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(54) **METHOD AND SYSTEM FOR TUNING OF INDUCTIVE SENSORS FOR DETECTION OF THE PRESENCE OF RAILWAY VEHICLE WHEELS**

(57) The method of inductive sensor tuning for detection of the presence of railway vehicle wheels, with the sensor including a generator system (G), a resonance circuit (LC), a detection system (UD), an amplifier system (WW) and an output stage (ZP), wherein internal signal (XD) and output signal (Y) are generated in the inductive sensor (C), wherein a reference value (XDref) is stored in internal signal values (XD), used in order to obtain a reference value (Yref) in the output signal (Y), characteristic for the absence of wheel over the inductive sensor according to the invention, characterised in that basic tuning of the internal signal value (XD) to the reference level (XDref) is performed by setting a frequency of the generator system (G), with the generator system being preferably numerically controlled, and subsequently, additional tuning is performed periodically by setting at least one internal threshold in the amplifier system (WW),

which is in turn used to separate large changes of the internal signal (XD) compared to the reference level (XDref), caused by the presence of a wheel, from small changes of the internal signal (XD) compared to the reference level (XDref), caused by sensor ageing processes and by changes to the working environment of the sensor.

System for tuning of inductive sensors for detection of a railway vehicle wheel according to the invention is characterised in that an oscillator system (OSC) with a constant first output frequency (F1) and a system setting a variable output frequency (USC) on the level of the second output frequency (F2) are installed in the generator system, wherein the system setting a variable output frequency on the level of the second output frequency is controlled numerically, by entering a binary word (S), or voltage-controlled, by providing a voltage signal (V) from the control unit (JS).

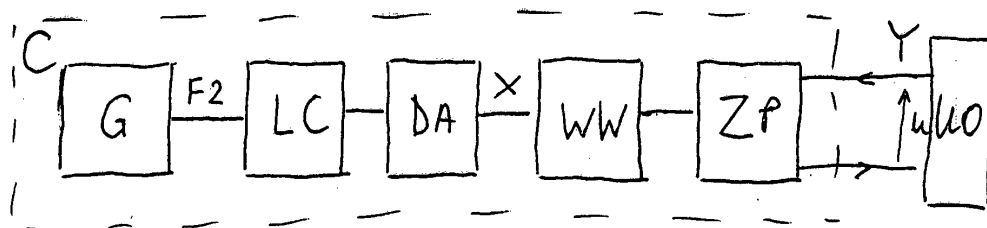


fig. 1

Description

[0001] The object of the invention is a method and a system for tuning of inductive sensors for detection of the presence of railway vehicle wheels, in particular for in presence electromagnetic interference and in presence of rail brakes.

[0002] Polish patent application P.414752 discloses a system for detection of the presence of railway vehicle wheels and a tuning method of said system. Another tuning method is known from the patent publication EP 1479 587 B1.

[0003] Various methods of inductive sensor parameter setting are used in order to tune the sensors, including parameters such as frequency, sensitivity, output current, as well as various methods of introducing changes to the aforementioned parameters, including remote methods and using non-volatile memory systems. Various techniques of communication with the sensor are known, including standard methods, such as conforming to the so-called Highway Addressable Remote Transducer Protocol, and non-standard methods, often using serial data transmission.

[0004] Tuning of inductive sensors for detection of the presence of railway vehicle wheels under real conditions, with the sensors installed in the environment of railway tracks of different sizes and with different influence is usually performed through modifications of impedance of the resonance circuit obtained either by ensuring correct distance relationships between the sensor and the rail, or by appropriate modifications of parameters of the resonance circuit, for example adding or removing additional elements to/from the inductive coil.

[0005] In addition, in order to ensure long-term stability of sensor signals influenced by environmental conditions, for example by temperature changes, corrective tuning in the form of thermal compensation is used, by correcting internal or output signals as a function of temperature, according to pre-defined correction values stored in the non-volatile memory. This type of tuning is limited by the fact that it does not account for the influence of phenomena related to sensor ageing.

[0006] The method of inductive sensor tuning for detection of the presence of railway vehicle wheels, with the sensor including a generator system, a resonance circuit, a detection system, an amplifier system and an output stage, characterised in that internal signal and output signal are generated in the inductive sensor, wherein a reference value is stored in internal signal values, used in order to obtain a reference value in the output signal, characteristic for the absence of wheel over the inductive sensor according to the invention, characterised in that basic tuning of the internal signal value to the reference level is performed by setting a frequency of the generator system, with the generator system being preferably numerically controlled. Subsequently, additional tuning is performed periodically by setting at least one internal threshold in the amplifier system, which is in turn used

to separate large changes of the internal signal compared to the reference level, caused by the presence of a wheel, from small changes of the internal signal compared to the reference level, caused by sensor ageing processes and by changes to the working environment of the sensor. Then, in the case of small changes, the internal signal is formed by its periodic modifications in specific intervals, using a correction value such that the internal signal is gradually corrected using compensation, according to the following relationships:

$$XD(i+1)=XD(i)+Xcorr \text{ for } XD(i)<XDref$$

$$XD(i+1)=XD(i)-Xcorr \text{ for } XD(i)>XDref,$$

where:

$XD(i)$ - the value of internal signal XD at time i ,

$XD(i+1)$ - the value of internal signal XD at time T after time i ,

$Xcorr$ - the value of the correction of internal signal XD during additional tuning,

$XDref$ - the reference value of internal signal XD , at which the output signal Y reaches its reference value $Yref$ characteristic for the absence of a wheel above the inductive sensor.

[0007] System for tuning of inductive sensors for detection of a railway vehicle wheel including a generator system, a resonance system, an amplitude and/or phase detection system, an amplifier system, preferably being a non-linear system, and an output stage, preferably configured as a current source, connected with an evaluation system according to the invention and characterised in that an oscillator system with a constant first output frequency and a system setting a variable output frequency on the level of the second output frequency are installed in the generator system. The system setting a variable output frequency on the level of the second output frequency is controlled numerically, by entering a binary word, preferably with a minimum length of 8 bits, or voltage-controlled, by providing a voltage signal from the control unit, preferably provided as a microprocessor, preferably integrated with the system setting the variable output frequency.

[0008] Preferably, an automatic resetting and/or signalling system is installed in the amplifier system. Preferably, the automatic resetting system is equipped with a summing amplifier, one of the outputs of which is connected to the first digital-analogue converter controlled by the control unit, preferably integrated with the converter, connected to an analogue-digital converter, preferably integrated with the control unit and connected to an output of the summing amplifier. The signalling system is preferably equipped with a summing amplifier, one of

the outputs of which is connected to the second digital-analogue converter controlled by a control unit, preferably integrated with the converter.

[0009] Use of the invention allows long-term stability of sensor signals to be achieved, which allows longer intervals between costly tuning operations performed by specialists.

[0010] The object of the invention is explained in more details in its embodiments and in the drawing, in which Fig. 1 presents the block diagram of the system, Fig. 2a presents the block diagram of the numerically controlled generator, Fig. 2b presents the block diagram of the generator system controlled using voltage signal, Fig. 3 presents the block diagram of the automatic resetting system, Fig. 4 presents the block diagram of the signalling system and Fig. 5 schematically presents the tuning method.

Example 1

[0011] As Fig. 1 shows, the inductive sensor C includes a generator system G, a resonance system LC, a detection system UD, an amplifier system WW and an output stage ZP, connected with the evaluation system OC. As Fig. 2a shows, the generator system G is equipped with a high stability oscillator OSC generating the first, fixed output frequency F1, which is subsequently converted by the system setting the variable output frequency USC on the level of the second output frequency F2, with the system being numerically controlled using a binary word S with a length of 16 bits by the control unit JS. The system setting the variable output frequency USC uses the clock of a microprocessor acting as the control unit JS, including an overflow signal of the accumulator summing signal pulses from the oscillator OSC with the given value S, comprising the numerically controlled generator (oscillator) system with a variable output frequency F2.

[0012] Signal from the generator G is filtrated by the resonance system LC, parameters of which are modified as a result of wheel presence near the sensor, and subsequently processed by the detection system UD. The detection system UD may be a phase or an amplitude detector system, with internal signal X being generated at its output. The internal signal X is sent to the amplifier system WW, the first stage of which is executed on the basis of a system adding the signal X to the correcting signal XDcorr, according to the diagram presented in Fig. 3. The amplifier system WW is equipped with a summing amplifier WS, one of the outputs of which is connected to the first digital-analogue converter C/A1 controlled by the control unit JS equipped with the analogue-digital converter A/C, connected to an output of the summing amplifier WS.

[0013] Basic tuning of the inductive sensor C includes such a modification of the output frequency F2 that the expected value of the internal signal XD at the reference level XDref is achieved at the output of the detector. This operation is executed by a cyclic measurement of the

value of the internal signal XD using the first analogue-digital converter A/C1 of the control unit JS, followed by a comparison of the measured internal signal XD with the reference value XDref. Next, a correction of the output frequency F2 is introduced. The tuning process is triggered using a control signal CTRL, which achieves the required level if polarisation of the supply voltage U of the inductive sensor C is reversed, and continued until a value of the internal signal XD close to the reference value XDref is obtained.

[0014] Additional tuning of the inductive sensor C, as shown schematically in Fig. 5, is performed using periodic corrections of the internal signal XD, in intervals T, with the correction value Xcorr and using the first digital-analogue converter C/A1 of the control unit JS, connected to the input of the summing amplifier WS, according to the following relationships:

$$XD(i+1)=XD(i)+Xcorr \text{ for } XD(i)<XDref$$

$$XD(i+1)=XD(i)-Xcorr \text{ for } XD(i)\geq XDref,$$

where:

XD(i) - the value of internal signal XD at time i,
 XD(i+1) - the value of internal signal XD at time T after time i,
 Xcorr - the value of the correction of internal signal XD during additional tuning,
 XDref - the reference value of internal signal XD, at which the output signal Y reaches its reference value Yref characteristic for the absence of a wheel above the inductive sensor.

Example 2

[0015] The inductive sensor C described in Example 1 was modified by using a generator system G presented in Fig. 2b. The generator system G is equipped with a high stability oscillator OSC generating fixed, first output frequency F1. The output frequency F1 is processed by the system setting the variable output frequency USC on the level of the second output frequency F2. The system setting the variable output frequency USC uses a phase resonance loop system with variable output frequency F2, the value of which is proportional to the control voltage V (voltage controlled oscillator) supplied by the control unit JS.

Example 3

[0016] The inductive sensor C described in Example 1 and Example 2 was modified by adding a signalling system US informing about internal states of the sensor, such as temperature, vibrations, malfunctions. As Fig. 4

shows, the signalling system US is equipped with a summing amplifier WS, one of the outputs of which is connected to the second digital-analogue converter C/A2 controlled by the control unit JS integrated with it. The control unit JS records selected variables related to sensor operation and to environmental conditions. This information is coded to the XS signal, added to the internal signal XD and sent to the evaluating unit OC.

Claims

1. The method of inductive sensor tuning for detection of the presence of railway vehicle wheels, with the sensor including a generator system (G), a resonance circuit (LC), a detection system (UD), an amplifier system (WW) and an output stage (ZP), wherein internal signal (XD) and output signal (Y) are generated in the inductive sensor, wherein a reference value (XDref) is stored in internal signal values (XD), used in order to obtain a reference value (Yref) in the output signal (Y), characteristic for the absence of wheel over the inductive sensor according to the invention, **characterised in that** basic tuning of the internal signal value (XD) to the reference level (XDref) is performed by setting a frequency of the generator system (G), with the generator system being preferably numerically controlled, and subsequently, additional tuning is performed periodically by setting at least one internal threshold in the amplifier system (WW), which is in turn used to separate large changes of the internal signal (XD) compared to the reference level (XDref), caused by the presence of a wheel, from small changes of the internal signal (XD) compared to the reference level (XDref), caused by sensor ageing processes and by changes to the working environment of the sensor, and in the case of small changes, the internal signal (XD) is formed by its periodic modifications in specific intervals (T), using a correction value (Xcorr) such that the internal signal (XD) is gradually corrected using compensation, according to the following relationships:

$$XD(i+1)=XD(i)+Xcorr \text{ for } XD(i)<XDref$$

$$XD(i+1)=XD(i)-Xcorr \text{ for } XD(i)\geq XDref,$$

where:

XD(i) - the value of internal signal XD at time i,
 XD(i+1) - the value of internal signal XD at time T after time i,
 Xcorr - the value of the correction of internal signal XD during additional tuning,

XDref - the reference value of internal signal XD, at which the output signal Y reaches its reference value Yref characteristic for the absence of a wheel above the inductive sensor.

2. System for tuning of inductive sensors for detection of a railway vehicle wheel including a generator system (G), a resonance system (LC), an amplitude and/or phase detection system (UD), an amplifier system (WW), preferably being a non-linear system, and an output stage (ZP), preferably configured as a current source, connected with an evaluation system (UO), **characterised in that** an oscillator system (OSC) with a constant first output frequency (F1) and a system setting a variable output frequency (USC) on the level of the second output frequency (F2) are installed in the generator system, wherein the system setting a variable output frequency on the level of the second output frequency is controlled numerically, by entering a binary word (S), preferably with a minimum length of 8 bits, or voltage-controlled, by providing a voltage signal (V) from the control unit (JS), preferably provided as a microprocessor, preferably integrated with the system setting the variable output frequency (USC).
3. System according to claim 2, **characterised in that** an automatic resetting system (UA) and/or a signalling system (US) are installed in the amplifier system (WW).
4. System according to claim 2 or 3, **characterised in that** the automatic resetting system (UA) is equipped with a summing amplifier (WS), one of the outputs of which is connected to the first digital-analogue converter (C/A1) controlled by the control unit (JS), preferably integrated with the converter and connected to an analogue-digital converter (A/C), preferably integrated with the control unit (JS) and connected to an output of the summing amplifier (WS).
5. System according to claim 2 or 3, **characterised in that** the signalling system (US) is equipped with a summing amplifier (WS), out of the outputs of which is connected to the second digital-analogue converter (C/A2) controlled by the control unit (JS), preferably integrated with the converter.

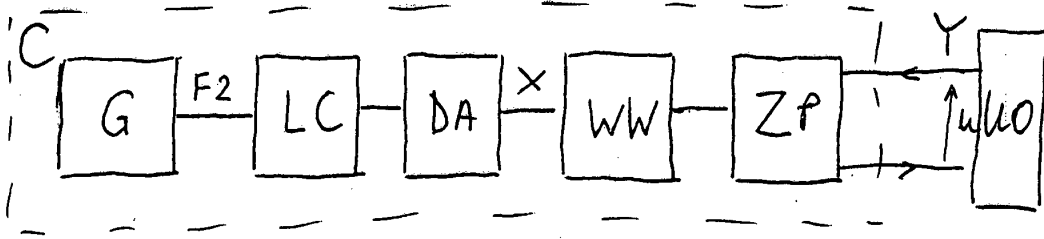


fig. 1

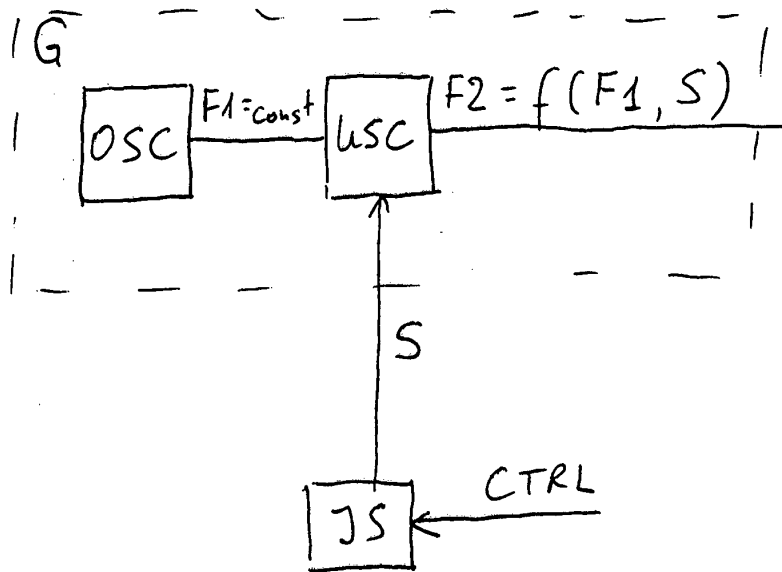


fig. 2a

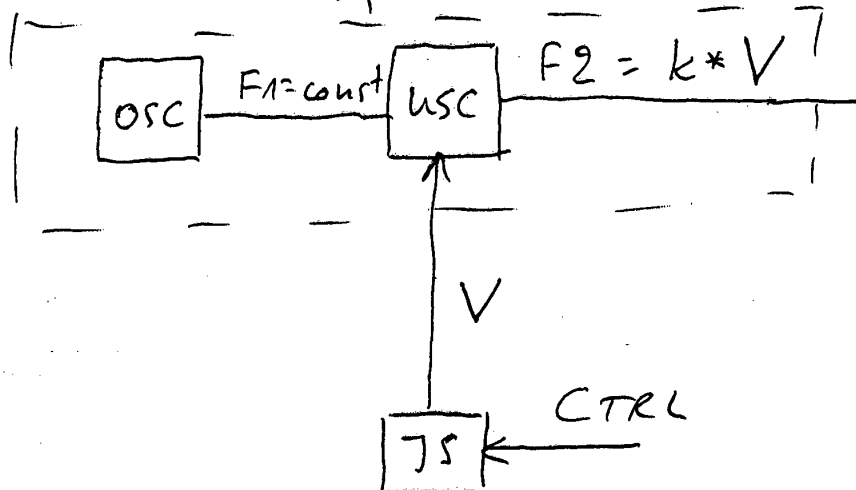
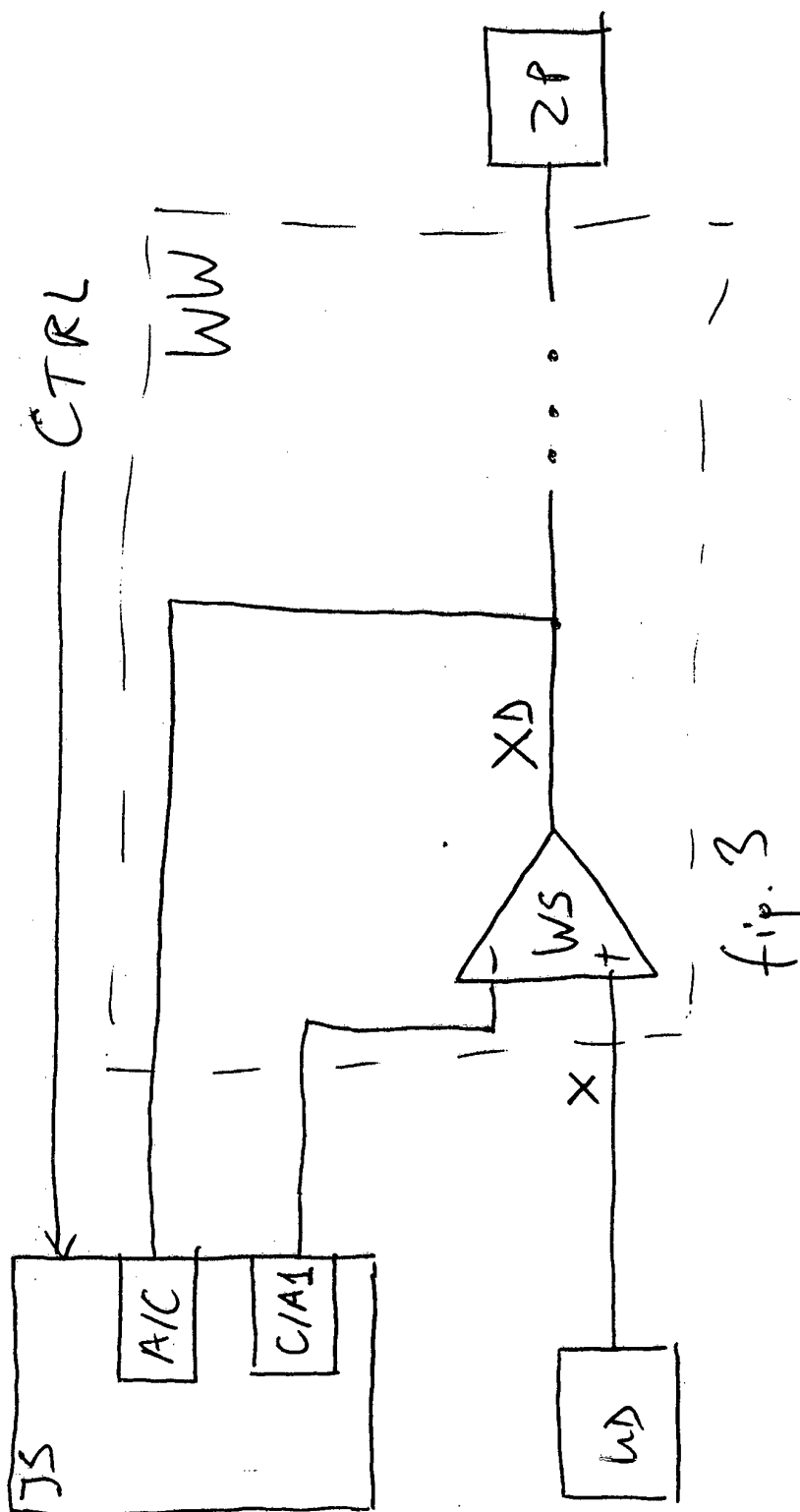


fig. 2b



RZECZNIK PATENTOWY
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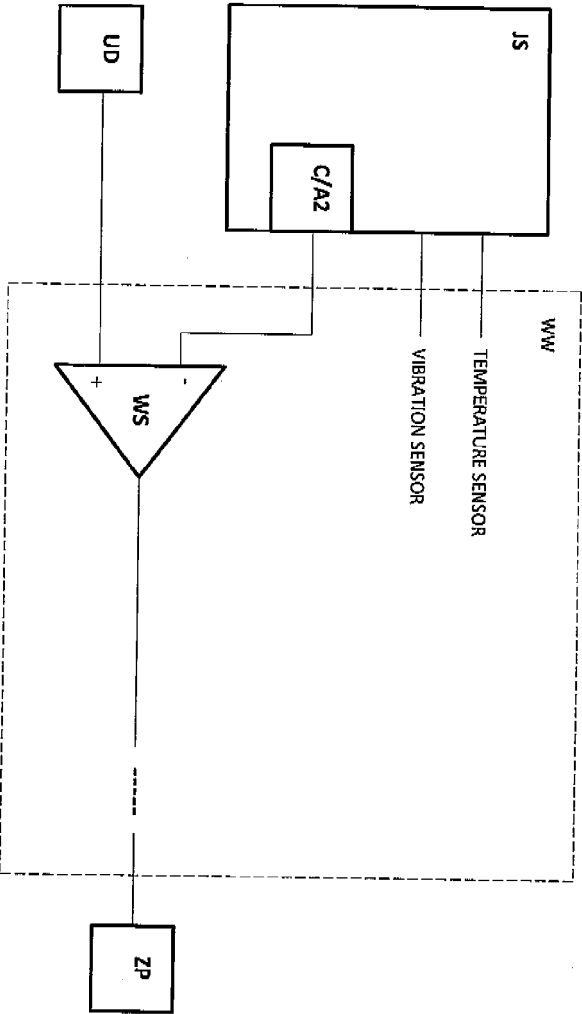


Fig. 4

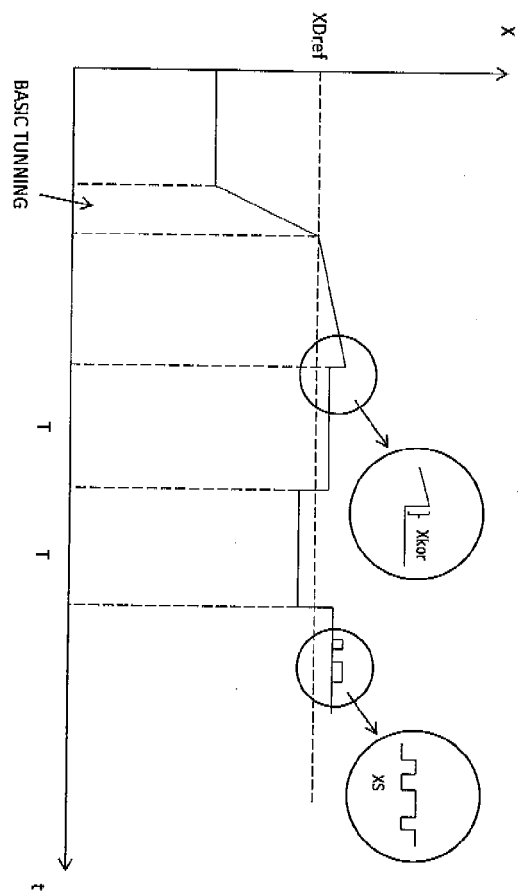


Fig. 5

REFERENCES CITED IN THE DESCRIPTION

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