Method and apparatus for processing ultrasonic signals.

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Publication date:
2009

Document Version
Publisher's PDF, also known as Version of record

(19) DANMARK

(10) **DK 2008 00633 L**

(12) PATENTANSØGNING

Patent- og
Varemærkestyrelsen

(51) Int.Cl.[8]: ***G 10 K 11/34 (2006.01)*** ***G 01 S 7/52 (2006.01)*** ***G 01 S 7/523 (2006.01)***

(21) Patentansøgning nr: **PA 2008 00633**

(22) Indleveringsdag: **2008-05-02**

(24) Løbedag: **2008-05-02**

(41) Alm. tilgængelig: **2009-05-23**

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(54) Benævnelse: **Method and apparatus for processing ultrasonic signals**

(57) Sammendrag:

A method of processing ultrasonic signals, comprising during first periods of time, emitting ultrasonic energy into a volume comprising a matter; during second periods of time interlaced with the first periods of time, acquiring sets of detected signals by parallel detection of ultrasonic energy caused by interaction between the emitted ultrasonic energy and the matter; and performing first beam forming to generate multiple first image lines, where the multiple first image lines are generated from respective sets of detected signals. Further, performing second beam forming to generate multiple second image lines, where a second image line is generated from multiple of the first image lines.

fortsættes

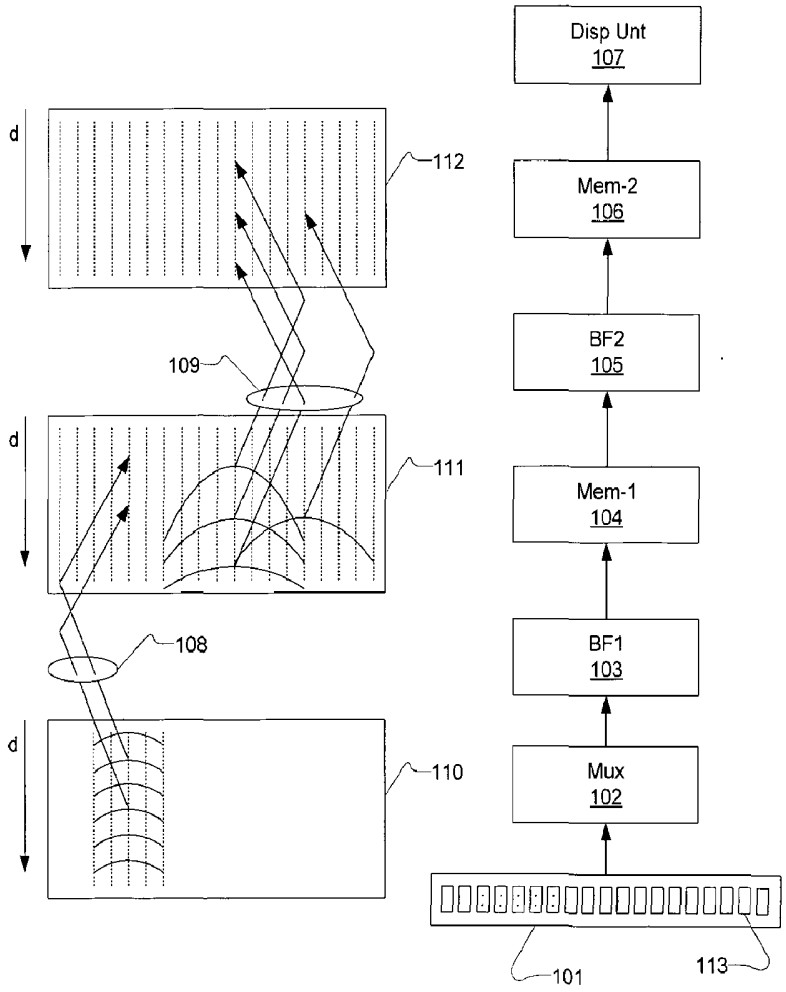
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Fig. 1

Claims

1. A method of processing ultrasonic signals, comprising:

- during first periods of time, emitting ultrasonic energy into a volume comprising a matter;
- during second periods of time interlaced with the first periods of time, acquiring sets of detected signals by parallel detection of ultrasonic energy caused by interaction between the emitted ultrasonic energy and the matter;
- performing first beam forming to generate multiple first image lines, where the multiple first image lines are generated from respective sets of detected signals;

CHARACTERIZED in

- performing second beam forming to generate multiple second image lines, where a second image line is generated from multiple of the first image lines.

2. A method according to claim 1, where ultrasonic energy is emitted by a transducer with an array of transducer elements; and where a stimulation signal is applied to stimulate a set of the transducer elements at respective points in time comprising delaying the stimulation signal respective first delay amounts to provide focusing of the emitted ultrasonic energy in predefined points.

3. A method according to claim 2, where the respective first delay amounts are fixed, and where the emitted ultrasonic energy is focused in a single point with a fixed position relative to the set of transducer elements.

4. A method according to claim 1, where the ultrasonic energy is detected by a transducer with an array of transducer elements providing the set of detected signals from respective elements, and where first beam forming is

performed by delaying the detected signals respective second delay amounts and summing the delayed signals to thereby provide focusing in predefined points.

5. A method according to claim 4, where the difference between a delay amount for a signal of a reference element and a delay amount for a signal of a respective receiving transducer element is proportional to the difference between the distance from the focus point to the reference element and the distance from the focus point to the respective receiving element.

6. A method according to claim 4, where the respective second delay amounts are fixed, and where focus is established in a single point with a fixed position relative to the set of transducer elements.

7. A method according to claim 4, where an image point in a first image line is calculated from detected signals from respective transducer elements at positions that are proportional to the sum of: the distance from the depth of the transmit focus point, the distance from the transmit focus point to an image point, the distance from the image point to the receive focus point, and the distance from the receive focus point to the respective transducer element.

8. A method according to claim 1, where ultrasonic energy is emitted by a transducer to be focused in a first set of points at predefined positions, and where first beam forming is performed to provide focusing in a second set of points coincident with the first set of points.

9. A method according to claim 3 and 6, where the first delay amounts and the second delay amounts are similar to provide substantially coincident focus points.

10. A method according to claim 1, where a first image line and/or second image line is generated symmetrically from a set of signals acquired symmetrically about the first image line.

11. A method according to claim 1, where first stage beam forming is performed by analogue delay units and an analogue adder; and where the analogue adder provides its output to an analogue-to-digital converter to subsequently store first image lines in a first memory.

12. A method according to claim 1, where detected signals are converted to digital signals with digital values and where first stage beam forming is performed by selecting respective digital values and adding them digitally to subsequently store first image lines in a first memory.

13. A method according to claim 1, comprising:
- during the second periods of time, storing detected signals acquired in parallel in a first memory;

14. A method according to claim 1,
- where a set of the first image lines are stored in the first memory during one of the second periods of time;
- where first beam forming is performed on the set of the first image lines that are stored in the first memory during one of the second periods of time before acquisition of a further set of line signals commences; and
- storing first image line signals in a second memory.

15. A method according to claim 1, where the sets of detected signals are provided by multiple sub-arrays of the transducer array; and at least two sub-arrays are concurrently used to detect signals.

16. A method according to claim 1, where second beam forming is performed by generating a second image line with values that are generated by summing values of multiple of the first image line signals at respective instances of time.

17. A method according to claim 1, where second beam forming is performed to provide receive focusing, focused in a multitude of points coincident with at least one of the second image line.

18. A method according to claim 1, comprising:
- determining the respective instances of time from a multitude of delay profiles in a matrix structure that comprises a delay amount for respective ones of the line signals for a given position in a first image line;
- using delay profile from the matrix structure to calculate a majority of the values of the second image lines.

19. A method according to claim 1, where the ultrasonic energy is focused in a transmit focus point at a predefined depth in multiple of the first lines; where in the first beam forming, a receive focus point is established at a predefined depth in multiple of the first lines; where second beam forming is performed by generating an image point of a second image line with a value that is generated by summing, from respective time instances, values of the multiple of the first image line signals; and where a respective time instance of a selected line of the multiple of the first lines is proportional to the sum of: the depth of the transmit focus point for the selected line, the distance from the transmit focus point for the selected line to the image point, the distance from the image point to the receive focus point for the selected line, and the depth of the receive focus point for the selected line.

20. A method according to claim 1, where the ultrasonic energy is un-focused; where in the first beam forming, a receive focus point is established

at a predefined depth in multiple of the first lines; where second beam forming is performed by generating an image point of a second image line with a value that is generated by summing, from respective time instances, values of the multiple of the first image line signals; and where a respective time instance of a selected line of the multiple of the first lines is proportional to the sum of: the depth of the image point, the distance from the image point to the receive focus point, and the depth of the receive focus point for the selected line.

21. A method according to claim 1, where the multiple first image lines are stored in a line buffer, and where the line buffer is cleared when a complete image of second image lines has been formed.

22. A method according to claim 1, where the multiple first image lines are stored in a line buffer of the first-in-first-out type, and where a complete image of second image lines is formed from N of the first image lines, and where second image lines is created at a more frequent rate than the rate of beam forming all first image line signals of an image.

23. An apparatus configured to perform the method as set forth in any of the above claims.

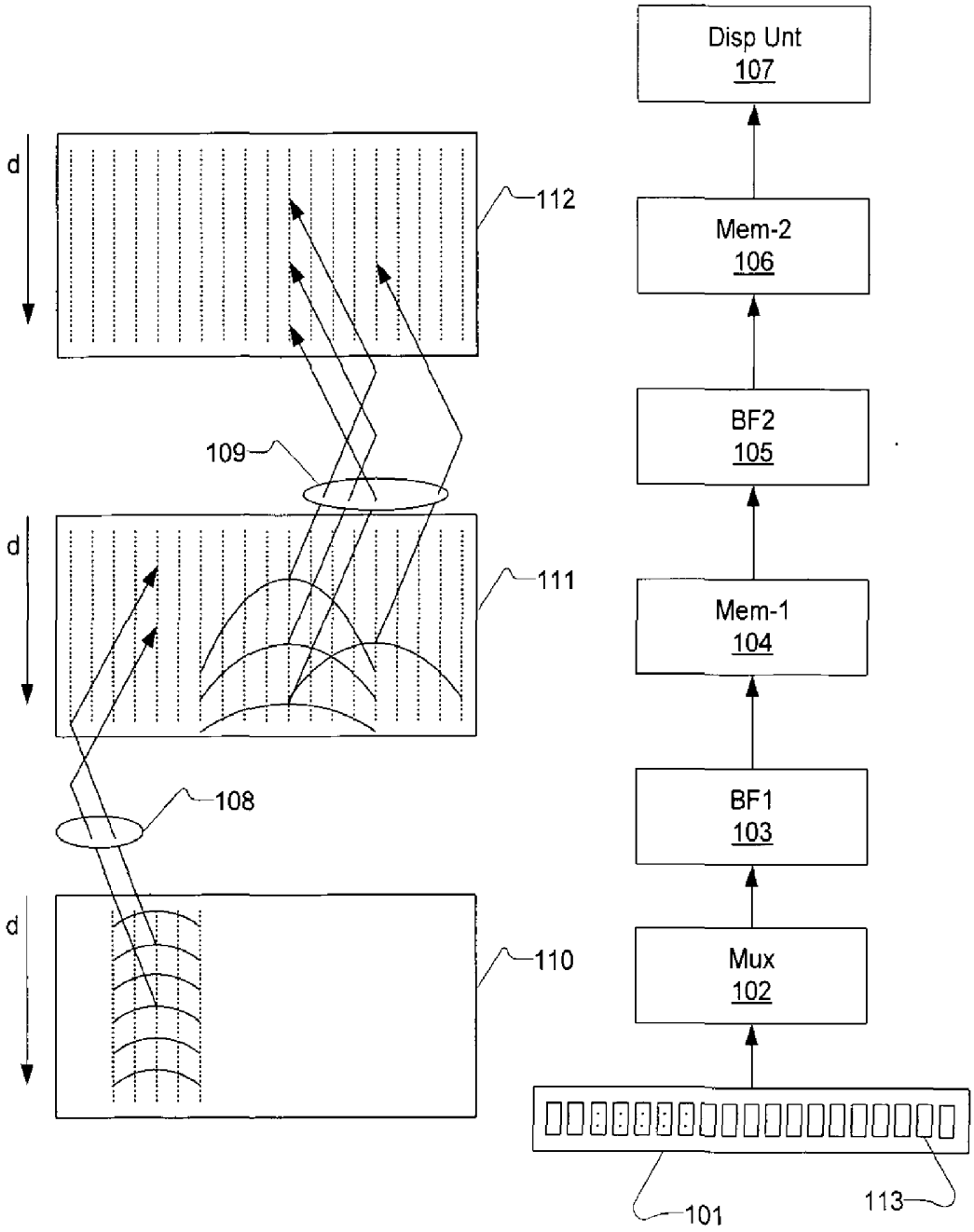
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Fig. 1

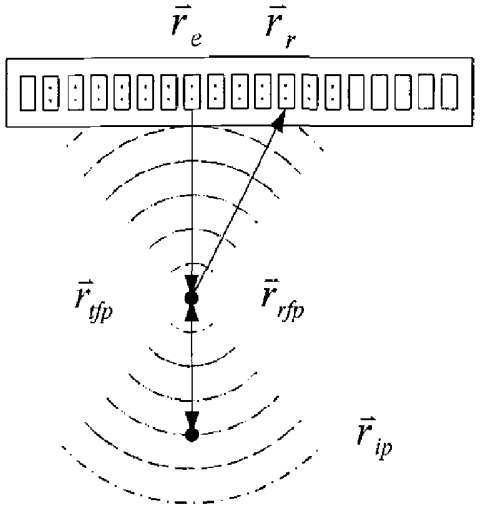


Fig. 2a

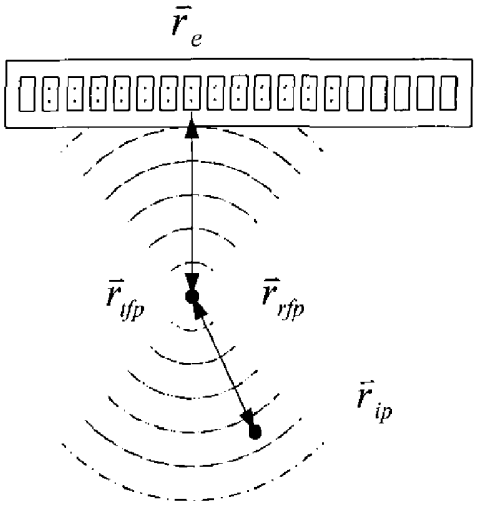


Fig. 2b

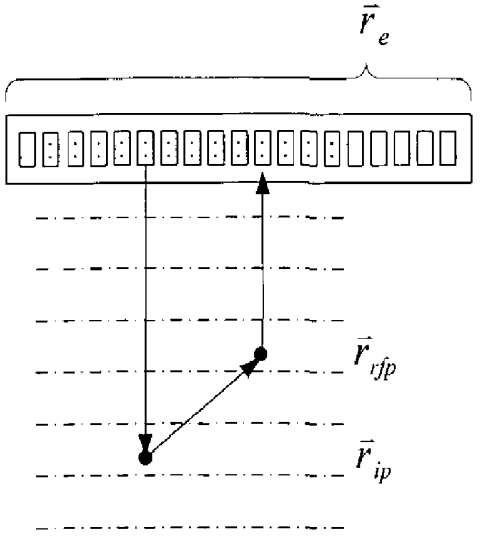


Fig. 2c

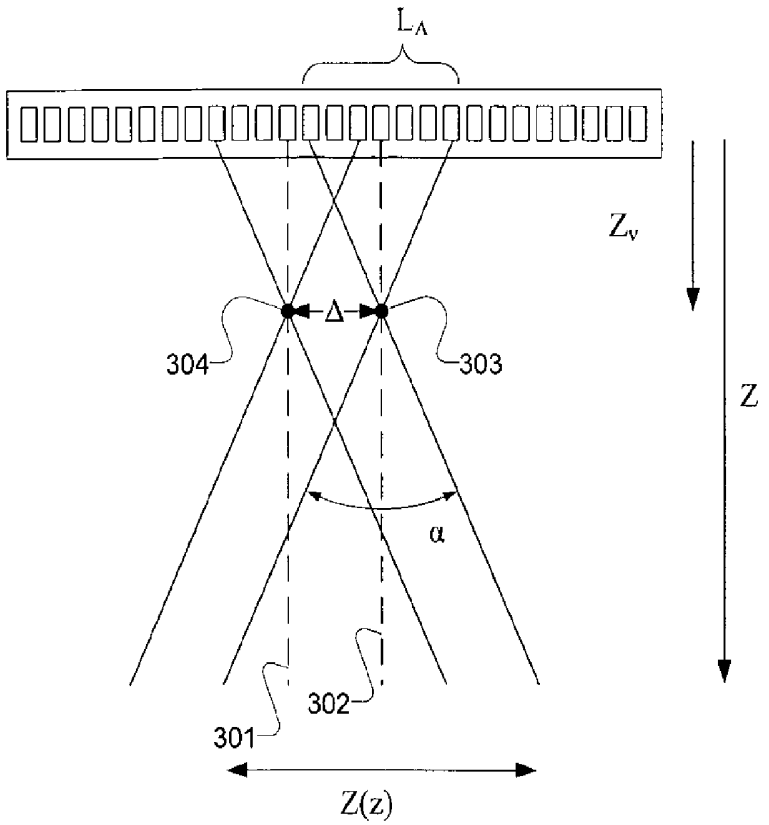
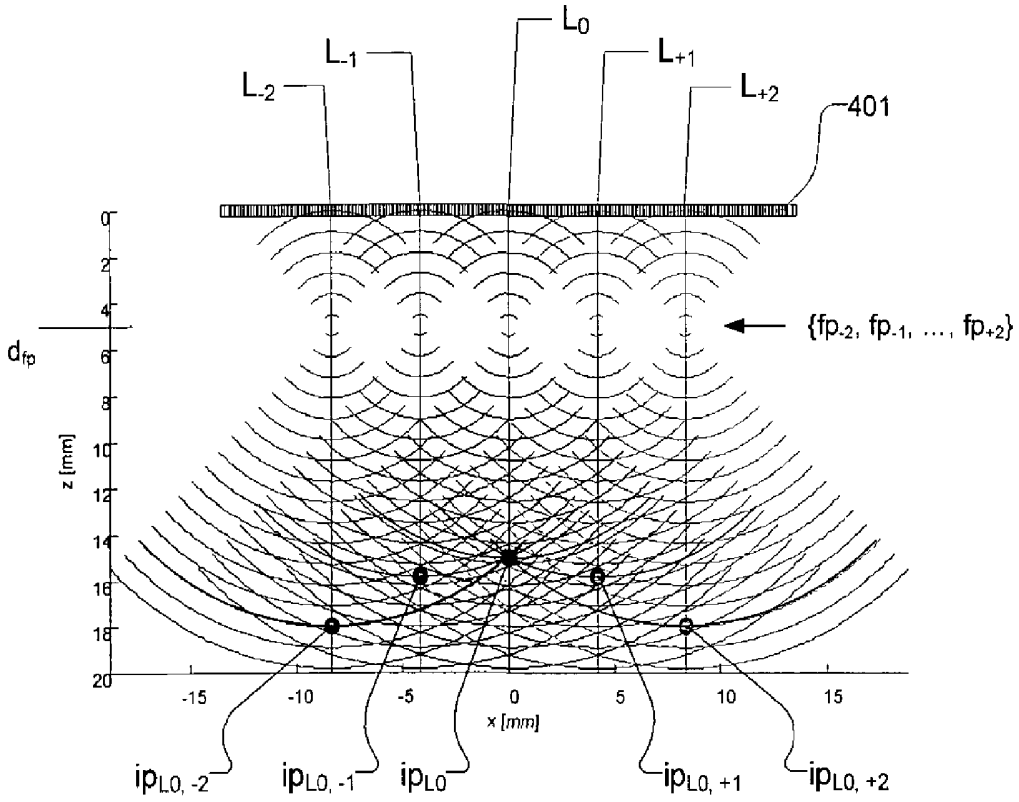


Fig. 3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ipL0, +2

Fig. 4

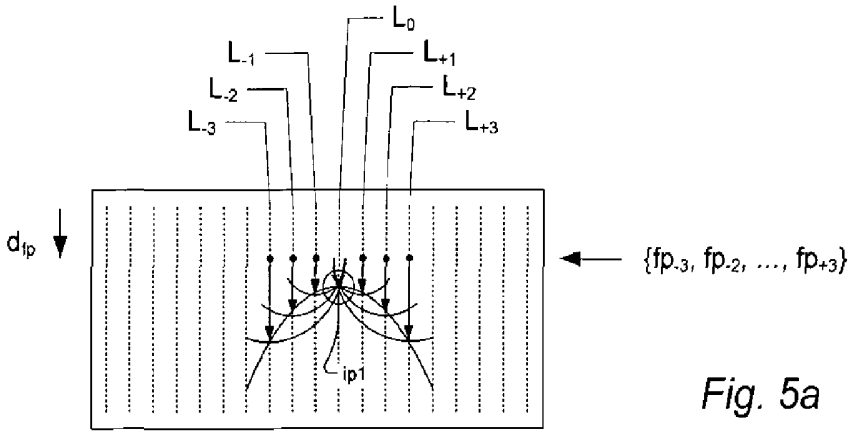

Fig. 5a

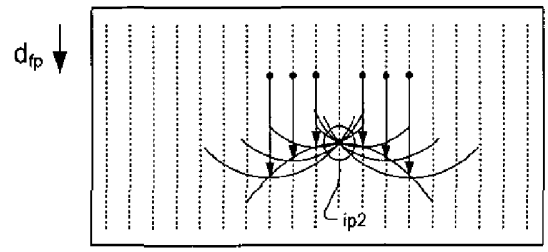

Fig. 5b

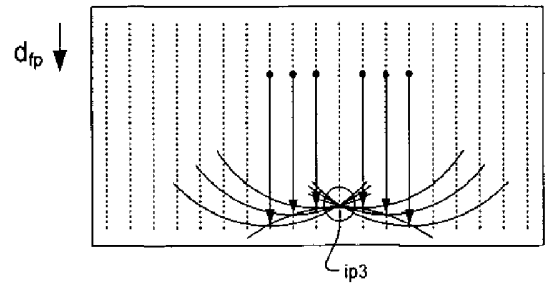

Fig. 5c

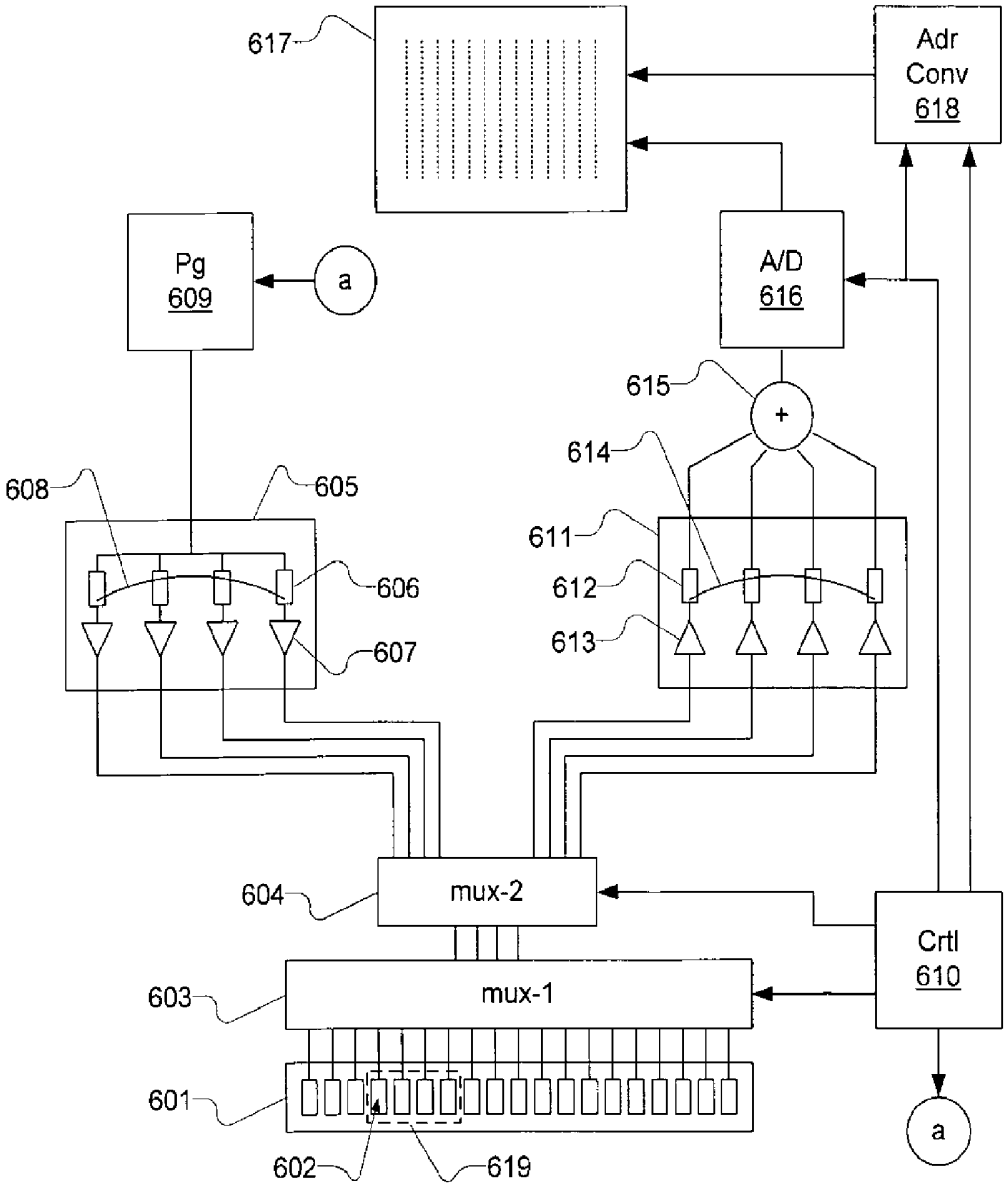
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Fig. 6

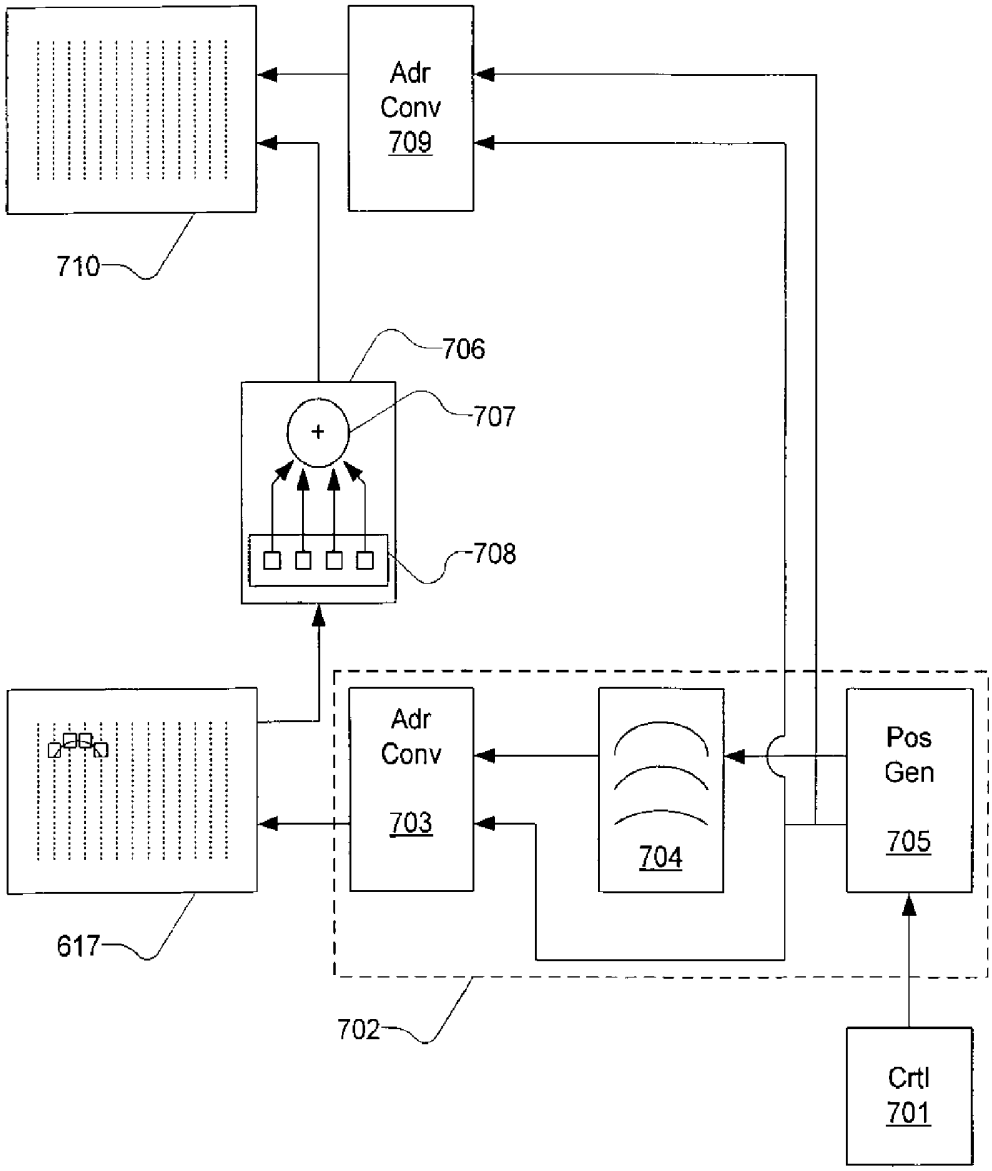
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Fig. 7