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(54) **METHOD AND APPARATUS FOR ADVANCED FREQUENCY TUNING**

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*H03L 7/00* (2006.01)
*H05B 7/18* (2006.01)
*H05H 1/24* (2006.01)

(52) **U.S. Cl.** ..................................... **331/35**; 315/111.21

(58) **Field of Classification Search** ................. 331/1 R, 331/34, 35, 126, 127; 315/111.21
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,543,689 A * 8/1996 Ohta et al. .............. 315/111.21

6,707,255 B2 3/2004 Coumou et al.
6,902,646 B2 6/2005 Mahoney et al.
7,145,398 B2 * 12/2006 Dalton et al. ............... 331/1 A
7,476,233 B1 * 1/2009 Wiener et al. ............... 606/169

FOREIGN PATENT DOCUMENTS

JP 02884056 B2 4/1999
JP 2006-054148 2/2006

OTHER PUBLICATIONS

Jung, Jong Han, "International Search Report re Application No. PCT/US09/037001", Oct. 16, 2009, Published in: PCT.
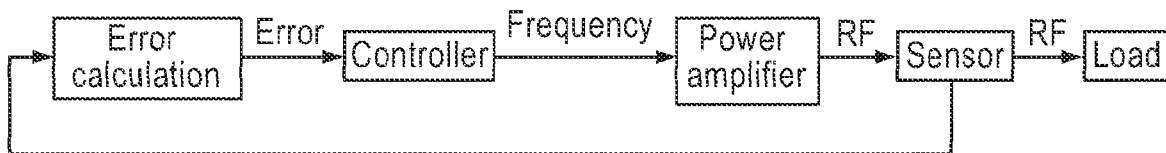
* cited by examiner

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(57) **ABSTRACT**

A method and apparatus for tuning the operational frequency of an electrical generator coupled to a time-varying load is described. One illustrative embodiment rapidly calculates an error (reflection coefficient magnitude) at the current operational frequency of the electrical generator; adjusts the frequency of the electrical generator by an initial step size so; rapidly calculates a second error; and if the magnitude of the second error is smaller than the magnitude of the first error, then the step size is increased and the frequency is adjusted by the increased step size.
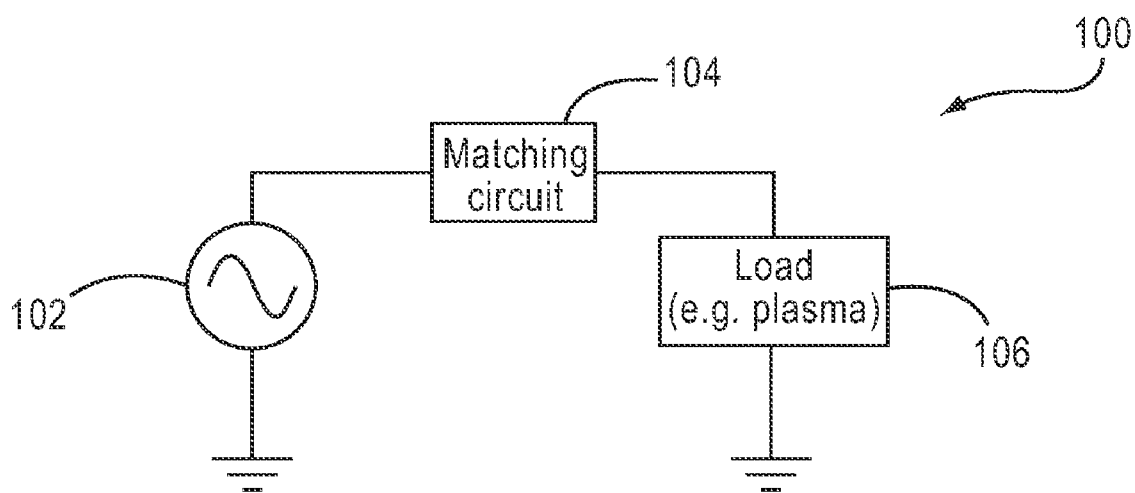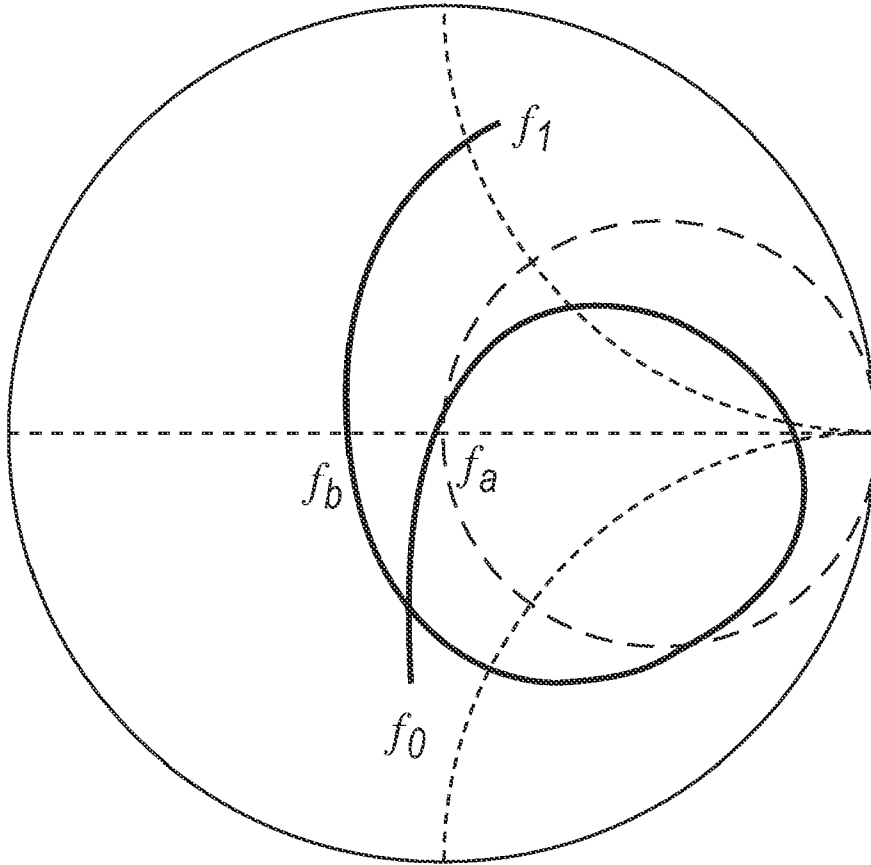
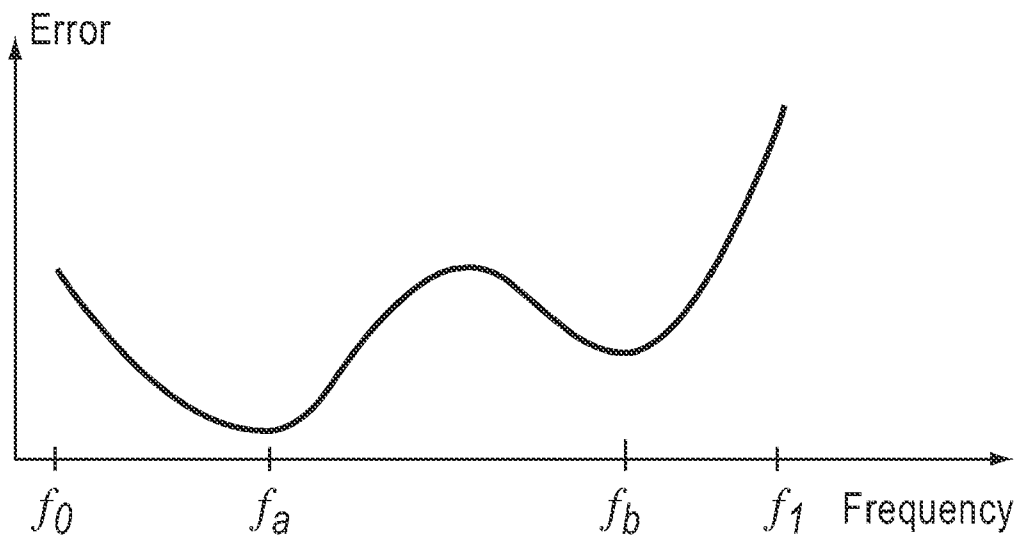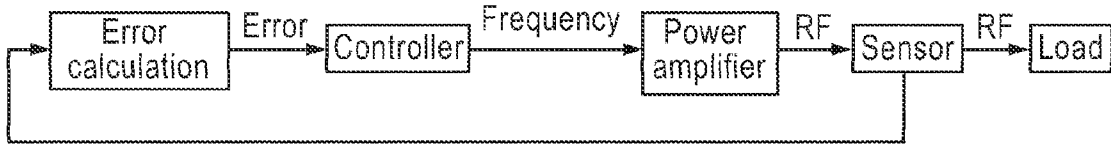**16 Claims, 12 Drawing Sheets**

FIG.1

FIG.2



FIG.3

FIG.4



$$Frequency(t) = \int_0^t Error(\tau)h(t-\tau)d\tau + Frequency(0)$$

Linear controller (rarely possible due
to non-monotonic relationship
between frequency and error
except in special cases where apriori
information is available)

Weighting function (time-reversed impulse response, $h$)

FIG.5



Samples considered in determining next frequency

Algorithmic controller

FIG.6

FIG.7



Error as a function of frequency at time $t_0$-
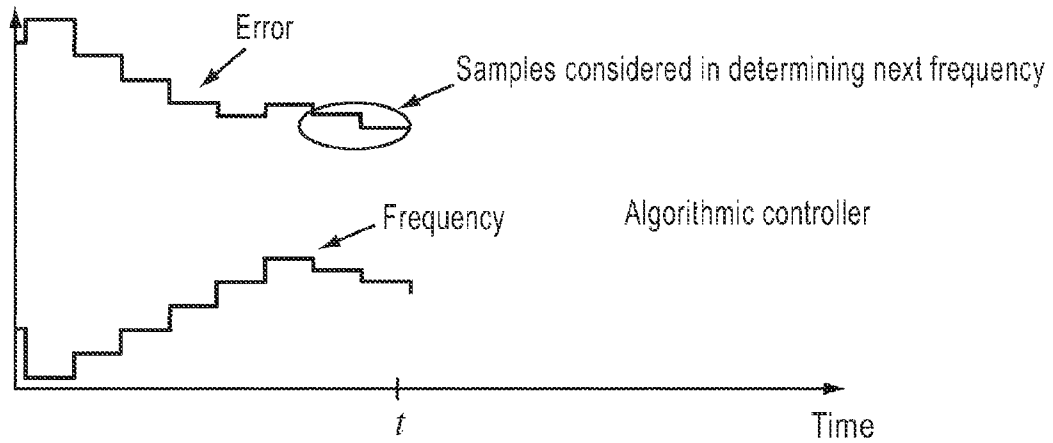
Error as a function of frequency at time $t_1$-

FIG.8

# DOCKET ALARM
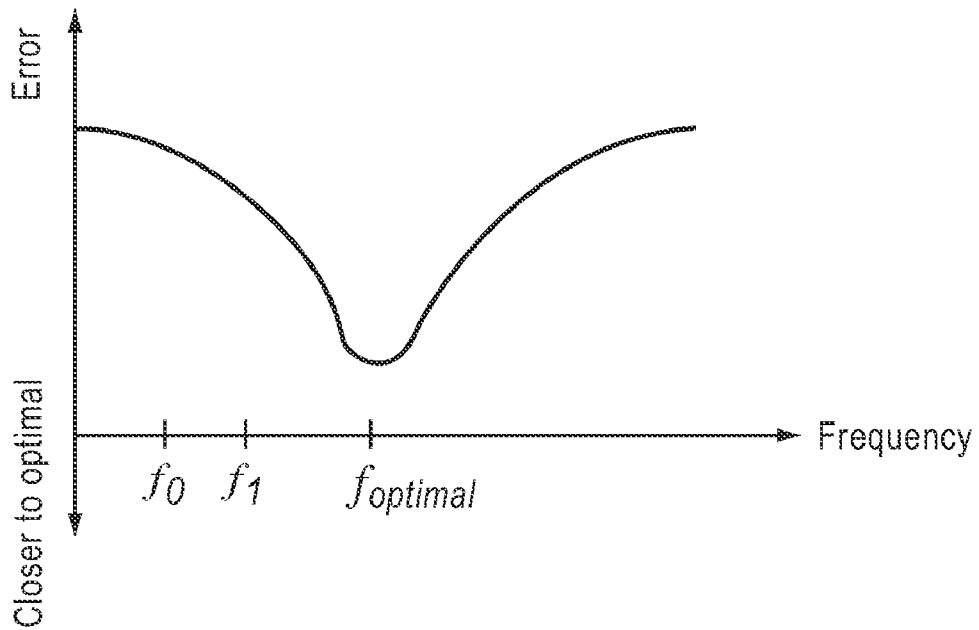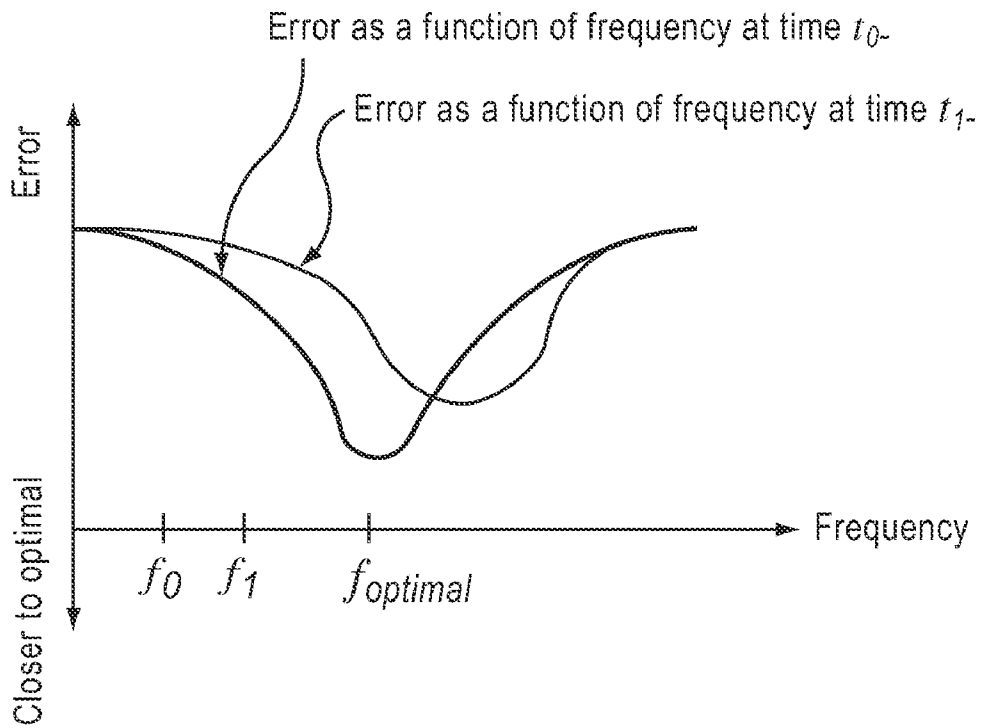
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