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(54) **Title:** METHOD FOR TEMPORARY COMPARISON BETWEEN ANALOG ELECTRIC STIMULI AND MECHATRONIC SYSTEM PROVIDED WITH METHOD FOR TEMPORARY COMPARISON BETWEEN ANALOG ELECTRIC STIMULI

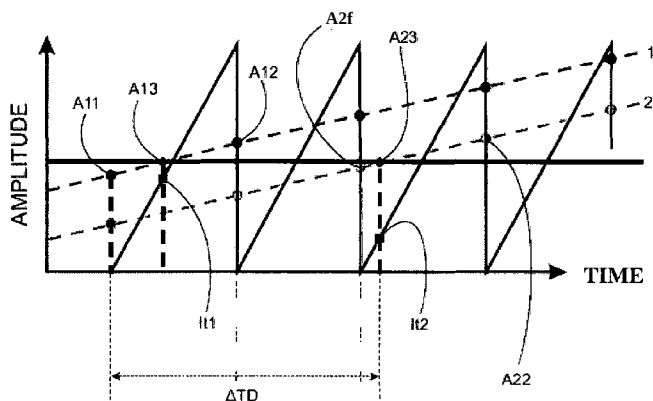


FIG. 12

(57) **Abstract:** The present invention refers to a method for temporal comparison between analog electric stimuli and to a system for performing said method, the system comprising at least an analog sensor and preferably a microprocessor. Generally, the presently disclosed method comprises treating two or more analog signals by means of temporal analysis between two digitized samples of each of said analog signals. This treatment takes into account two comparison parameters: an arbitrary benchmark (a known value which may or may not be related to the analog signals) and a temporal scale.



"METHOD FOR TEMPORARY COMPARISON BETWEEN ANALOG ELECTRIC STIMULI AND MECHATRONIC SYSTEM PROVIDED WITH METHOD FOR TEMPORARY COMPARISON BETWEEN ANALOG ELECTRIC STIMULI"

Field of the Invention

5 The present invention refers to a method for temporary comparison between analog electric stimuli and, more particularly, a method for temporary comparison between analog electric stimuli capable of determining, through a different benchmark, eventual delays between two analog electric stimuli.

10 The present invention is further directed to a preferably microprocessed system comprising at least an analog sensor, provided with the method for temporary comparison between analog electric stimuli.

Background of the Invention

15 As it is already known from those skilled in the art, microprocessed or microcontrolled systems are capable of dealing only with digital signals. On the other hand, natural stimuli, in their majority, can be considered as analog signals.

 In this regard, it should be pointed out that the basic difference between those signals resides in the fact that analog signals possess possible infinite values between any two finite levels while digital signals only possess two levels and represent analog magnitudes through variation of these levels over time.

20 Nevertheless, in order to enable microprocessed or microcontrolled electronic and mechatronic systems to deal with natural stimuli, signal converters have been developed, which can convert an analog signal into a digital signal (analog-digital converter) or convert a digital signal into an analog signal (digital-analog converter). Therefore, it is common to use analog-digital converters to sample (transform) real-world signals into digital signals, and
25 from those, to act in microprocessed or microcontrolled electronic systems. In this context, there will be found which current state of the art predicts the existence of either analog-digital or digital analog converters already incorporated into microprocessors and microcontrollers.

 A comparison between two or more analog signals, or also a comparison between an analog signal and a "reference value", is also known from those skilled in the art. An
30 example of these applications can be seen in microprocessed or microcontrolled systems which operate based on analog sensors - such as, for example, magnetic sensors (generating an electric magnitude analogous to the variation of a magnetic field) - whose measurable values are usually compared to a "reference value" for checking and controlling purposes. According to the intrinsic functioning (mentioned above) of microprocessed or
35 microcontrolled systems, circuits or modules for comparison of analog signals generate output digital signals.

 A number of analog signal comparison circuits or modules for comparison of analog

signals, which, in their majority, rely on one same functional principle, are known in the current prior art. According to said functional principle, two distinct analog signals (usually a signal of interest and an arbitrary benchmark) have their amplitudes compared. In case that a signal of interest has amplitude higher than the amplitude of the linear arbitrary benchmark, a digital signal of high or low logical level (dependent on logic used) is generated. In case that the signal of interest has amplitude lower than the amplitude of the linear arbitrary benchmark, a digital signal of lower or high logical level (respectively to the formerly mentioned logic) is generated.

The current comparison circuits or modules of analog signals can be based on hardware processing (in simple circuits consisting of amplifiers and transistors), or even based on software processing (in processing units).

Comparison circuits or modules of analog signals based on hardware processing are usually used in industrial applications but have limitations. In this case, analog signals are automatically compared therebetween, thus generating, as a result, a digital signal. This processing mode presents two great disadvantages: one refers to the circuit sizes (number of electronic components used is proportional to the number of signals to be compared), and the other refers to instabilities in the final results (instability caused by the quality of components).

With regard to comparison circuits or modules of analog signals based on software processing, which are widely used in industrial applications, they present a simply digital operation flow, that is, analog signals are firstly converted to digital signals and then subjected to a pre-defined logic (usually Boolean logic). Said circuits and modules are highly functional in traditional applications where analog signals are foreseeable and regular.

However, such circuits or modules cannot be considered as entirely reliable when used in especial applications where analog signals, in addition to being irregular and unpredictable, have substantially high amplitude alteration rates.

Those limitations result in part from the functionality of the analog-digital converters themselves, which cannot present discretizations sufficient and capable of differing two subsequent samplings (of one same analog signal) of very near values. Furthermore, it is also verified that the current analog-digital converters present a huge limitation related to analog system sampling time for systems operating at real time, mainly in embarked systems, and this limitation jeopardizes the conversion reliability. The other part of such limitations is essentially related to limitations of processing and sharing of microprocessors and memory modules responsible for executing the software.

Anyhow, the current analog signal comparers are not able to process two analog signals formed by slight and relevant magnitude variations. Moreover, they are also not capable of identifying similar events (of two different analog signals) occurring at different

time points.

Objects of the Invention

Firstly, one object of the present invention is to provide a method for temporary comparison between analog electric stimuli without the functional limitations related to the current analog signal comparers.

Another object of the present invention is to provide a method for temporary comparison between analog electric stimuli, which is capable of comparing two or more analog signals whose amplitude variation occurs in minimal time intervals.

Additionally, an object of the present invention is to provide a method for temporary comparison between analog electric stimuli, which has the ability to determine temporary measurements related to delays in compared analog signals. In this sense, another object of the present invention resides in the fact that the method for temporary comparison between analog electric stimuli must be capable of determining a time interval related to the occurrence of similar measured events in different analog signals.

A further object of the present invention refers to a microprocessed mechatronic system comprising at least an electric motor and at least an analog sensor provided with the presently disclosed method for temporary comparison between electric analog stimuli.

Summary of the Invention

All the above-mentioned objects are entirely achieved by the method for temporary comparison between analog electric stimuli, which comprises determining the delay between at least two analog signals relative to at least an arbitrary benchmark and essentially comprises the steps of capturing at least a first sampling of a first analog signal and initiating a time counting simultaneously to such capture; capturing at least a second sampling of the first analog signal, and terminating the time counting simultaneously to this capture; checking and validating the samples, based on the arbitrary benchmark; determining the time interval between samplings; determining the virtual sampling, and determining the time point at which the virtual sampling occurs; capturing at least a first sampling of a second analog signal, and initiating a time counting simultaneously to same; capturing at least a second sampling of the second analog signal, and terminating the time counting simultaneously to this capture; checking and validating the samples based on the arbitrary benchmark; determining the time interval between the samplings; determining the virtual sampling, and determining the time point at which the virtual sampling occurs; and determining the time interval between the time point and the time point.

According to the present invention, time countings can be synchronous and/or asynchronous. Furthermore, the arbitrary benchmark can comprise a continuous value, or also a variable value. And, the arbitrary benchmarks (for compared analog signals) are identical.

Within the above context, it should be pointed out that virtual sampling (of the first analog signal) comprises an amplitude value of the first analog signal similar to the arbitrary benchmark, wherein this virtual time is obtained by interpolation between the first sampling and the second sampling of the first analog signal. The same occurs with the virtual sampling (of the second analog signal). Furthermore, the time points comprise the projection of each of the virtual samplings over the time counting. And the time interval of "interest" comprises a temporary delay between the analog signals, wherein said delay can be temporary, angular or phasorial.

It is also worth to mention that, in accordance with the present invention, a time interval of "interest" encompasses at least one temporary counting cycle and it can further encompass multiple cycles of temporary counting, or further a fraction of temporary counting cycle.

The present invention also discloses a mechatronic system provided with the method for temporary comparison between analog electric stimuli, essentially comprising at least an electric motor and at least an analog sensor associated with functional movement of the electric motor, which is capable of determining a delay between an analog parameter if the electric feed of the electric motor and the analog sensor output signal by determining the time interval existing between at least a virtual sampling of the analog parameter of the electric feed of the electric motor and at least a virtual sampling of analog sensor output signal. In this sense, said mechatronic system provided with the method for temporary comparison between analog electric stimuli is embarked in a single microprocessor and/or microcontroller. Optionally, same can further be embarked in multiple microprocessors and/or microcontrollers.

The above mentioned system can comprise a rotary motor fluid compressor or further a linear motor fluid compressor.

Preferably, the magnitude of analog sensor is proportional to the linear actuator speed, or to the position of a linear actuator. Optionally, the magnitude of analog sensor is proportional to the position of an electric motor rotor, or further, to the electric current of this motor.

Further preferably, temporary measurement between electric magnitudes of the analog sensor and electric feed of the motor is used to control the linear compressor operation frequency.

Brief Description of the Figures

The present invention will be described in detail based on figures listed below, wherein:

Fig. 1 illustrates a block diagram concerning the method in accordance with the present invention;

Figs. 2 to 5 illustrate didactical graphs related to the first analog signal processing in accordance with the method of the present invention;

Figs. 6 to 9 illustrate didactic graphs related to the second analog signal processing in accordance with the present invention;

5 Figs. 10 and 11 illustrate schematic overlapping of graphs shown in Figs. 5 and 9; and

Fig. 12 illustrates an overlapping graph of substantially delayed analog signals.

Detailed Description of the Invention

10 In accordance with the concepts and objects listed above, a novel method for temporary comparison between analog electric stimuli, wherein said method is capable of determining through an arbitrary benchmark a delay between two or more analog electric stimuli is disclosed.

15 In general, the presently disclosed method comprises treating two or more analog signals by a comparison analysis between at least two "digital samplings" of each of analog signals. This treatment takes into account two comparison parameters: one arbitrary benchmark (a known value which may or may not be related to analog signals) and a temporary scale.

20 As it is known from those skilled in the art, analog signals are transformed into "digital samplings" such that they can be treated, studied and processed into microprocessed and/or microcontrolled systems. Therefore, in accordance with the method of the present invention, it is essentially required that two analog signals are firstly converted into "digital samplings."

25 From a conceptual viewpoint, in the method of the present invention, each of the analog signals is subjected to a first interdependent treatment and then to a second comparative treatment.

Said interdependent treatment of each of the analog signals comprises determining a temporary time point at which each analog signal "reaches" an arbitrary benchmark. By doing so, it is aimed at partly solving the limitations related to sampling rates referring to analog-digital converters pertaining to the current state of the art.

30 Such interdependent treatment generally takes place by capturing two "digital samplings" of each analog signal, wherein time counting is initiated simultaneously to the "first digit sampling" and this time counting being terminated simultaneously to the "second digital sampling."

35 To make this time counting useful, it is necessary to confirm whether said "digital samplings" are in different "quadrants" of the arbitrary benchmark (i.e. whether a "digital sampling" is greater than the arbitrary benchmark, and whether the other "digital sampling" is smaller than the arbitrary benchmark).

In the event that the "digital samplings" are in different "quadrants" of the arbitrary benchmark, it is possible to determine the time point at which the presently studied analog signal reaches its arbitrary benchmark.

That is, it is possible to determine the occurrence of a "virtual sampling" (sampling
5 virtually calculated and related to the exact crossing between analog signal and arbitrary benchmark), and the time point at which same occurs in a time scale defined between first and second "digital samplings."

Therefore, the exact time point at which each of the analog signals has reached its respective arbitrary benchmark is known. Based on these data (time points of occurrence of
10 events at one same temporary scale) it is possible to determine the time interval between them.

This permits, for example, to check a (temporary or phasorial or angular) delay existing between two analog signals of one same system. Or it also permits to check time interval (or delay) at which one same "event" takes place when analyzed in different analog
15 signals.

Eventually, the presently disclosed concept can be applied with more than two analog signals.

The concepts disclosed above will become clearer by analyzing a functional flowchart illustrated in Figure 1, where the following steps are observed:

20 "Processing" of the first analog signal:

1.1 - Converting the first analog signal into digital signal (digital samplings);

1.2 - Determining an arbitrary benchmark $R1$;

1.3 - Capturing a first sampling $A11$ and initiating time counting $T1$;

1.4 - Capturing a second sampling $A12$ and terminating time counting $T1$;

25 1.5 - Checking (quadrants) and validating samplings $A11$ and $A12$;

1.6 - Determining and storing time interval $\Delta T1$ between the previously validated samplings $A11$ and $A12$;

1.7 - Interpolating between previously validated $A11$ and $A12$ samplings;

1.8 - Determining the virtual sampling $A13$ (in the crossing with the benchmark $R1$);

30 1.9 - Determining a time point $IT1$ at which the virtual sampling $A13$ occurs;

1.10 - Determining time interval $\Delta T1$ between one of the samplings $A11$ or $A12$ and the virtual sampling $A13$;

"Processing" of the second analog signal:

2.1 - Converting the first analog signal into digital signal (digital samplings);

35 2.2 - Determining an arbitrary benchmark $R2$;

2.3 - Capturing a first sampling $A21$ and initiating time counting $T2$;

2.4 - Capturing a second sampling $A22$ and terminating time counting $T2$;

2.5 - Checking (quadrants) and validating samplings A21 and A22;

2.6 - Determining and storing the time interval ΔT_2 between the previously validated samplings A21 and A22;

2.7 - Interpolating between previously validated A21 and A22 samplings;

5 2.8 - Determining a virtual sampling A23 (in the crossing with the benchmark R1);

2.9 - Determining a time point IT2 at which the virtual sampling A23 occurs;

2.10 - Determining a time interval ΔT_2 between one of the samplings A21 or A22 and the virtual sampling A23;

"Processing" of temporary comparison:

10 3 - Determining time interval ATD;

Figs. 2, 3, 4 and 5 illustrate in a simplified way the processing of the first analog signal, and Figs. 6, 7, 8 and 9 illustrate in a simplified way the processing of the second analog signal.

Concerning Figs. 10 and 11, they illustrate in a simplified way the processing of
15 temporary comparison, wherein interval of interest ATD is illustrated, which refers to the interval between virtual samplings A13 and A23. That is, the interval of interest ATD comprises a delay between the now compared two analog systems.

In this scenario, it should be emphasized that in graphs illustrated in Figs. 2 to 11, virtual samplings A13 and A23 occur between immediately subsequent samplings (A11 and
20 A12; A21 and A22), and, therefore, said virtual samplings A13 and A23 are obtained by a single "cycle" of time counting (T_1 and T_2), which may also be re-initiated to repeat the process.

In this regard, it is worth to mention that, in accordance with a preferred embodiment of the present invention, a time counting is based on time cycles (having frequency
25 preferably higher than the frequency of analog signal samplings), wherein termination of a "first time cycle" is simultaneous to the initialization of "a next time cycle." To this effect, all and any sampling of analog signals (irrespective of their value relative to arbitrary benchmarks) is capable of terminating the "present" time cycle and simultaneously initiating a "next" time cycle.

30 This allows for two analog signals, even very delayed, to be subsequently compared. A situation based on an eventual situation of this type is illustrated in Fig. 12.

From Fig. 12 it can be seen that a first analog signal has its first samplings (A11 and A12) respectively below and above the arbitrary benchmark, and, therefore, it is possible to
35 determine the virtual sampling A13 just in the first time counting "cycle."

The same does not occur with the second analog signal, which has (for

exemplification purposes) its three first samplings below the arbitrary benchmark and, consequently, its fourth sampling above the arbitrary benchmark. In this context, the "first sampling A21" comprises the third real sampling, and the "second sampling A22" comprises in fact the fourth real sampling.

5 In this regard, it can be observed that the expressions "first sampling" and "second sampling" are essentially related to an arbitrary benchmark, that is, it is preferably considered the "first sampling" (A1 1 and A21), the last sampling for each of the analog signals in which no change of quadrant has yet been occurred, and the "second sampling" (A12 and A22) is preferably considered the first sampling of different level (always in relation to the arbitrary
10 benchmark). This scenario can be better seen in Fig. 12 itself, where first samplings A11 and A22 have a level lower than the level of the arbitrary benchmark, and second samplings A12 and A22 have a level superior to the level of the arbitrary bench even if in the case of the second analog system, the second sampling A22 is substantially delayed from the second sampling A12 of the first analog signal.

15 In this example of Fig. 12, not only is the interval of interest A/D established in one single temporary counting "cycle" but also in two complete "cycles" and one fraction of a third temporary counting "cycle."

The present invention also discloses a preferably microprocessed and mechatronic system provided with the method for temporary comparison between analog electric stimuli
20 as mentioned above.

Generally, said system can be implemented in devices comprising at least an analog sensor, at least an electric motor and at least a (microprocessed or microcontrolled) core of conventional processing.

25 More specifically, said system provided with the presently disclosed method for comparison is particularly implemented in devices whose electric motor and analog sensor are associated with a functional and positive displacement as it is in the case of rotary motor compressors, or also, linear motor compressors.

30 In any way, system provided with the comparison method is intended to determine a delay between a first analog parameter of electric feed of the electric motor and the analog sensor output signal by determining a time interval existing between at least a virtual sampling of the analog parameter of the electric feed of the electric motor and at least a virtual sampling of the analog sensor output signal. Again, said comparison takes into account as comparison parameters an arbitrary benchmark and a temporary scale.

35 A functional example of application of this system provided with the presently disclosed method for comparison in electric compressors is directed to a comparison of the analog current of the feed of the electric motor and the piston displacement (monitored by an analog output magnetic sensor). In this application, the system is intended to check a delay

in those signals and provide parameters for eventual correlations which shall be needed.

After having described the method for temporary comparison between analog electric stimuli and at least an application example, it should be construed that the scope of the present invention contemplates other possible variations, and same is only limited by the
5 contents of the appended claims, also including therein possible equivalent means.

CLAIMS

1. Method for temporary comparison between multiple analog electric stimuli, comprising determining the delay between at least two analog electric signals in relation to at least an arbitrary benchmark (R1 , R2), CHARACTERIZED in that it essentially comprises the steps of:

capturing at least a first sampling (A1 1) of a first analog signal, and initiating a time counting (T1) simultaneously to this capture;

capturing at least a second sampling (A12) of the first analog signal, and terminating said time counting (T1) simultaneously to this capture;

checking and validating said samples (A1 1) and (A12) based on the arbitrary benchmark (R1);

determining a time interval ($\Delta T1$) between said samplings (A1 1) and (A12);

determining a virtual sampling (A13), and determining a time point (IT1) at which said virtual sampling (A13) occurs;

capturing at least a first sampling (A21) of a second analog signal, and initiating a time counting (T2) simultaneously to same;

capturing at least a second sampling (A22) of a second analog signal, and terminating the time counting (T2) simultaneously to this capture;

checking and validating said samples (A21) and (A22) based on the arbitrary benchmark (R2);

determining a time interval ($\Delta T2$) between said samples (A21) and (A22);

determining a virtual sampling (A23), and determining a time point (IT2) at which said virtual sampling (A23) occurs;

determining a time interval ($\Delta T2$) between the time point (IT1) and time point (IT2).

2. Method for comparison, in accordance with claim 1, CHARACTERIZED in that at least said samplings and time countings (T1 , T2) are synchronous.

3. Method for comparison, in accordance with claim 1, CHARACTERIZED in that said samplings and time countings (T1 , T2) are asynchronous.

4. Method for comparison, in accordance with claim 1, CHARACTERIZED in that said arbitrary benchmark (R1 , R2) comprises a continuous value.

5. Method for comparison, in accordance with claim 1, CHARACTERIZED in that said arbitrary benchmarks (R1 , R2) comprise a variable value.

6. Method for comparison, in accordance with claim 1, CHARACTERIZED in that said arbitrary benchmarks (R1 , R2) are identical.

7. Method for comparison, in accordance with claim 1, CHARACTERIZED in that said virtual sampling (A13) comprises an analog signal amplitude value similar to the arbitrary benchmark (R1) value.

8. Method for comparison, in accordance with claim 7, CHARACTERIZED in that said virtual sampling (A13) is obtained by interpolation between said first sampling (A1 1) and second sampling (A12) of the analog signal.

9. Method for comparison, in accordance with claim 1, CHARACTERIZED in that said virtual sampling (A23) comprises said analog signal amplitude value similar to the arbitrary benchmark (R2) value.

10. Method for comparison, in accordance with claim 9, CHARACTERIZED in that said virtual sampling (A23) is obtained by interpolation between said first sampling (A21) and second sampling (A22) of the analog signal.

11. Method for comparison, in accordance with claim 1, CHARACTERIZED in that said time point (IT1) comprises a projection of said virtual sampling (A13) over the time counting (T1).

12. Method for comparison, in accordance with claim 1, CHARACTERIZED in that said time point (IT2) comprises a projection of said virtual sampling (A12) over the time counting (T2).

13. Method for comparison, in accordance with claim 1, CHARACTERIZED in that said time interval (ATD) comprises a temporary delay between the analog signal (1) and the analog signal (2).

14. Method for comparison, in accordance with claim 1, CHARACTERIZED in that said time interval (ATD) comprises an angular delay between said analog signal (1) and analog signal (2).

15. Method for comparison, in accordance with claim 1, CHARACTERIZED in that said time interval (ATD) comprises a phasorial delay between the analog signal (1) and analog signal (2).

16. Method for comparison, in accordance with claim 1, CHARACTERIZED in that said time interval (ATD) encompasses at least a temporary counting cycle.

17. Method for comparison, in accordance with claim 1, CHARACTERIZED in that said time interval (ATD) encompasses multiple temporary counting cycles.

18. Method for comparison, in accordance with claim 16 or 17, CHARACTERIZED in that said time interval (ATD) encompasses at least a fraction of temporary counting cycle.

19. Mechatronic system provided with the method for temporary comparison between analog electric stimuli as defined in claims 1 to 14, and essentially comprising at least an electric motor and at least an analog sensor associated with the functional movement of said electric motor, said system being CHARACTERIZED in that it comprises determining a delay between an analog parameter of the electric feed of the electric motor and the analog sensor output signal by determining a time interval (ATD) existing between at

least a virtual sampling of said analog parameter of the electric feed of said electric motor and at least a virtual sampling of the analog sensor output signal.

20. Mechatronic system, in accordance with claim 19, CHARACTERIZED in that it is embarked in a single microprocessor and/or microcontroller.

5 21. Mechatronic system, in accordance with claim 19, CHARACTERIZED in that it is embarked in multiple microprocessors and/or microcontrollers.

22. Mechatronic system, in accordance with claim 19, CHARACTERIZED in that it comprises a rotary motor fluid compressor.

10 23. Mechatronic system, in accordance with claim 19, CHARACTERIZED in that it comprises a linear motor fluid compressor.

24. Mechatronic system, in accordance with claim 19, CHARACTERIZED in that the magnitude of said analog sensor is proportional to the speed of a linear actuator.

25. Mechatronic system, in accordance with claim 19, CHARACTERIZED in that the magnitude of said analog sensor is proportional to the position of a linear actuator.

15 26. Mechatronic system, in accordance with claim 19, CHARACTERIZED in that the magnitude of said analog sensor is proportional to the position of an electric motor rotor.

27. Mechatronic system, in accordance with claim 26, CHARACTERIZED in that said analog parameter of the feed of said electric motor is proportional to the electric current of said motor.

20 28. Mechatronic system, in accordance with claim 19, CHARACTERIZED in that temporary measurement between electric magnitudes of said analog sensor and said feed of the electric motor is used to control the linear compressor operation frequency.

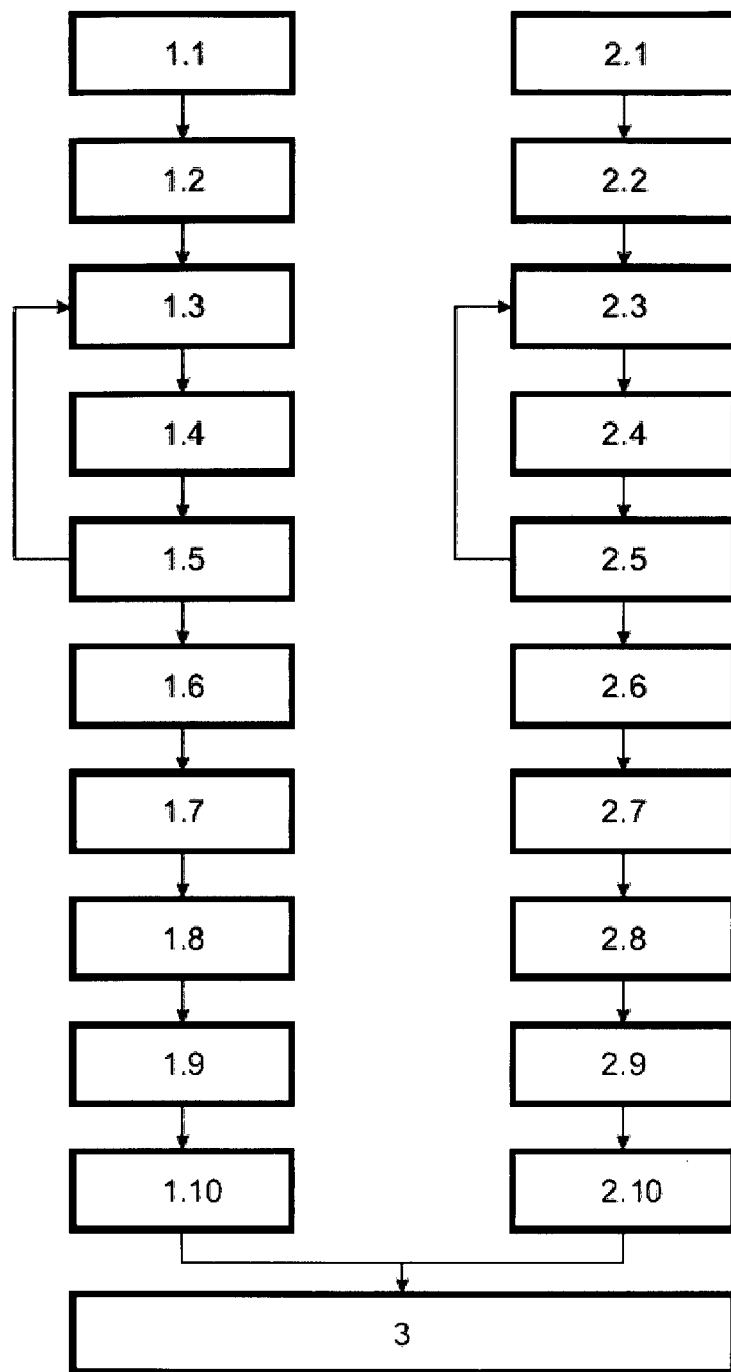


FIG. 1

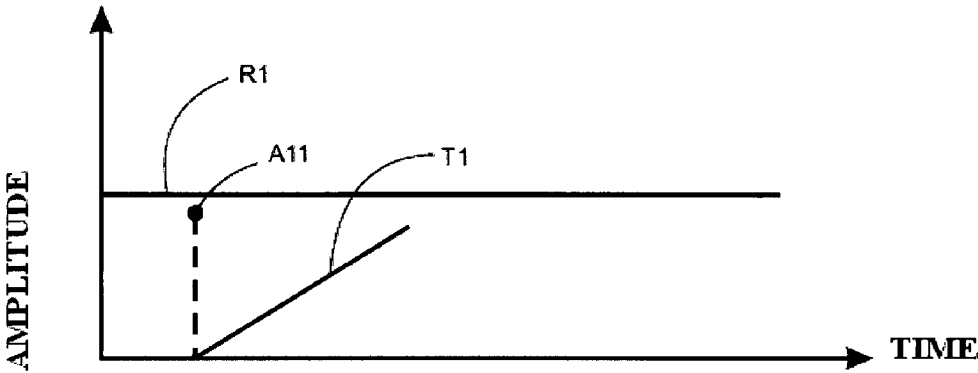


FIG. 2

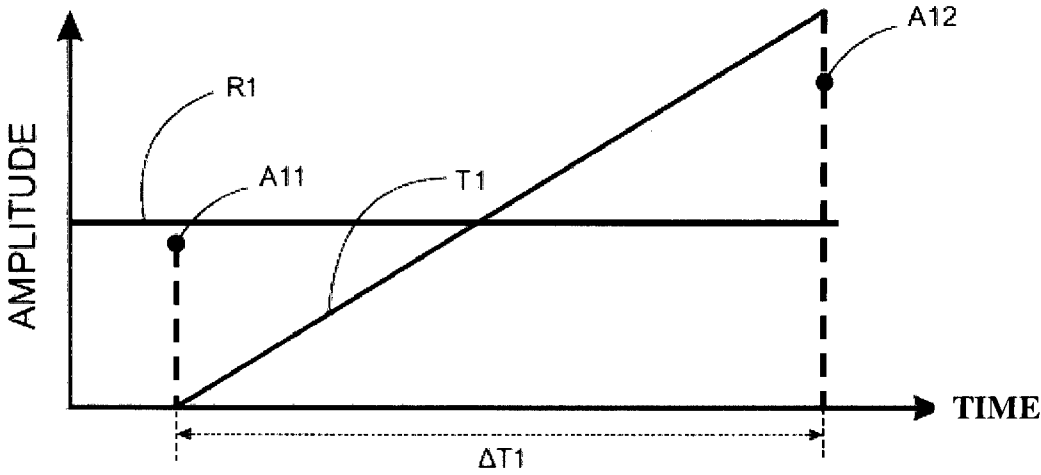


FIG. 3

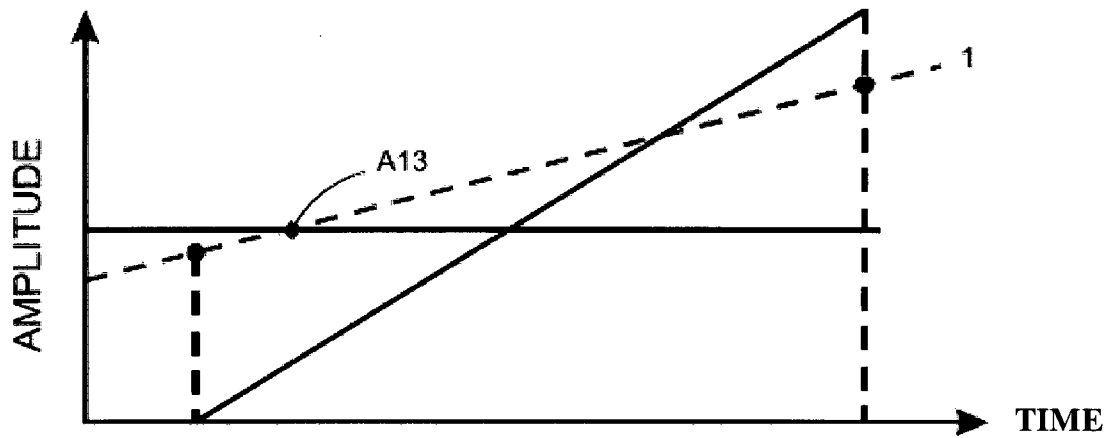


FIG. 4

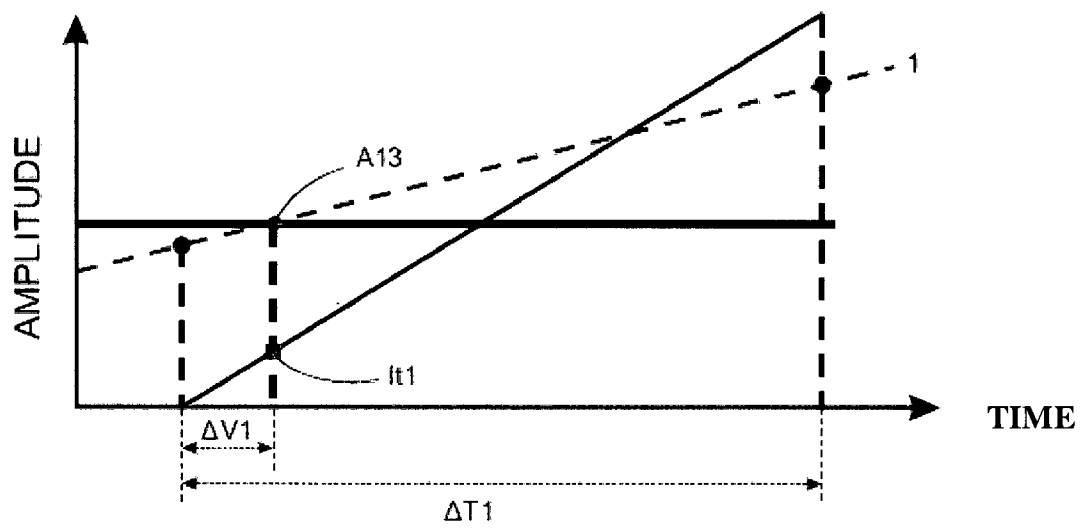


FIG. 5

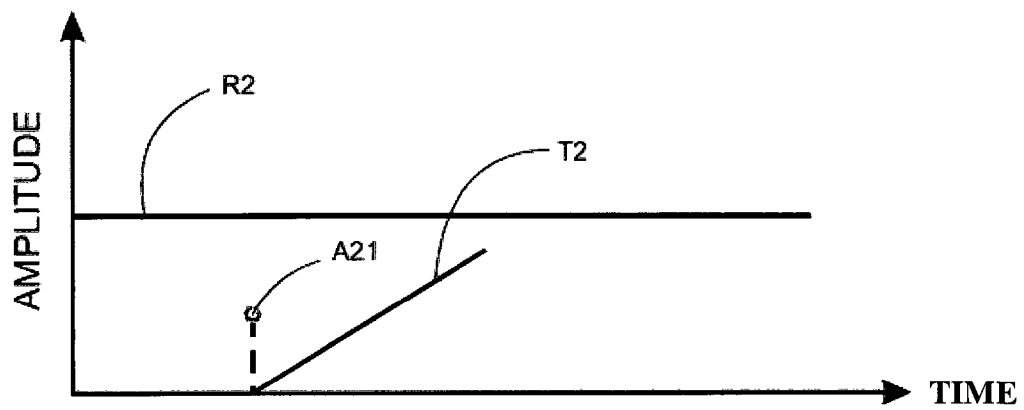


FIG. 6

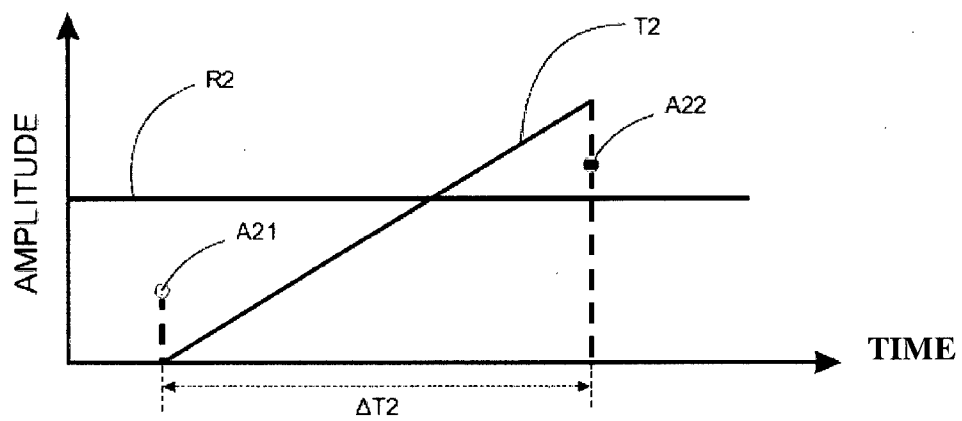


FIG. 7

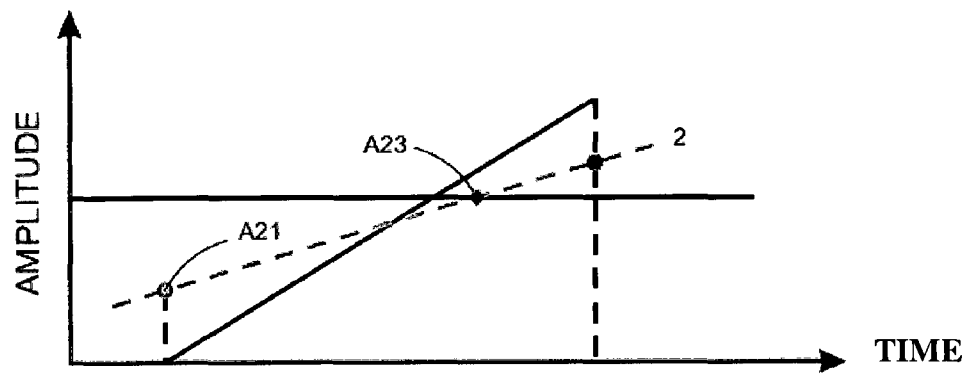


FIG. 8

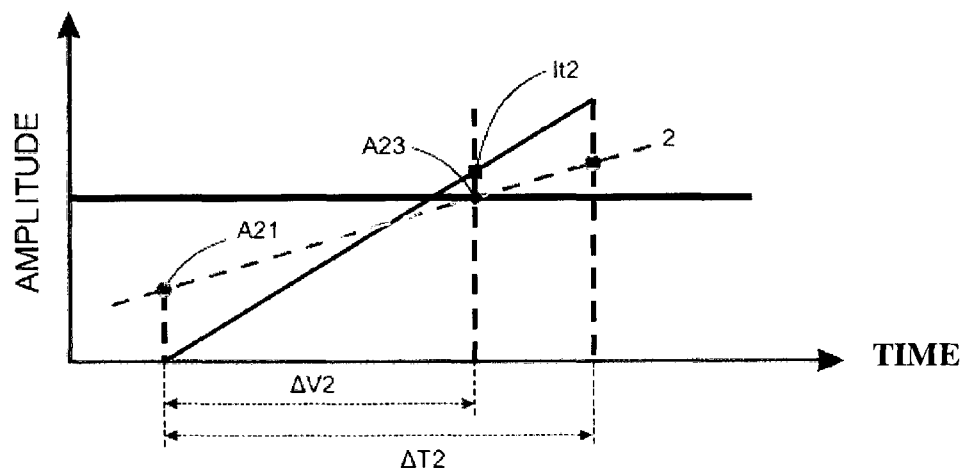


FIG. 9

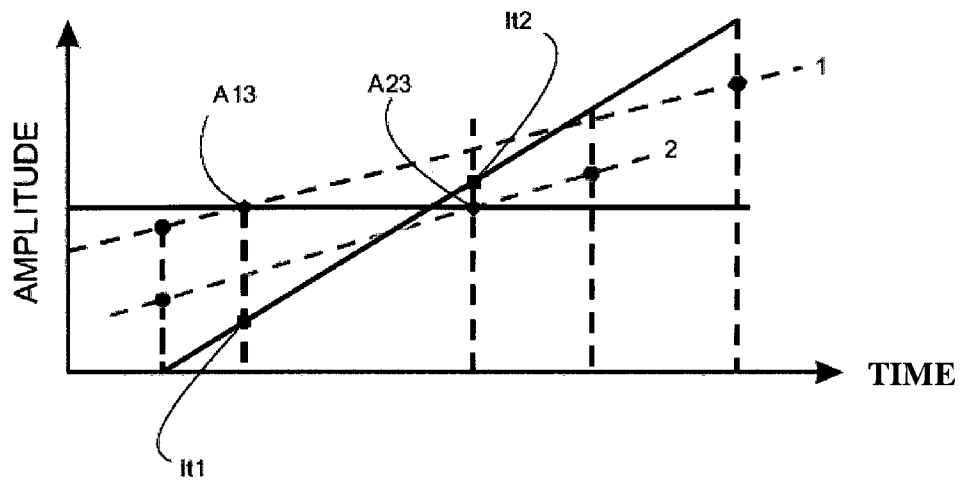


FIG. 10

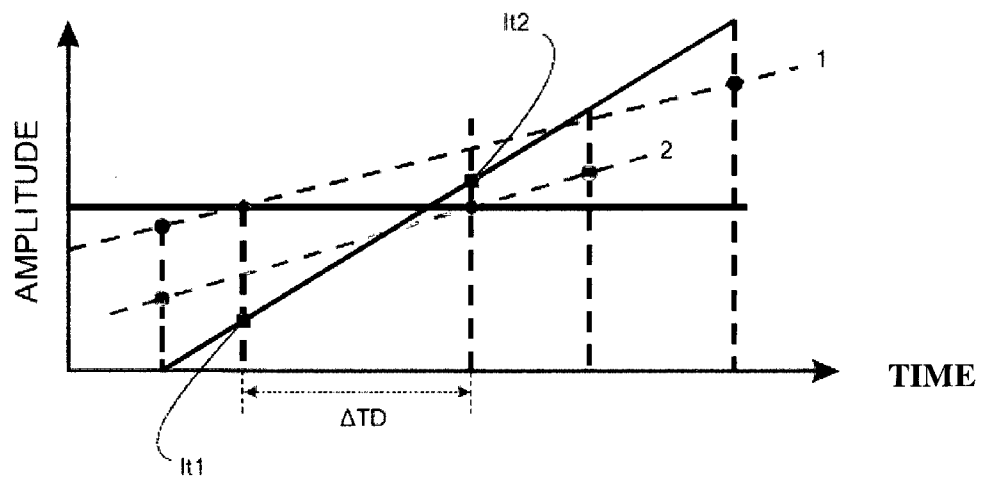


FIG. 11

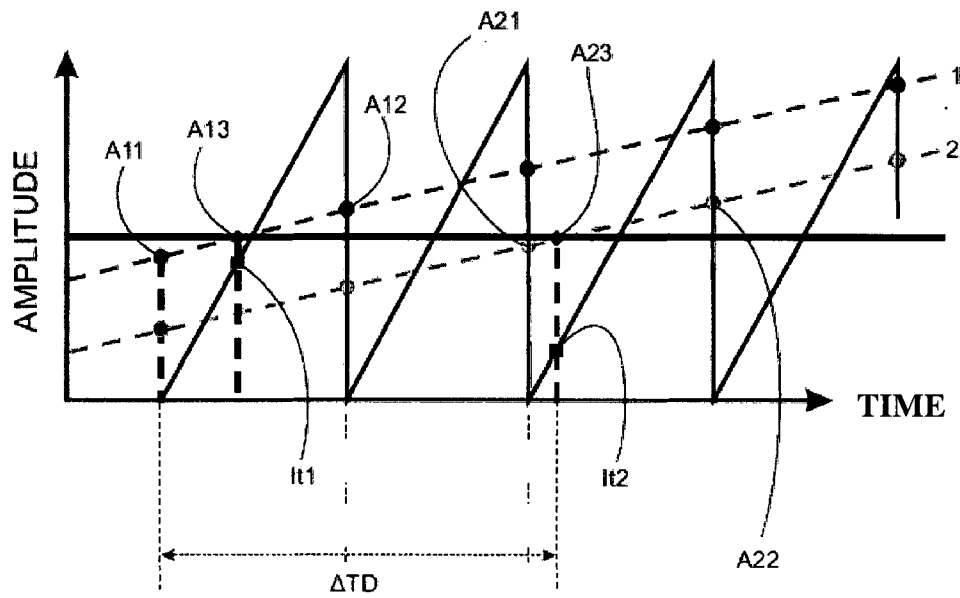


FIG. 12

INTERNATIONAL SEARCH REPORT

International application No

PCT/BR2012/000490

A. CLASSIFICATION OF SUBJECT MATTER

INV. H02P6/18 G04F10/06 G04F10/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H03M H02P G04F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	AKSAMOVIC A ET AL: "Numerical algorithm for measurement of angle phase shift for sines signal", ELECTRONICS, CIRCUITS AND SYSTEMS, 2004. ICECS 2004. PROCEEDINGS OF THE 2004 11TH IEEE INTERNATIONAL CONFERENCE ON TEL AVIV, ISRAEL DEC. 13-15, 2004, PISCATAWAY, NJ, USA, IEEE, 13 December 2004 (2004-12-13), pages 451-454, XP010774293, DOI: 10.1109/ICECS.2004.1399715 ISBN: 978-0-7803-8715-7 Section 4 Equations 1-6, 9, 14, 15 figures 1,4-6 ----- -/- .	1-4, 6-16, 18



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"&" document member of the same patent family

Date of the actual completion of the international search

19 March 2013

Date of mailing of the international search report

03/04/2013

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INTERNATIONAL SEARCH REPORT

International application No

PCT/BR2012/000490

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 8 030 867 B1 (ALLISON III REX L [US]) 4 October 2011 (2011-10-04) column 2, lines 12-20 column 3, line 35 column 5, lines 16-17 column 5, lines 35-37 column 5, lines 40-43 column 6, lines 8-10 column 6, lines 20-33 column 6, line 66 - column 7, line 3 column 7, lines 4-16 column 7, lines 29-49 column 8, lines 15-24 figures 1-6 -----	1-28

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/BR2012/000490

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 8030867	BI	04-10-2011	US 8030867 BI 04-10-2011
			US 8358093 BI 22-01-2013
