Description

Background of the Invention

This invention relates to transducer positioning and more particularly to servo systems for accessing and following data tracks on a rotating medium.

Known methods of determining transducer position apply an amplitude measurement of signals from adjoining servo tracks to generate a net signal indicative of the radial displacement from a predetermined track centerline. As track densities have increased, the capability of this technique has been enlarged by progressing from dibit to tribit to pentabit servo formats to increase the number of tracks in the capture area and enable more precise track identification. Any of these techniques has been susceptible to inaccuracy as a result of random electrical noise occurring during the servo signal window, and to mitigate this disability, the servo format has often used redundant signals which are averaged to obtain a more uniform approximation to the true value.

DE-A-2 657642 describes a servo system in a disk file with a transducer which is radially movable between track positions, this servo system being based upon the determination of the transducer position through a pulse length measurement of signals generated from a recorded pattern having marks with a length varying radially.

DE-A-1 524775 discloses a servo system for the head of a magnetic disk to position the head over a desired data track. The data tracks are interleaved with servo tracks having portions of same frequency but alternately in phase opposition. Each servo track utilizes for a coarse adjustment, phase reversals that define predetermined distances that identify the desired data track.

Summary of the Invention

It is the object of the invention to reduce the result of noise and of lack of synchronisation. The invention is set out in claim 1.

The number of cycles within each field is arbitrary except that with more cycles it is possible to average the phase measurement over more transitions and reduce the influence of noise signals.

Phase is measured modulo 360°. The phase of a given field will go through 360° every M tracks. Several fields can be used having different values of M to obtain coarse, medium and fine position resolution with the same servo pattern and demodulation scheme.

This servo pattern is less susceptible to track-type dependent squeeze than previous servo patterns. Different frequency and phase contents of the signals written on odd or even tracks in the tribit servo pattern cause unpredictable amounts of squeeze between adjacent tracks. The pentabit servo pattern has four track types, each having different frequency and phase content.

Head to head variations in frequency response and off-track pickup make the squeeze difficult to control with these patterns. With the phase modulation servo pattern, the servo information is encoded at a single frequency so that frequency response of the head cannot affect the position error signal to first order. Also, the context for every field in the servo pattern is the same at every track position so that the off-track pickup from the sides of the read/write gap cannot cause squeeze between adjacent tracks. Since the amplitude of the off-track pickup is reduced rapidly as the frequency is raised, it is clearly advantageous to use many cycles at a fairly high frequency to minimize squeeze effects due to off-track pickup.

Because some types of read/write recording heads can pick up low frequency signals written of the disk over a much wider region than 1 track, it is important that no systematic coherent low frequency patterns be written into the servo patterns. If this is not done, then the analog servo signals end up riding on a base line which is not flat.

Brief Description of the Drawing

Figure 1 is a schematic showing of an optimum form of a phase shift servo pattern.

Figure 2 is a schematic illustration to illustrate the repeat distance of 360° of phase shift difference related to radial displacement.

Figure 3 is an illustration similar to figure 2 showing three scales of phase shift resolution.

Figure 4 illustrates a two field phase shift magnetic transition pattern.

Figure 5 is similar to figure 4, but modified to show a split field phase shift magnetic transition pattern used to eliminate speed variation errors.

Figure 6 shows a phase shift transition servo pattern over eight tracks using a clock field and three fields with varying phase shift patterns to obtain varying phase shift difference resolutions.

Figure 7 shows a two field, eight track phase shift magnetic transition pattern wherein the splitting of one field results in a common center shared by the two fields.

Figure 8 is a block diagram of a demodulator for producing a position signal from detected phase differences.

Detailed Description

In the servo device described herein, servo information is encoded in the phase of the servo pattern instead of the amplitude of the servo signal lobes. Further, the impact of random noise in the media has less influence when averaging many transitions rather than using one or a few peaks. Also amplitude should have reduced importance to render the automatic gain control (AGC) function less critical.

Figure 1 shows an idealized phase shift servo position with the concentric tracks represented horizontally and radial position represented as vertical movement. One polarity of the magnetic particles within the servo area is shown in the form of shaded portions with unshaded portions

being the reverse polarity. The figure shows two fields written at the same frequency. Since the polarity has two transitions per track, a transducer head greater than half the track pitch will encounter a change of phase associated with radial displacement that changes both continuously and linearly with such radial displacement.

Also required is a clock or signal source running at the same frequency as the two fields and a means for detecting the phase of each field with respect to the clock. The phase difference between the fields gives the radial position of the transducer modulo some number of tracks, which number of tracks may be an integer or a non-integer. As illustrated in figure 2, the repeat distance may be any distance that equal 360° of phase difference. This distance in tracks is chosen with respect to the desired function subject to noise and hardware performance considerations. The use of three fields enables the use of three different repeat distances corresponding to the phase differences between various interfield differences, to allow the position to be unambiguously detected on three different scales of distances (coarse, medium and fine). For sector servo applications, these multiple degrees of resolution will be especially useful in seek mode.

Although the transition pattern shown in figure 1 is optimal in providing a continuous and linear phase change with radial movement of the transducer, the problems associated with writing the pattern make a modified form that provides good performance a more practical resolution of the problem. To produce the pattern of figure 1, it is most practical to use a special transducer head having slanted gaps. It is also necessary to precisely record the servo tracks to provide continuous transitions inclined to a radial line or transducer path.

However, it is not necessary that the pattern be written with slanted transitions in order to obtain good performance provided the head or channel filters out the third and higher harmonics of the signal frequency. With a head approximately two-thirds the width of a track, excellent position error linearity can be obtained with only half-track resolution in writing the patterns provided no more than 90° of phase shift per half track is used on any field in the pattern. This will allow each field to change by up to 180° per track for a total of 360° per track within two fields and writing one-half track patterns. A useful system for sector servo would also include a clock field for recognizing the start of the servo fields and a coarse servo field.

As seen in figure 4, the position error signal is encoded as a phase difference between two patterns written on the disk. Figure 4 shows phase displacement of the pattern occurring each half-track. The phase displacement as shown is equal in both fields but occurs in opposite circumferential directions. The pattern shows a displacement D between the centers of the two fields whose phases are being compared.

The demodulator which processes the signal uses the signal produced by the magnetic recording head to determine the radial position of the head. The head signal consist of two periodic sequences of transitions produced as the head traverse the patterns of the two fields in the circumferential direction at almost constant radial displacement. The demodulator measures the relative phase difference between the average phase in field 1 and the average phase in field 2 by comparing both to a common reference clock whose transitions are coherent over both fields. This reference clock is obtained by dividing down a higher frequency crystal clock whose transitions are not necessarily synchronized with the transitions in the head signal. This lack of synchronization does not effect the result since the demodulator output consists of a difference of the phase of field 1 minus the phase of the reference and the phase of field 2 minus the phase of the reference. Thus the phase of the reference clock cancels out. However, if the frequency of the repetitive patterns within each field does not match the frequency of the reference clock then the output of the demodulator will not represent the actual phase shift between the two fields. The phase error in radians will be the product of the difference between the pattern and reference frequencies in radians per second times the displacement between the centers of the fields in meters divided by the disk surface velocity under the head in meters per second. The frequency differences causing the errors might arise from spindle speed variations between the time the signals were written on the disk surface and later readback or from different frequencies being used to write and later demodulate the servo information.

This source of error may be greatly reduced by minimizing the effective displacement between the centers of the two fields. This is done by splitting one of the two fields into two subfields equally distant on either side of the other field. Thus the centers of mass of the two fields coincide causing the error term to vanish. The key is that the fields may be divided into multiple subfields and that it is the displacement between the centers of mass of the fields that determines the error. Figure 5 illustrates the simplest pattern which reduces the error term to zero although clearly many other more complex patterns could be devised using the same principle. Figure 5 shows a two field pattern wherein field 1 has been partitioned into subfields 1a and 1b which are respectively uniformly positioned before and after field 2. The centers of mass of the fields now coincide, and the phase error is eliminated.

Figure 6 shows one possible implementation of a servo pattern for a file with the motor speed synchronized to a crystal clock, that is known frequency. The showings of figures 6 and 7 show rectangular areas having a half track width with one polarity shown by dotted rectangles and the opposite polarity as open rectangles. The clock field allows recognition of the boundaries of the

remaining fields for gating. The phase difference between fields 1 and 2 repeats (360° of phase difference) every eight tracks for use in seek mode. The difference between fields 2 and 3 repeats every track for track follow error signal.

If this pattern were written at 2.5 megahertz it would require 11,2 microseconds. Depending upon the type of phase detection used an AGC field may or may not also be required. For track following 400 nanoseconds of phase error would be equivalent to one track. At 1.000 tracks per inch (2,54 cm), one nanosecond error would be equivalent to 2,5 microinches (0,06 µm). In field 2 and 3, 16 transitions are available for timing the phase. Averaging of all of these individual phases would be good practice to reduce noise in the resulting position error signal.

An alternative embodiment to the showing of figure 6 would be to write the servo field patterns with a single phase transition per track which is ·omplished by writing the servo using one pass track. This would be simpler to execute during the servo writing operation, taking but half the time. However, since the product head that reads and writes data on the file is less than a full track pitch in width, regions of non-increasing signal during radial displacement would be encountered. The product head or transducer is normally between two-thirds and eight-tenths the track pitch or distance between adjacent track centerlines. When the transducer head moves half the head width from the track centerline, further radial movement causes no increase in the position error signal until the next phase shift is encountered. During this period of radial movement the position of the head is unknown beyond the fact that it is within the range of positions. To avoid this condition the phase shifted servo track portions should have a radial width no greater than the width of the transducer head.

The phase modulated servo technique is capable of a wide range of degrees of resolution ·ough modification of the number of tracks during which the page goes through 360° of phase shift in the various fields and the use of the initial clock field with unchanging phase as one of the fields used to obtain a phase difference value. In the disk servo environment it is valuable to have a low resolution over a modest number of tracks for use in multi-track accesses and a high resolution pattern repeating each track for track following purposes. By such phase shift alterations in a servo using three phase shifted fields, a range of low, intermediate and high resolution can be readily produced such as 16 tracks, 4 tracks and 1 track or 64 tracks, 8 tracks and 1 track.

Figure 7 illustrates the split burst approach to eliminate speed variation errors or irregularities wherein two phase shifted servo fields are used with common centers achieved by partitioning the first field into subfields disposed at opposite sides of the other field (field 2). This illustrates 360° over an eight track radial distance with the phase shifting in one-half track radial increments.

Figure 8 shows a typical phase demodulator for obtaining a position signal from two constant frequency servo fields having radially varying phase. The analog signal from the transducer head is received on line 10 and is converted by filter 11 and comparator 12 to a digital signal on line 13. The servo ID detector 14 identifies a servo sector, whereupon window and timing signal generator 15 creates the windows for the radially varying phase constant frequency servo fields. The crystal clock circuit 16 outputs a signal with the same frequency as the constant frequency servo fields. The phase of the crystal clock signal on line 17 is compared by a phase detector 18 with the phase of the digital signal for each of the constant frequency servo fields and the difference between the compared values derived from the two fields is ascertained by the phase difference processor 19 to produce a position signal one line 20 which is indicative of the transducer position within the radial distance encompassed by 360° of phase difference.

Claims

1. A servo system for a disk file having rotating a disk or disks presenting data surfaces with pattern fields comprising at least one wave form parameter varying radially and a transducer which is substantially radially moveable between track positions characterized in that it comprises:

two pattern fields (1, 2) recorded on a disk data surface; each pattern field comprising in the circumferential directions a same constant spatial frequency which varies in phase in the radial direction, the radial variation in the first pattern being opposite to the one of the second pattern; a source (16) of pulses running at said constant frequency;

detecting means (18) for detecting the phase of each of said two pattern fields with respect to the pulses generated by said source of pulses; and

means (19) for determining the difference between said detected phases.

2. System according to claim 1 wherein each of said two pattern fields has numerous transitions, whereby the detected phase difference is an average over many transitions to provide a value less effected by random noise.

3. System according to claim 2 wherein one (1) of said two pattern fields is divided into two subfields (1a, 1b) positioned at opposite circumferential sides of the other (2) of said two pattern fields, whereby any error due to the displacement between the centers of the two fields are minimized or eliminated.

4. System according to claim 2 further comprising a third field (3) having the same said constant spatial frequency and having a radially varying phase which differs from each of said two pattern fields; and

said means for detecting also detects the phase of said third field with respect to said pulses from said source of pulses.

5. System according to claim 1 or 2 wherein said detecting means further includes means (19)

remaining fields for gating. The phase difference between fields 1 and 2 repeats (360° of phase difference) every eight tracks for use in seek mode. The difference between fields 2 and 3 repeats every track for track follow error signal.

If this pattern were written at 2.5 megahertz it would require 11,2 microseconds. Depending upon the type of phase detection used an AGC field may or may not also be required. For track following 400 nanoseconds of phase error would be equivalent to one track. At 1.000 tracks per inch (2,54 cm), one nanosecond error would be equivalent to 2,5 microinches (0,06 µm). In field 2 and 3, 16 transitions are available for timing the phase. Averaging of all of these individual phases would be good practice to reduce noise in the resulting position error signal.

An alternative embodiment to the showing of figure 6 would be to write the servo field patterns with a single phase transition per track which is accomplished by writing the servo using one pass per track. This would be simpler to execute during the servo writing operation, taking but half the time. However, since the product head that reads and writes data on the file is less than a full track pitch in width, regions of non-increasing signal during radial displacement would be encountered. The product head or transducer is normally between two-thirds and eight-tenths the track pitch or distance between adjacent track centerlines. When the transducer head moves half the head width from the track centerline, further radial movement causes no increase in the position error signal until the next phase shift is encountered. During this period of radial movement the position of the head is unknown beyond the fact that it is within the range of positions. To avoid this condition the phase shifted servo track portions should have a radial width no greater than the width of the transducer head.

The phase modulated servo technique is capable of a wide range of degrees of resolution through modification of the number of tracks during which the page goes through 360° of phase shift in the various fields and the use of the initial clock field with unchanging phase as one of the fields used to obtain a phase difference value. In the disk servo environment it is valuable to have a low resolution over a modest number of tracks for use in multi-track accesses and a high resolution pattern repeating each track for track following purposes. By such phase shift alterations in a servo using three phase shifted fields, a range of low, intermediate and high resolution can be readily produced such as 16 tracks, 4 tracks and 1 track or 64 tracks, 8 tracks and 1 track.

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1. A servo system for a disk file having rotating a disk or disks presenting data surfaces with pattern fields comprising at least one wave form parameter varying radially and a transducer which is substantially radially moveable between track positions characterized in that it comprises:

two pattern fields (1, 2) recorded on a disk data surface; each pattern field comprising in the circumferential directions a same constant spatial frequency which varies in phase in the radial direction, the radial variation in the first pattern being opposite to the one of the second pattern; a source (16) of pulses running at said constant frequency;

detecting means (18) for detecting the phase of each of said two pattern fields with respect to the pulses generated by said source of pulses; and

means (19) for determining the difference between said detected phases.

2. System according to claim 1 wherein each of said two pattern fields has numerous transitions, whereby the detected phase difference is an average over many transitions to provide a value less effected by random noise.

3. System according to claim 2 wherein one (1) of said two pattern fields is divided into two subfields (1a, 1b) positioned at opposite circumferential sides of the other (2) of said two pattern fields, whereby any error due to the displacement between the centers of the two fields are minimized or eliminated.

4. System according to claim 2 further comprising a third field (3) having the same said constant spatial frequency and having a radially varying phase which differs from each of said two pattern fields; and

said means for detecting also detects the phase of said third field with respect to said pulses from said source of pulses.

5. System according to claim 1 or 2 wherein said detecting means further includes means (19)

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for ascertaining the phase difference between said two pattern fields, which phase difference is indicative of the radial position of said transducer within the set of tracks encompassed by 360° of phase shift.

6. System according to claim 4 wherein said detecting means further ascertains a first phase difference between said two pattern fields (1, 2) and second and third phase difference of values between said third field (3) and each of said two pattern fields (1, 2) to provide three phase difference values indicative of radial position.

7. System according to claim 6 wherein said first, second and third phase differences are each associated with a different number of tracks within 360° of phase shift, whereby one phase difference provides coarse position resolution, a second phase difference provides intermediate resolution, and the third phase difference provides fine resolution.

8. System according to claim 1 wherein each of said constant frequency fields comprise radially varying transitions confronting said substantially radially moveable transducer head such that movement of said transducer causes a continuous change in the phase difference signal generated by said detecting means.

9. System according to claim 8 wherein the radially varying phase of said constant frequency fields is effected by a recorded servo pattern that has a phase change at least two times per track.

10. System according to claim 8 wherein the phase change within said constant frequency fields varies linearly with radial movement of said transducer.

11. System according to claim 3 wherein said divided constant frequency field is equally divided and disposed symmetrically at each side of the said other constant frequency field such that said divided field and said other field have a common center.

Patentansprüche

1. Servo-System für eine Plattendatei mit einer oder mehreren drehenden Platten, die Datenoberflächen mit Musterfeldern aufweisen und zumindest einen Wellenformparameter beinhalten, der sich radial ändert, sowie einen Transducer, der im wesentlichen radial zwischen den Spurpositionen verschoben werden kann, dadurch gekennzeichet, dass es weiter aufweist:

zwei auf einer Datenfläche der Platte registrierte Musterfelder (1, 2), die jeweils in Umfangsrichtung eine gleiche konstante, in Phase in radialer Richtung variierende Ortsfrequenz aufweisen, wobei die radiale Variation des ersten Musters der des zweiten Musters entgegengesetzt ist; eine Source (16) von Impulsen, die mit der genannten konstanten Frequenz auftreten;

Sensormittel (18), um die Phase jedes der beiden genannten Musterfelder im Verhältnis zu den von der genannten Impulsquelle erzeugten Impulsen festzustellen; und

Mittel (19), um die Differenz zwischen den genannten erkannten Phasen festzustellen.

2. System nach Anspruch 1, bei dem jedes der beiden genannten Musterfelder zahlreiche Übergänge aufweist, wodurch die festgestellte Phasendifferenz einen Mittelwert aus vielen Übergängen darstellt, der weniger vom weissen Rauschen beeinflusst wird.

3. System nach Anspruch 2, bei dem eines (1) der genannten zwei Musterfelder in zwei Unterfelder (1a, 1b) unterteilt ist, die jeweils an entgegengesetzten Umfangsseiten des anderen (2) der genannten zwei Musterfelder angeordnet sind, wodurch ein auf eine Verlagerung zwischen den Mittelpunkten der beiden Felder zurückzuführender Fehler minimiert oder ganz aufgehoben wird.

4. System nach Anspruch 2, das im weiteren ein drittes Feld (3) beinhaltet mit derselben genannten konstanten Ortsfrequenz und einer radial variierenden Phase, die sich von jeder der genannten zwei Musterfelder unterscheidet;

wobei das Sensormittel ebenfalls die phase des genannten dritten Feldes im Verhältnis zu den genannten Impulsen aus der genannten Impulsquelle erkennt.

5. System nach Anspruch 1 oder 2, bei dem das genannte Sensormittel weiter Mittel (19) zum Absichern der Phasendifferenz zwischen den genannten zwei Musterfeldern aufweist, wobei diese Phasendifferenz die radiale Position des genannten Transducers innerhalb des Spursatzes angibt, der durch eine Phasenverschiebung um 360° umspannt wird.

6. System nach Anspruch 4, bei dem das genannte Sensormittel des weiteren eine erste Phasendifferenz zwischen den genannten zwei Musterfeldern (1, 2) sowie eine zweite und eine dritte Phasendifferenz der Werte zwischen dem genannten dritten Feld (3) und jedem der beiden genannten Musterfelder (1, 2) erkennt, um drei Phasendifferenzwerte zu erstellen, die die radiale position angeben.

7. System nach Anspruch 6, bei dem die genannte erste, zweite und dritte Phasendifferenz jeweils einer verschiedenen Anzahl von Spuren innerhalb der 360°-Spanne der Phasenverschiebung zugeordnet ist, wodurch die erste Phasendifferenz eine grobe Auflösung der Position, die zweite Phasendifferenz eine mittlere und die dritte Phasendifferenz eine feine Auflösung der Position erstellt.

8. System nach Anspruch 1, bei dem jedes der genannten konstanten Frequenzfelder radial variierende Übergänge aufweist, die dem genannten, im wesentlichen in radialer Richtung beweglichen Transducerkopf gegenüberstehen, so dass eine Bewegung des genannten Transducers eine kontinuierliche Änderung des Phasendifferenzsignals, das vom genannten Sensormittel erzeugt wird, hervorruft.

9. System nach Anspruch 8, bei dem die radial variierende Phase der genannten konstanten Frequenzfelder von einem registrierten Servo-Muster beeinflusst wird, dessen Phase sich zumindest zweimal pro Spur ändert.

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10. System nach Anspruch 8, bei dem die Phasenänderung innerhalb des genannten konstanten Frequenzfeldes linear mit der radialen Bewegung des genannten Transducers variiert.

11. System nach Anspruch 3, bei dem das genannte geteilte konstante Frequenzfeld gleichmässig geteilt und symmetrisch auf jeder Seite des genannten anderen konstanten Frequenzfeldes so angeordnet ist, dass das genannte geteilte Feld und das genannte andere Feld einen gemeinsamen Mittelpunkt aufweisen.

Revendications

1. Un système d'asservissement pour une mémoire à disques comportant un ou plusieurs disques rotatifs présentant des surfaces de données avec des champs de configurations comprenant au moins un paramètre de forme d'onde variant radialement et un transducteur qui est substantiellement et radialement mobile entre des emplacements de pistes, caractérisé en ce qu'il comprend:

deux champs de configurations (1, 2) enregistrés sur une surface de données de disque, chaque champ de configurations comprenant dans les directions circonférentielles une même fréquence spatiale constante qui varie en phase dans la direction radiale, la variation radiale dans la première configuration étant opposée à celle de la seconde configuration, une source (16) d'impulsions fonctionnant à ladite fréquence constante,

des moyens de détection (18) pour détecter la phase de chacun desdits deux champs de configurations par rapport aux impulsions générées par ladite source d'impulsions, et

des moyens (19) pour déterminer la différence entre lesdites phases détectées.

2. Système selon la revendication 1 dans lequel chacun desdits deux champs de configurations présente de nombreuses transitions, ce qui fait que la différence de phase détectée est une moyenne établie sur beaucoup de transitions pour donner une valeur moins affectée par le bruit aléatoire.

3. Système selon la revendication 2 dans lequel l'un (1) desdits deux champs de configurations est divisé en deux champs secondaires (1a, 1b) positionnés aux côtés circonférentiels opposés de l'autre (2) desdits deux champs de configurations, ce qui fait que toute erreur due au déplacement entre les centres des deux champs est réduite au minimum ou éliminée.

4. Système selon la revendication 2 comprenant en outre un troisième champ (3) ayant la même dite fréquence spatiale constante et ayant une phase variant radialement qui diffère de chacun desdits deux champs de configurations, et

lesdits moyens de détection détectent aussi la phase dudit troisième champ par rapport auxdites impulsions issues de ladite source d'impulsions.

5. Système selon la revendication 1 ou 2 dans lequel lesdits moyens de détection comprennent en outre des moyens (19) pour s'assurer de la différence de phase entre lesdits deux champs de configurations, laquelle différence de phase est indicatrice de la position radiale dudit transducteur sur l'ensemble des pistes englobées par 360° de déphasage.

6. Système selon la revendication 4 dans lequel lesdits moyens de détection s'assurent en outre d'une première différence de phase entre lesdits deux champs de configurations (1, 2) et de deuxième et troisième différences de phase entre ledit troisième champ (3) et chacun desdits deux champs de configurations (1, 2) pour donner trois valeurs de différences de phase indicatrices de la position radiale.

7. Système selon la revendication 6 dans lequel lesdites première, deuxième et troisième différences de phase sont chacune associées à un nombre différent de pistes à l'intérieur de 360° de déphasage, ce qui fait qu'une différence de phase assure une définition de position grossière, une deuxième différence de phase assure une définition intermédiaire et la troisième différence de phase assure une définition précise.

8. Système selon la revendication 1 dans lequel chacun desdits champs de fréquence constante comprend des transitions variant radialement confrontant ladite tête de transducteur substantiellement et radialement mobile de façon que le mouvement dudit transducteur provoque un changement continu dans le signal de différence de phase généré par lesdits moyens de détection.

9. Système selon la revendication 8 dans lequel la phase variant radialement desdits champs de fréquence constante est assurée par une servo-configuration enregistrée qui subit un changement de phase au moins deux fois par piste.

10. Système selon la revendication 8 dans lequel le changement de phase à l'intérieur desdits champs de fréquence constante, varie linéairement avec le mouvement radial dudit transducteur.

11. Système selon la revendication 3 dans lequel ledit champ de fréquence constante divisée est également divisé et disposé symétriquement de chaque côté dudit autre champ de fréquence constante de façon que ledit champ divisé et ledit autre champ aient un centre commun.

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