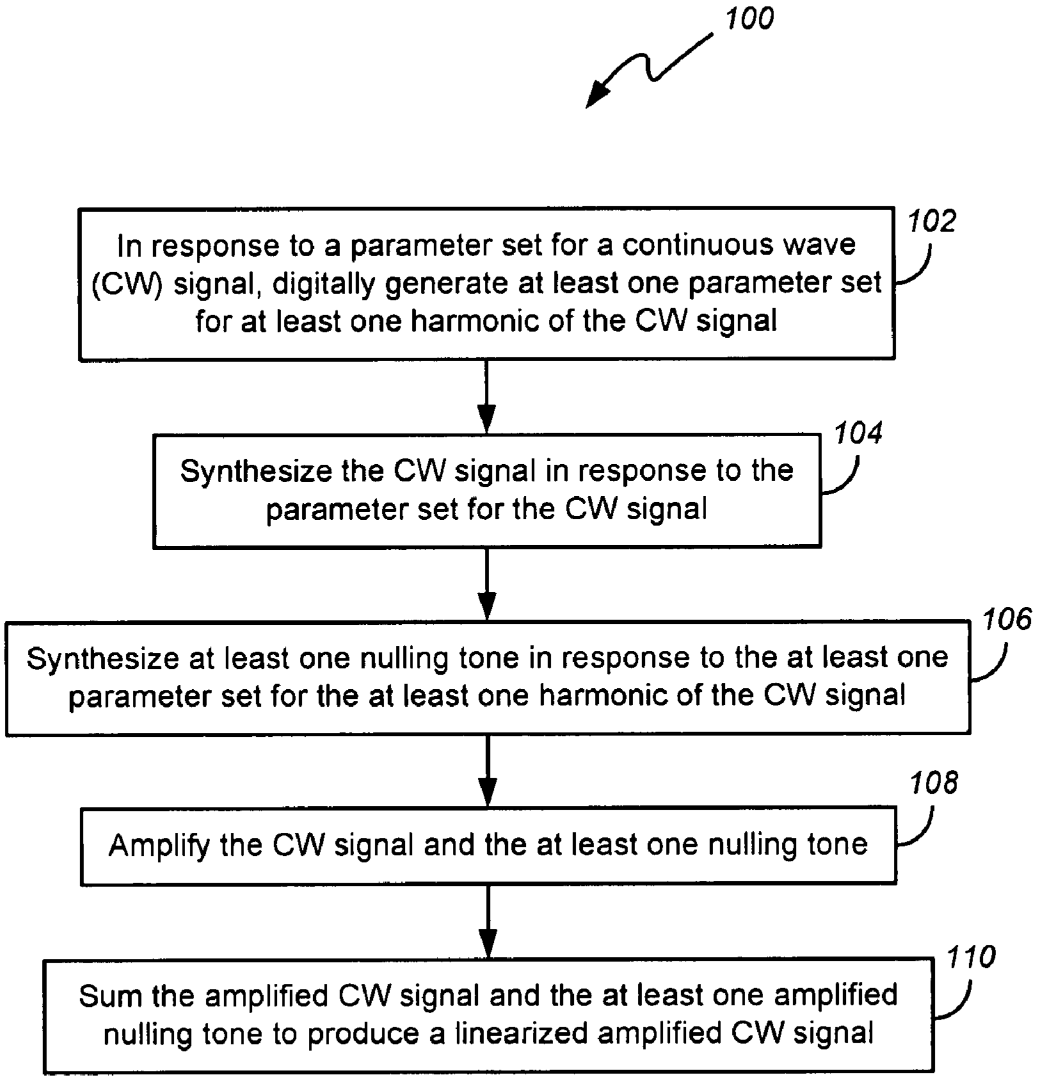

100
102
In response to a parameter set for a continuous wave (CW) signal, digitally generate at least one parameter set for at least one harmonic of the CW signal
104
Synthesize the CW signal in response to the parameter set for the CW signal
106
Synthesize at least one nulling tone in response to the at least one parameter set for the at least one harmonic of the CW signal
108
Amplify the CW signal and the at least one nulling tone
110
Sum the amplified CW signal and the at least one amplified nulling tone to produce a linearized amplified CW signal

FIG. 1

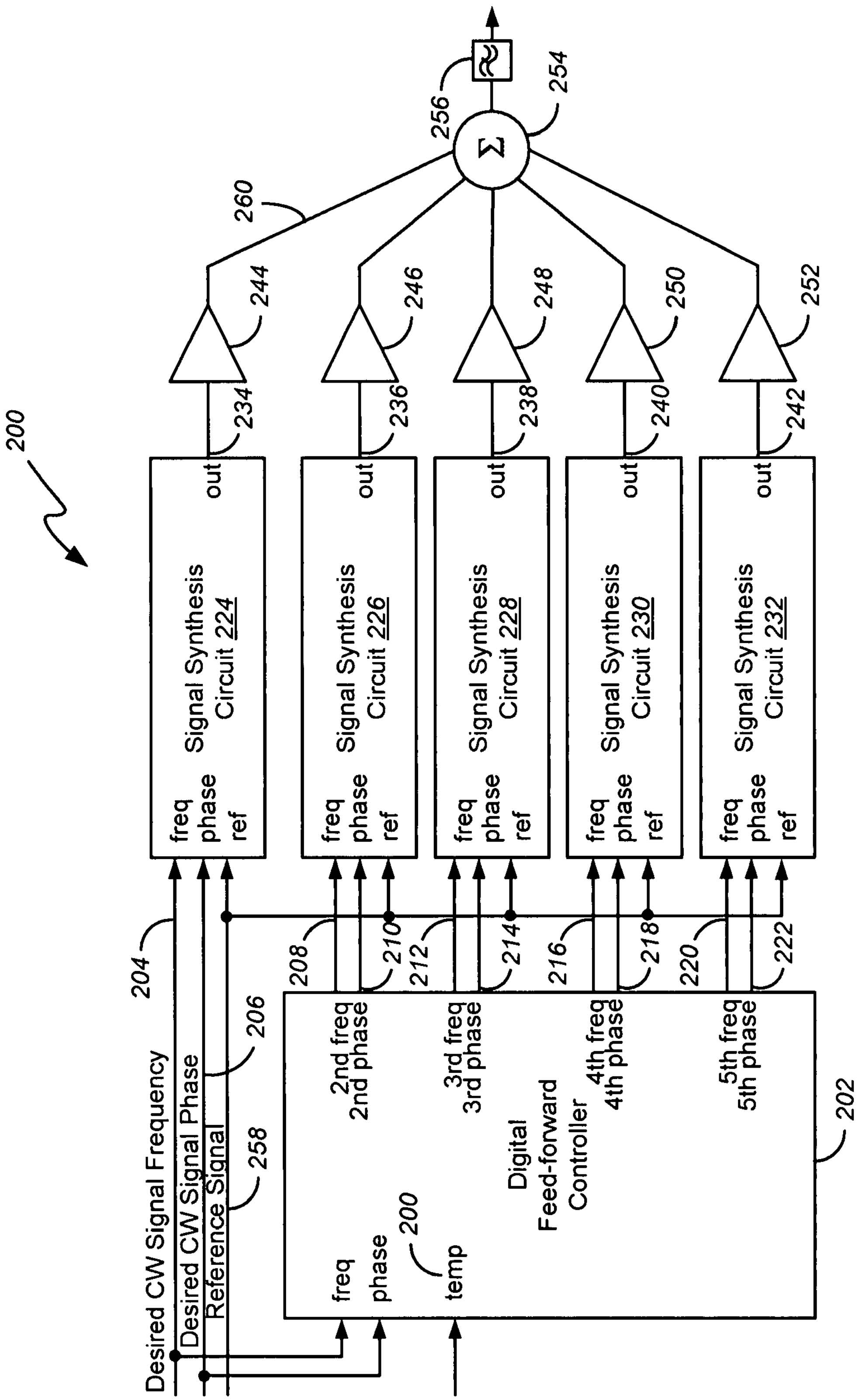

200
Desired CW Signal Frequency
Desired CW Signal Phase
Reference Signal
204
206
258
freq
phase
temp
200
Digital
Feed-forward
Controller
202
2nd freq
2nd phase
3rd freq
3rd phase
4th freq
4th phase
5th freq
5th phase
208
210
212
214
216
218
220
222
freq
phase
ref
Signal Synthesis
Circuit 224
Circuit 226
Circuit 228
Circuit 230
Circuit 232
out
234
236
238
240
242
244
246
248
250
252
260
Σ
254
256

FIG. 2

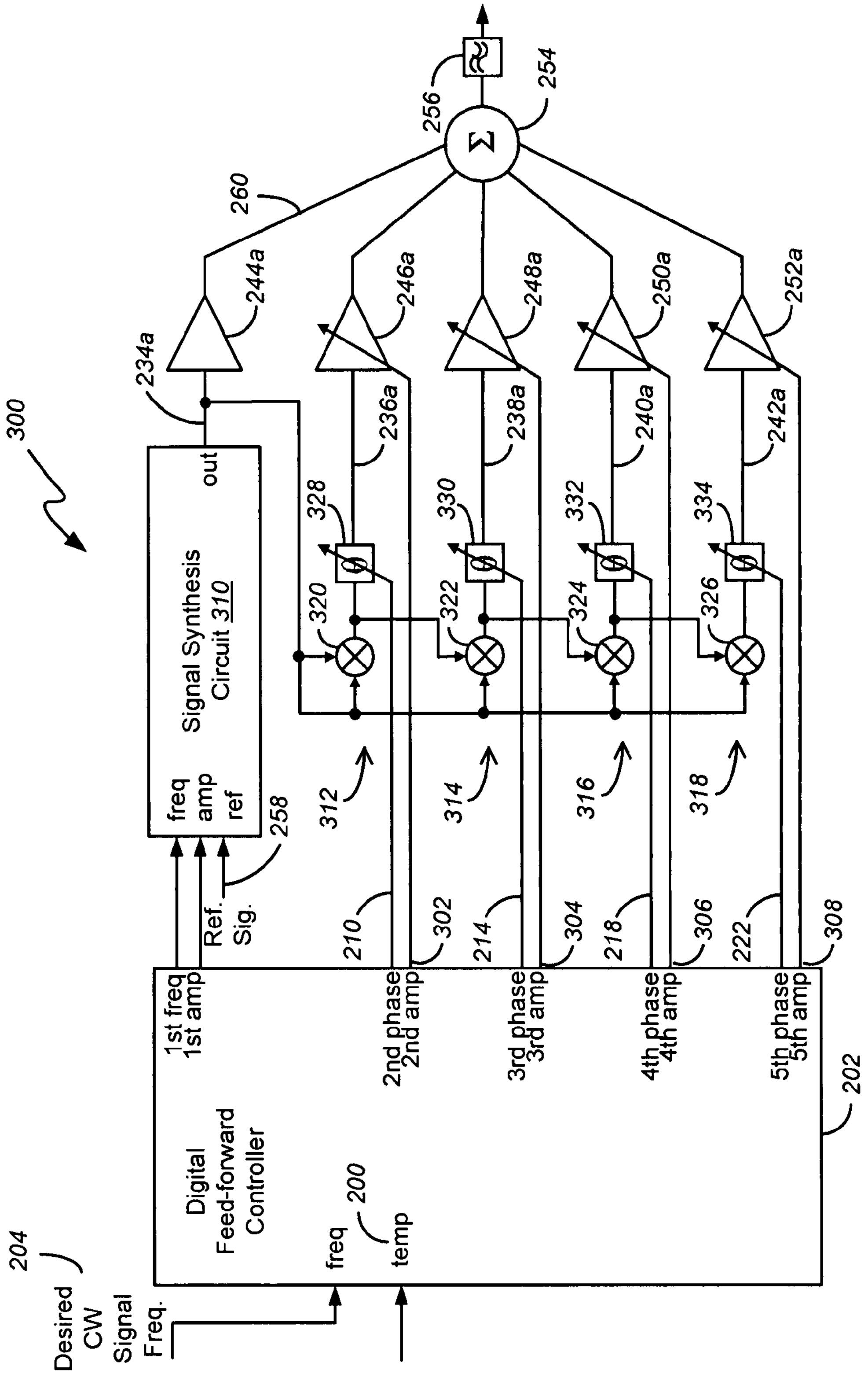

300
Desired CW Signal Freq.
204
freq
temp
200
Digital Feed-forward Controller
202
1st freq
1st amp
2nd phase
2nd amp
3rd phase
3rd amp
4th phase
4th amp
5th phase
5th amp
Ref. Sig.
258
freq
amp
ref
Signal Synthesis Circuit 310
out
234a
244a
260
210
302
214
304
218
306
222
308
312
314
316
318
320
322
324
326
328
330
332
334
236a
238a
240a
242a
246a
248a
250a
252a
254
256
Σ
θ

FIG. 3

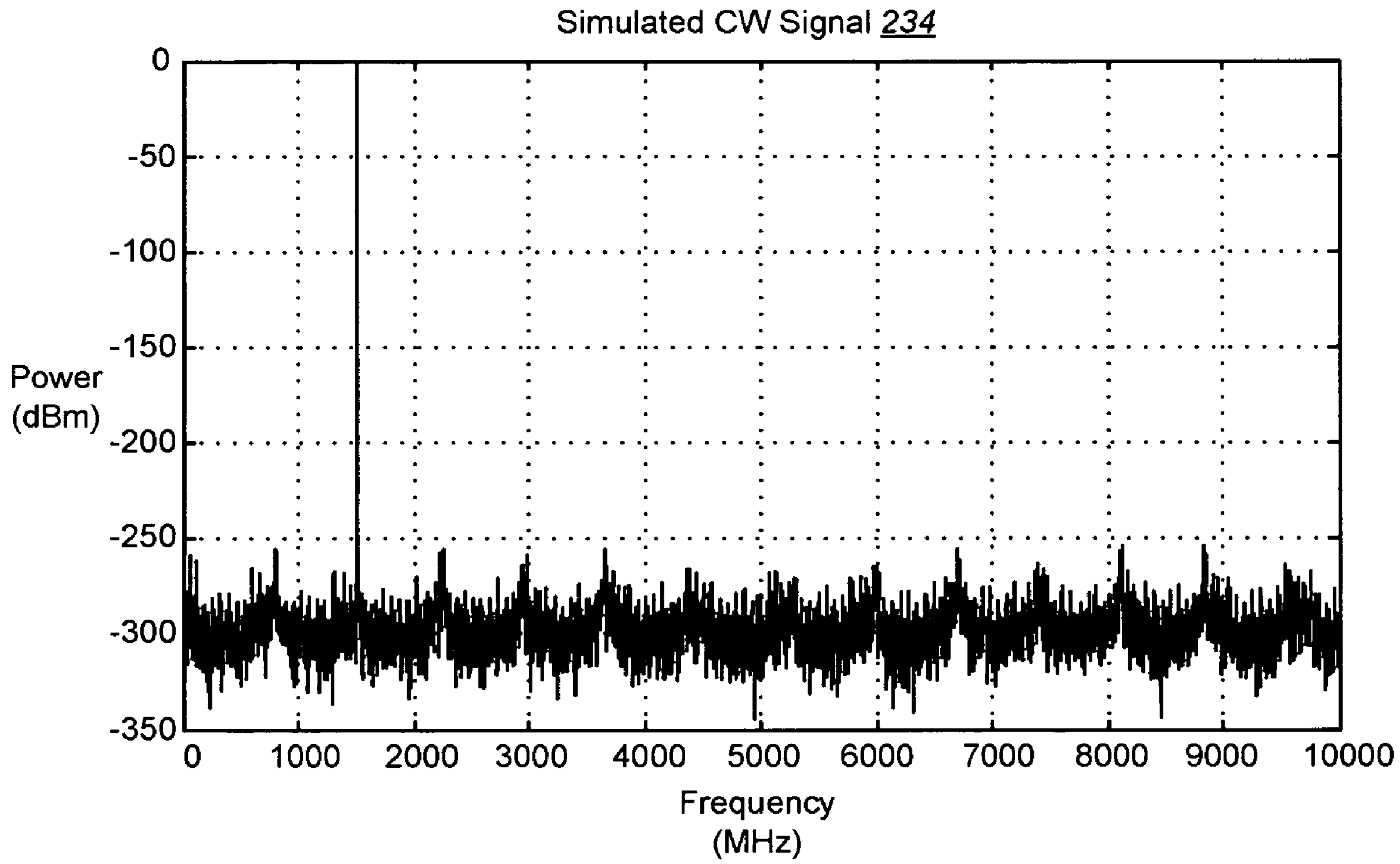

Simulated CW Signal 234
Power
(dBm)
0
-50
-100
-150
-200
-250
-300
-350
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
Frequency
(MHz)

FIG. 4

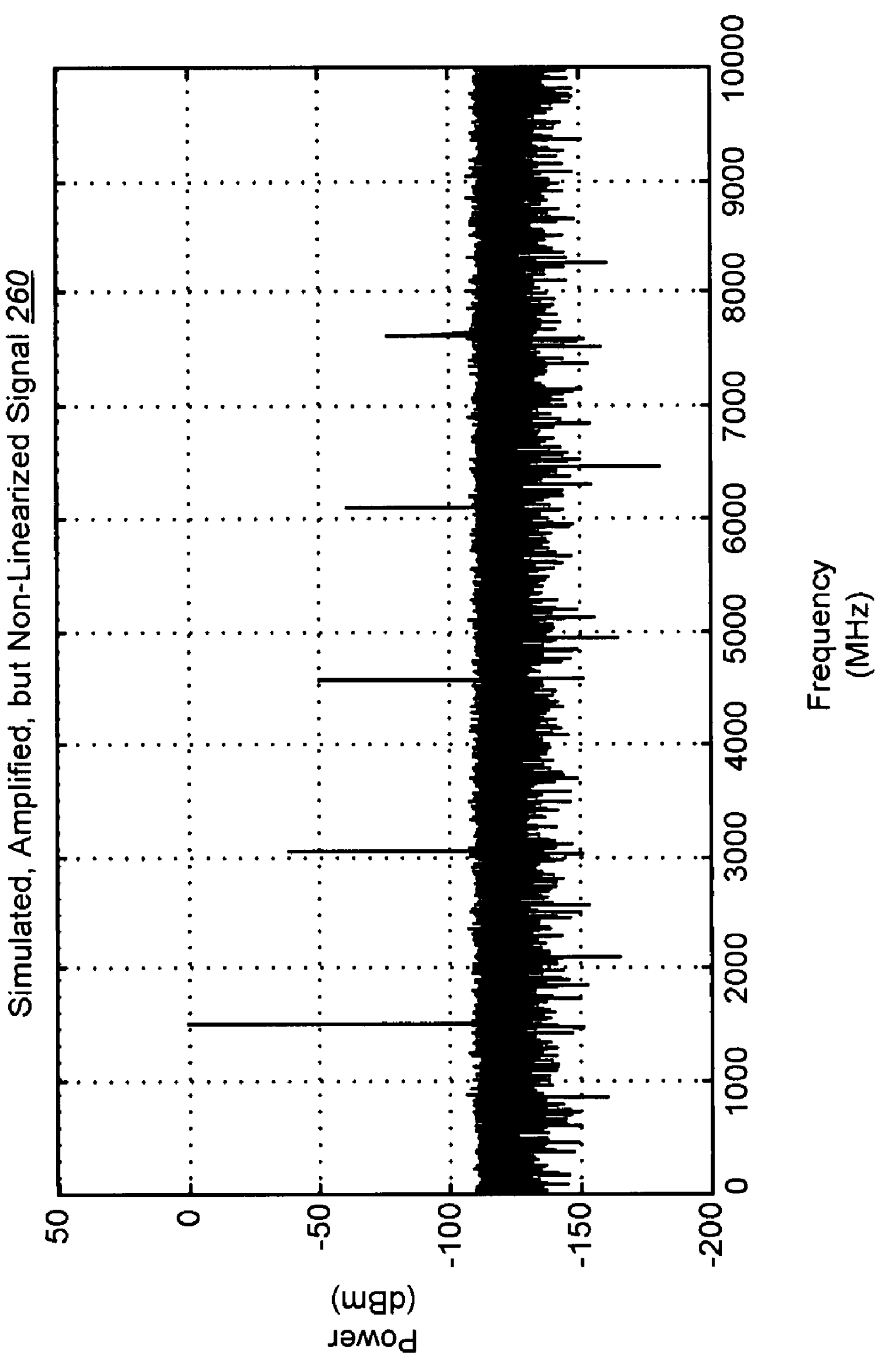

Simulated, Amplified, but Non-Linearized Signal 260

FIG. 5

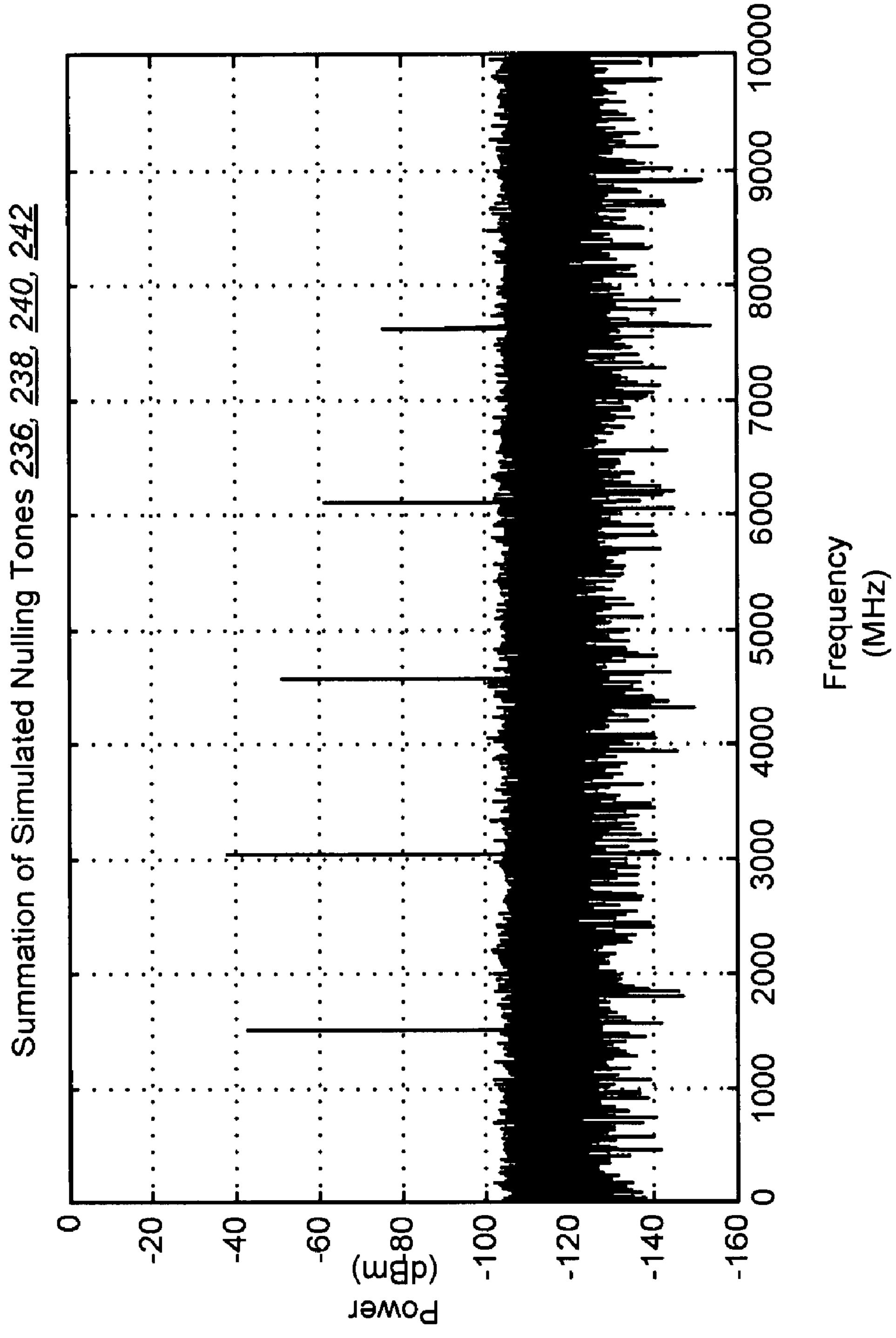

Summation of Simulated Nulling Tones 236, 238, 240, 242
Power
(dBm)
0
-20
-40
-60
-80
-100
-120
-140
-160
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
Frequency
(MHz)

FIG. 6

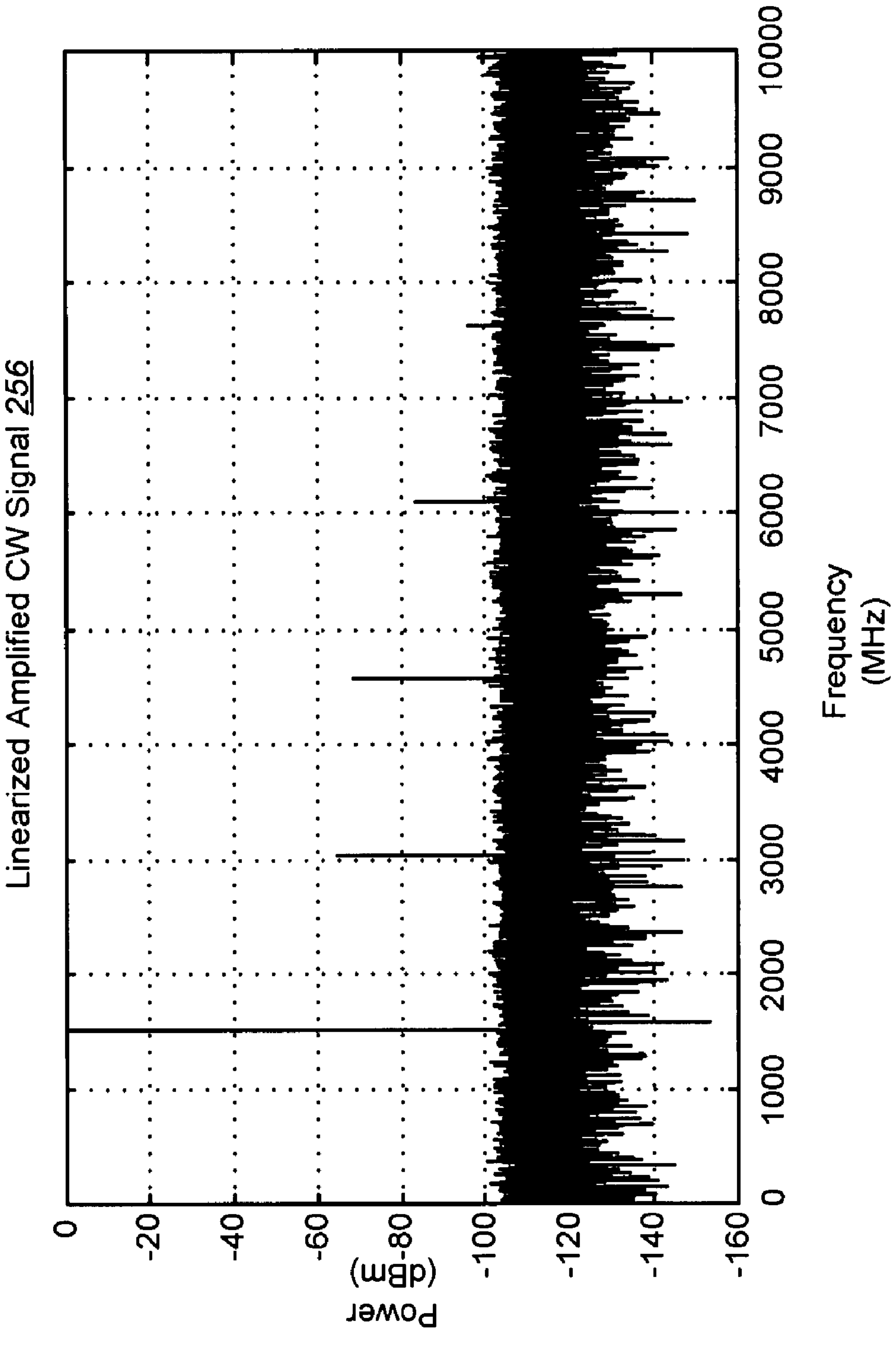

Linearized Amplified CW Signal 256
Power
(dBm)
0
-20
-40
-60
-80
-100
-120
-140
-160
Frequency
(MHz)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000

FIG. 7

Spur Levels Before and After Linearization

	f_c	$2*f_c$	$3*f_c$	$4*f_c$	$5*f_c$
Uncorrected PA Spur Level (dBc)	0.058	-38.43	-50.16	-60.87	-76.42
Feedforward Nulling Spur Level	-	-38.14	-51.28	-61.52	-75.58
Magnitude estimate error	-	8%	-20%	-7%	12%
Corrected PA Spur Level (dBc)	0.058	-67.74	-68.46	-83.38	-93.81

FIG. 8

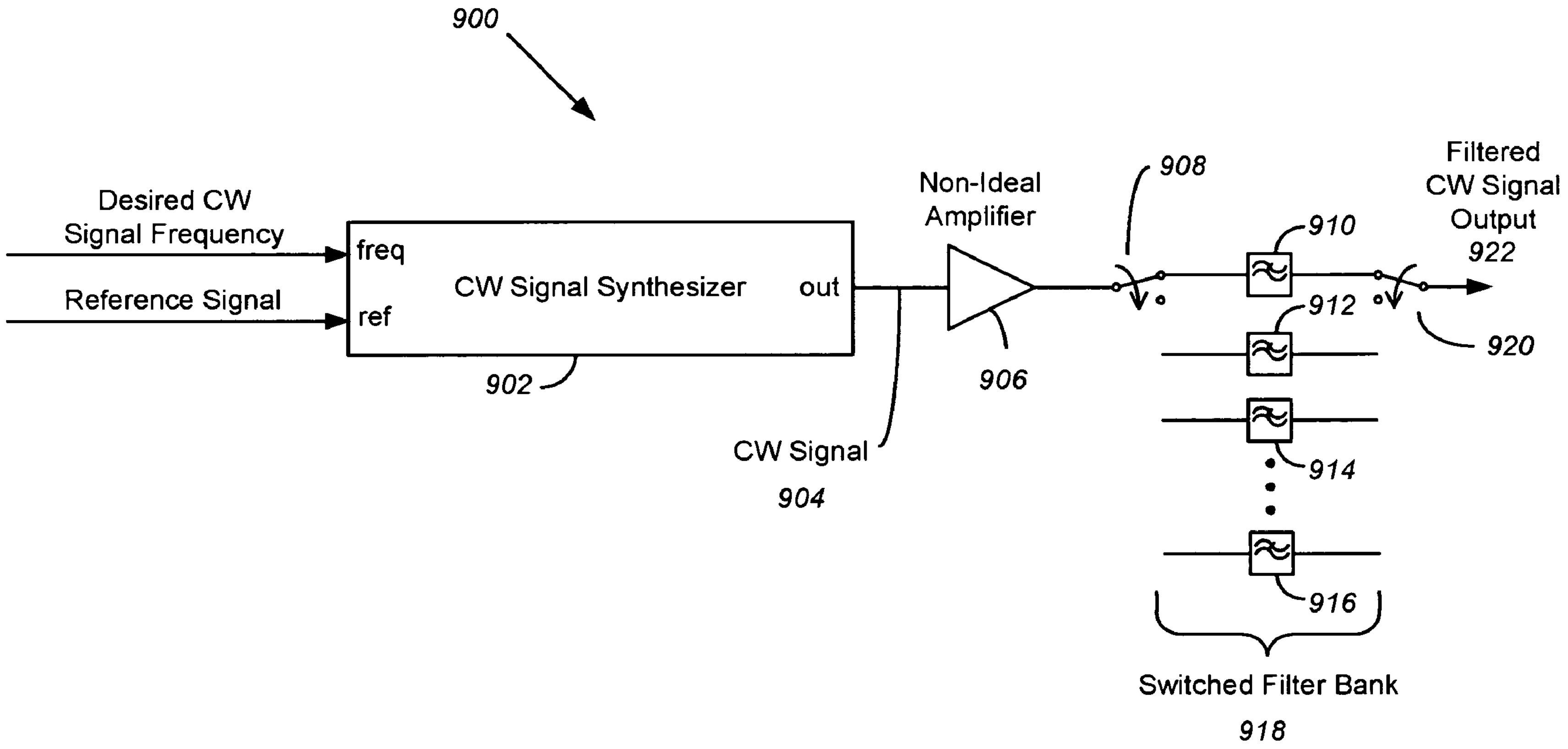

900
Desired CW
Signal Frequency
Reference Signal
freq
ref
CW Signal Synthesizer
out
902
CW Signal
904
Non-Ideal
Amplifier
906
908
910
912
914
916
Filtered
CW Signal
Output
922
920
Switched Filter Bank
918

FIG. 9

METHOD AND APPARATUS FOR PRODUCING A LINEARIZED AMPLIFIED CONTINUOUS WAVE (CW) SIGNAL

BACKGROUND

The traditional way to remove unwanted harmonics from a continuous wave (CW) signal, and thereby linearize the CW signal, is to filter the CW signal after amplification. Exemplary apparatus **900** for doing this is shown in FIG. **9** and comprises a signal synthesizer **902**, a non-ideal amplifier **906** and a switched filter bank **918**. In operation, the CW signal synthesizer **902** receives an indication of a desired CW signal frequency (at input freq) and a reference signal (at input ref), and in response synthesizes a CW signal **904**. The CW signal **904** is then amplified by the amplifier **906**, and the amplified CW signal is filtered by a filter of the switched filter bank **918**.

When the frequency of the CW signal **904** changes (i.e., because of a change in the desired CW signal frequency), the frequencies of the harmonics produced by the amplifier **906** also change. That is, the 2nd harmonic is located at $2*f_c$, the third at $3*f_c$, and so on (where f_c is the frequency of the CW signal **904**). Because the filters **910**, **912**, **914**, **916** of the switched filter bank **918** are typically built with passive components, and have fixed passbands and stopbands, changes in the harmonics produced by the amplifier **906** require different filters **910**, **912**, **914**, **916** to be switched into the signal path between the amplifier **906** and the filtered CW signal output **922** (e.g., via switches **908** and **920**).

The above approach works well so long as the unwanted harmonics produced by the amplifier **906** are sufficiently suppressed by the filters **910**, **912**, **914**, **916** of the switched filter bank **918**. However, if the filters **910**, **912**, **914**, **916** do not provide adequate filtering over a wide enough range of frequencies, the performance of the apparatus **900** shown in FIG. **9** can suffer.

BRIEF DESCRIPTION OF THE DRAWINGS

Illustrative embodiments of the invention are illustrated in the drawings, in which:

FIG. **1** illustrates an exemplary method for producing a linearized amplified CW signal;

FIG. **2** illustrates first exemplary apparatus for implementing the method of FIG. **1** and other methods;

FIG. **3** illustrates second exemplary apparatus for implementing the method of FIG. **1** and other methods;

FIG. **4** illustrates a simulated CW signal of the apparatus shown in FIG. **2**;

FIG. **5** illustrates a simulated output of one of the non-ideal amplifiers shown in FIG. **2**, in response to the simulated CW signal shown in FIG. **4**;

FIG. **6** illustrates a summation of simulated nulling tones produced by the apparatus shown in FIG. **2**;

FIG. **7** illustrates a simulated linearized amplified CW signal produced by the apparatus shown in FIG. **2**, in response to the simulated CW signal shown in FIG. **4** and the simulated nulling tones shown in FIG. **6**;

FIG. **8** illustrates simulated spur levels before and after linearization, in the context of the apparatus shown in FIG. **2**, the simulated CW signal shown in FIG. **4**, and the simulated nulling tones shown in FIG. **6**; and

FIG. **9** illustrates exemplary apparatus for removing unwanted harmonics from a CW signal, by filtering the CW signal after amplification.

DETAILED DESCRIPTION

FIG. **1** illustrates an exemplary new method **100** for producing a linearized amplified CW signal. In accord with the method **100**, at least one "parameter set", for at least one harmonic of a CW signal, is digitally generated in response to a "parameter set" for the CW signal (at block **102**). Each of the parameter sets may include, for example, a frequency indicator, an amplitude indicator, and/or a phase indicator. In response to the parameter set for the CW signal, the CW signal is synthesized (at block **104**); and in response to the at least one parameter set for the at least one harmonic of the CW signal, at least one nulling tone is synthesized (at block **106**). The CW signal and the at least one nulling tone are amplified (at block **108**); and the amplified CW signal and the at least one amplified nulling tone are then summed to produce a linearized amplified CW signal (at block **110**).

By way of example, the method **100** may be implemented by apparatus **200** such as that which is illustrated in FIG. **2**. The apparatus **200** comprises a digital feed-forward controller **202** that is configured to, in response to a parameter set for a CW signal, generate at least one parameter set for at least one harmonic of the CW signal. By way of example, the parameter set for the CW signal is shown to comprise a frequency indicator **204** (i.e., a desired CW signal frequency received at the freq input of the controller **202**) and a phase indicator **206** (i.e., a desired CW signal phase received at the phase input of the controller **202**). Similarly, and by way of example, each of the parameter sets for the harmonics of the CW signal is shown to comprise a frequency indicator and a phase indicator (labeled in FIG. **2** as 2nd freq **208** and 2nd phase **210**, 3rd freq **212** and 3rd phase **214**, 4th freq **216** and 4th phase **218**, and 5th freq **220** and 5th phase **222**).

The apparatus **200** further comprises a plurality of signal synthesis circuits **224**, **226**, **228**, **230**, **232**, including i) a first signal synthesis circuit **224** configured to synthesize the CW signal **234** in response to the parameter set for the CW signal, and ii) at least one additional signal synthesis circuit **226**, **228**, **230**, **232** configured to respectively synthesize at least one nulling tone **236**, **238**, **240**, **242** in response to the at least one harmonic of the CW signal. Of note, the signal synthesis circuits **224**, **226**, **228**, **230**, **232** function as digital-to-analog converters.

The apparatus **200** further comprises a plurality of non-ideal amplifiers **244**, **246**, **248**, **250**, **252** for respectively amplifying the CW signal **234** and at least one nulling tone **236**, **238**, **240**, **242** output from the signal synthesis circuits **224**, **226**, **228**, **230**, **232**. In some embodiments, the non-ideal amplifiers **244**, **246**, **248**, **250**, **252** may be power amplifiers, although they need not be. A summer **254** sums the amplified CW signal and at least one amplified nulling tone to produce a linearized amplified CW signal **256**.

Preferably, each of the signal synthesis circuits **224**, **226**, **228**, **230**, **232** receives a common reference signal **258**, such as a 10 MHz sign wave, and is configured to phase lock to the common reference signal **258**.

The digital feed-forward controller **202** (or means for generating at least one parameter set for at least one harmonic of the CW signal) may be implemented in various ways. In one embodiment, the digital feed-forward controller **202** may comprise one or more lookup tables, and the parameter set(s) for the CW signal harmonic(s) may be generated by indexing one or more lookup tables in response to the parameter set for the CW signal. In another embodiment, the digital feed-forward controller **202** may comprise one or more digital filters that generate the parameter set(s) for the CW signal harmonic(s) in response to the parameter set for the CW signal. In still another embodiment, the digital feed-forward controller **202** may implement a mathematical function, such as a polynomial function, to derive the parameter set(s) for the CW signal harmonic(s) from the parameter set for the CW signal.

The complexity of the table(s), filter(s) or function(s) implemented by the digital feed-forward controller **202** may vary depending on the characteristics of the non-ideal amplifiers **244**, **246**, **248**, **250**, **252** and the degree of linearization desired. Preferably, the digital feed-forward controller **202** is calibrated (e.g., at the factory or on power-up) to account for the characteristics of the amplifiers **244**, **246**, **248**, **250**, **252**. Calibration may comprise measuring the phases and amplitudes of the harmonics produced by the amplifiers **244**, **246**, **248**, **250**, **252**. In some cases, calibration may take into account the characteristics of each amplifier **244**, **246**, **248**, **250**, **252**, and in other cases, calibration may assume that all of the amplifiers **244**, **246**, **248**, **250**, **252** have substantially identical characteristics, or that the characteristics of the amplifier **244** are determinative.

The characteristics of the non-ideal amplifiers **244**, **246**, **248**, **250**, **252** will often vary with temperature, and the amplitudes and phases of their harmonics are therefore likely to change with temperature. As a result, the digital feed-forward controller **202** may be calibrated for different operating temperatures, and the digital feed-forward controller **202** may be configured to generate the parameter set(s) for the CW signal harmonic(s) in response to a temperature of one or more of the amplifiers **244**, **246**, **248**, **250**, **252**.

As already mentioned, calibration of the digital feed-forward controller **202** may be performed at the factory or on power-up. The latter can be facilitated, for example, by a radio frequency (RF) measurement path between the amplifier **244** and a measurement circuit of a device (e.g., an instrument) in which the apparatus **200** is installed.

The signal synthesis circuits **224**, **226**, **228**, **230**, **232** (or means for synthesizing the CW signal in response to the parameter set for the CW signal, and means for synthesizing at least one nulling tone in response to the at least one harmonic of the CW signal) may also be implemented in various ways. Preferably, the signal synthesis circuits **224**, **226**, **228**, **230**, **232** and amplifiers **244**, **246**, **248**, **250**, **252** are comparatively "low cost" circuits, because each is replicated a number of times. As a result, and in one embodiment, each of the signal synthesis circuits **224**, **226**, **228**, **230**, **232** may comprise a direct digital synthesis (DDS) circuit. DDS circuits are useful because of their ability to phase lock to the fundamental frequency of the CW signal, and thereby synthesize a CW signal **234** and nulling tones **236**, **238**, **240**, **242** with locked phases and frequencies. In some cases, the phases of the nulling tones **236**, **238**, **240**, **242** may be tuned via programmable delay elements. However, programmable delay elements may only be practical for higher frequency output signals.

Because DDS circuits cannot currently generate high-frequency signals (e.g., 20 GHz signals), frequency translators may be respectively coupled to the outputs of each DDS circuit.

FIG. **3** illustrates another exemplary embodiment of apparatus **300** (FIG. **3**) for implementing the method **100**. The apparatus **300** comprises a digital feed-forward controller **202***a* that is similar in many ways to the controller **202**. However, the controller **202***a* receives only a frequency indicator **204** of a CW signal parameter set, and then generates a frequency indicator and an amplitude indicator (1st freq, 1 st amp) for the CW signal. The frequency and amplitude indicators are then provided to a signal synthesis circuit **310** that synthesizes a CW signal **234***a*. The controller **202***a* also generates at least one parameter set for at least one harmonic of the CW signal. However, in the case of the controller **202***a*, and by way of example, each of the parameter sets for the harmonics of the CW signal is shown to comprise a phase indicator and an amplitude indicator (labeled in FIG. **3** as 2nd phase **210** and 2nd amp **302**, 3rd phase **214** and 3rd amp **304**, 4th phase **218** and 4th amp **306**, and 5th phase **222** and 5th amp **308**).

The apparatus **300** further comprises a plurality of signal synthesis circuits **310**, **312**, **314**, **316**, **318**, including i) the signal synthesis circuit **310** for synthesizing the CW signal **234***a* in response to a parameter set for the CW signal **234***a*, and ii) at least one additional signal synthesis circuit **312**, **314**, **316**, **318** configured to respectively synthesize at least one nulling tone **236***a*, **238***a*, **240***a*, **242***a* in response to the at least one harmonic of the CW signal.

By way of example, each of the signal synthesis circuits **312**, **314**, **316**, **318** that synthesizes a nulling tone **236***a*, **238***a*, **240***a*, **242***a* comprises 1) a circuit **320**, **322**, **324**, **326** for synthesizing a nulling tone at a desired frequency, and 2) a phase adjustor circuit **328**, **330**, **332**, **334** that is responsive to a respective phase indicator **210**, **214**, **218**, **222** output by the controller **202***a*. Of note, the nulling tone synthesizer circuits **320**, **322**, **324**, **326** each receive 1) the CW signal **234***a*, and 2) a next higher order harmonic (or the fundamental frequency) of the CW signal **234***a*. In this manner, each nulling tone **236***a*, **238***a*, **240***a*, **242***a* is based on the fundamental frequency of the CW signal **234***a*, and the signal synthesis circuits **312**, **314**, **316**, **318** do not require phase locking to the reference signal **258**.

The apparatus **300** further comprises a plurality of non-ideal amplifiers **244***a*, **246***a*, **248***a*, **250***a*, **252***a* for respectively amplifying the CW signal **234***a* and at least one nulling tone **236***a*, **238***a*, **240***a*, **242***a* output from the signal synthesis circuits **310**, **312**, **314**, **316**, **318**. In some embodiments, the non-ideal amplifiers **244***a*, **246***a*, **248***a*, **250***a*, **252***a* may be power amplifiers, although they need not be. The amplifiers **246***a*, **248***a*, **250***a*, **252***a* are also responsive to respective amplitude outputs **302**, **304**, **306**, **308** of the controller **202***a*, to adjust the amplitudes to which the nulling tones **236***a*, **238***a*, **240***a*, **242***a* are amplified. Similarly to the apparatus **200** (FIG. **2**), a summer **254** sums the amplified CW signal and at least one amplified nulling tone to produce a linearized amplified CW signal **256**.

The method **100** and apparatus **200**, **300** illustrated in FIGS. **1-3** may be used to null any number of spur frequencies. However, past work suggests that, for non-clipping signals, power amplifiers are 'weakly nonlinear'. As such, the first few harmonics dominate. In addition, because power amplifiers are weakly distorting (for example, their harmonics are below −40 dBc), the harmonics introduced by the nulling signal amplifiers **246**, **248**, **250**, **252** (or **246***a*, **248***a*, **250***a*, **252***a*) will be at least another 40 dB below those of the spur amplitudes. Hence the distortion along the correction path does not introduce significant distortion in the output signal. As a result, and in some embodiments, the method **100** and apparatus **200**, **300** may only generate parameter sets for second and third order harmonics of the CW signal.

Signals produced by simulating the apparatus **200** are shown in FIGS. **4-7**. The simulation on which the signals shown in FIGS. **4-7** are based assumes that the simulated apparatus **200** is provided with simulated power amplifiers **224**, **226**, **228**, **230**, **232**, each having harmonics at or below −40 dBc. The simulation also assumes that the parameter sets **208**/**210**, **212**/**214**, **216**/**218**, **220**/**222**, from which the simulated nulling tones **236**, **238**, **240**, **242** are synthesized, are computed based on a nonlinearity model of the simulated power amplifiers **244**, **246**, **248**, **250**, **252**.

FIG. **4** illustrates a simulated CW signal **234** of the simulated apparatus **200**. The simulated CW signal **234** may be input to the simulated power amplifier **244** to generate a simulated, amplified, but non-linearized CW signal **260** (see FIG. **5**). FIG. **6** illustrates a summation of the simulated nulling tones **236**, **238**, **240**, **242**. Of note, the simulation assumes that there is no phase noise or jitter in the simulated CW signal **234**, or in the simulated nulling tones **236**, **238**, **240**, **242**. Also, the simulated apparatus **200** has perfectly phase-locked signals **234**, **236**, **238**, **240**, **242**. In addition, the simulation length is chosen to minimize spectral leakage and ensure that the fundamental and harmonic frequencies are centered on discrete Fourier transform (DFT) frequency bins.

FIG. **7** illustrates a simulated linearized amplified CW signal **256** produced by the apparatus **200**, in response to the simulated CW signal **234** shown in FIG. **4** and the simulated nulling tones **236**, **238**, **240**, **242** shown in FIG. **6**. As shown, even with an imprecise knowledge of spur magnitude, significant harmonic cancellation is possible, as shown in FIG. **8**, which illustrates simulated spur levels before and after linearization (e.g., 8% error ->30 dB suppression).

The method **100** and apparatus **200** can provide extremely broadband linearization of a CW signal, by 1) digitally, and in a feed-forward manner, generating parameter sets that define one or more nulling tones corresponding to the spur frequencies of a CW signal, and then 2) amplifying and summing the CW signal and nulling tones in an analog domain. Use of the common reference signal **258**, as well as constructing respective signal synthesis circuits **224**, **226**, **228**, **230**, **232** and non-ideal amplifiers **244**, **246**, **248**, **250**, **252** as matched circuits, helps to ensure that the nulling tones **236**, **238**, **240**, **242** have precise phase and frequency relationships with respect to the fundamental frequency of the CW signal **234**.

One disadvantage of the apparatus **900** shown in FIG. **9** is that it requires multiple passive filters **910**, **912**, **914**, **916** and RF switches **908**, **920**. This is an expensive solution in both price and power (as well as size). Power-wise, an implementation of the apparatus **900** may require 50 Watts to operate but yield only 0.1 Watts of high fidelity signal **922**, due to amplifier inefficiency, filtering loss, and switching loss. An additional disadvantage of the apparatus **900** is that the phase of the output signal **922** can shift abruptly as the filters **910**, **912**, **914**, **916** are switched in and out. This behavior is not desirable for some applications. In contrast, the apparatus **200** can be built using multiple lower cost and lower performance signal synthesis circuits **224**, **226**, **228**, **230**, **232** and amplifiers **244**, **246**, **248**, **250**, **252**. Also, because the method **100** and apparatus **200** rely on digital feed-forward methods, the magnitude and phase of the linearized amplified CW signal **256** are precisely known and digitally adjustable. This eliminates the abrupt phase shifts due to switching filters into and out of the signal path.

Although the embodiments of the method **100** and apparatus **200** described herein provide for linearization of a single CW signal (or tone), the method **100** and apparatus **200** are not limited to the linearization of a single CW signal. However, linearization pf two or more CW signals requires the synthesis of an ever increasing number of nulling tones. For example, one CW signal requires two nulling tones to null spurs due to second and third order harmonics, while two CW signals (superimposed) require ten nulling tones to null spurs due to second and third order harmonics.

The method **100** and apparatus **200** have various applications. In one application, the linearized amplified CW signal produced by the method **100** or apparatus **200** may be used to transmit a network stimulus from a network analyzer. A network analyzer is a type of measurement instrument used for conducting stimulus/response testing of a network. Often, the quality of the stimulus signal impacts the information retrieved in the response (i.e., a lower fidelity stimulus results in lower fidelity response). Thus, the method **100** and apparatus **200** are useful in the realm of network analysis. In addition, the method **100** and apparatus **200** are useful in other applications where wideband linear amplification of simple signals is needed.

What is claimed is:

1. Apparatus, comprising:

a digital feed-forward controller, configured to, in response to a parameter set for a continuous wave (CW) signal, generate at least one parameter set for at least one harmonic of the CW signal;

a plurality of signal synthesis circuits, including i) a first signal synthesis circuit configured to synthesize the CW signal in response to the parameter set for the CW signal, and ii) at least one additional signal synthesis circuit configured to respectively synthesize at least one nulling tone in response to the at least one harmonic of the CW signal;

a plurality of non-ideal amplifiers for respectively amplifying the CW signal and the at least one nulling tone; and

a summer for summing the amplified CW signal and the at least one amplified nulling tone to produce a linearized amplified CW signal.

2. The apparatus of claim **1**, wherein the digital feed-forward controller generates the at least one parameter set, for the at least one harmonic of the CW signal, by indexing at least one lookup table in response to the parameter set for the CW signal.

3. The apparatus of claim **1**, wherein the digital feed-forward controller comprises at least one digital filter that generates the at least one parameter set, for the at least one harmonic of the CW signal, in response to the parameter set for the CW signal.

4. The apparatus of claim **1**, wherein the digital feed-forward controller implements a mathematical function to derive the at least one parameter set, for the at least one harmonic of the CW signal, from the parameter set for the CW signal.

5. The apparatus of claim **1**, wherein each of i) the parameter set for the CW signal, and ii) the at least one parameter set for the at least one harmonic of the CW signal, comprises at least one indicator selected from the group consisting of: a frequency indicator, an amplitude indicator, and a phase indicator.

6. The apparatus of claim **1**, wherein the at least one parameter set for the at least one harmonic of the CW signal comprises parameter sets for at least second and third harmonics of the CW signal.

7. The apparatus of claim **1**, wherein each of the plurality of signal synthesis circuits comprises a direct digital synthesis circuit.

8. The apparatus of claim **1**, wherein each of the plurality of signal synthesis circuits comprises i) a direct digital synthesis circuit, and ii) a frequency translator coupled to an output of the direct digital synthesis circuit.

9. The apparatus of claim **1**, wherein each of the signal synthesis circuits receives a common reference signal and is configured to phase lock to the common reference signal.

10. The apparatus of claim **1**, wherein the digital feed-forward controller is further configured to generate the at least one parameter set, for the at least one harmonic of the CW signal, in response to a temperature of at least one of the plurality of non-ideal amplifiers.

11. A method, comprising:

in response to a parameter set for a continuous wave (CW) signal, digitally generating at least one parameter set for at least one harmonic of the CW signal;

synthesizing the CW signal in response to the parameter set for the CW signal;

synthesizing at least one nulling tone in response to the at least one parameter set for the at least one harmonic of the CW signal;

amplifying the CW signal and the at least one nulling tone; and

summing the amplified CW signal and the at least one amplified nulling tone to produce a linearized amplified CW signal.

12. The method of claim **11**, wherein generating the at least one parameter set for the at least one harmonic of the CW signal comprises indexing at least one lookup table in response to the parameter set for the CW signal.

13. The method of claim **11**, wherein generating the at least one parameter set for the at least one harmonic of the CW signal comprises implementing a mathematical function that derives the at least one harmonic of the CW signal from the parameter set for the CW signal.

14. The method of claim **11**, wherein each of i) the parameter set for the CW signal, and ii) the at least one parameter set for the at least one harmonic of the CW signal, comprises at least one indicator selected from the group consisting of: a frequency indicator, an amplitude indicator, and a phase indicator.

15. The method of claim **11**, wherein the at least one parameter set for the at least one harmonic of the CW signal comprises parameter sets for only second and third harmonics of the CW signal.

16. The method of claim **11**, further comprising, synthesizing the CW signal and the at least one nulling tone to phase lock with a common reference signal.

17. The method of claim **11**, further comprising, generating the at least one parameter set for the at least one harmonic of the CW signal in response to a temperature of at least one non-ideal amplifier used to perform the amplifying.

18. The method of claim **11**, further comprising, using the linearized amplified CW signal to transmit a network stimulus from a network analyzer.

19. The method of claim **11**, further comprising:

measuring phases and amplitudes of harmonics produced by at least one non-ideal amplifier used to perform the amplifying; and

using the measured phases and amplitudes of the harmonics produced by the at least one non-ideal amplifier to calibrate the generating of the at least one parameter set for the at least one harmonic of the CW signal.

20. Apparatus, comprising:

means for, in response to a parameter set for a continuous wave (CW) signal, digitally generating at least one parameter set for at least one harmonic of the CW signal;

means for synthesizing the CW signal in response to the parameter set for the CW signal;

means for synthesizing at least one nulling tone in response to the at least one parameter set for the at least one harmonic of the CW signal;

means for amplifying the CW signal and the at least one nulling tone; and

means for summing the amplified CW signal and the at least one amplified nulling tone to produce a linearized amplified CW signal.

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