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"A method and device for monitoring flying height and the performance of a slider-disk interface"

This invention relates to a method and device for monitoring flying height and the performance of a slider-disk interface at the drive level using a slider itself as a flying height transducer.

In-situ monitoring of the flying height of a slider-disk interface is becoming an increasingly important issue in disk drive manufacturing. As Head Disk Interface (HDI) technology moves to proximity recording and eventually contact recording, the monitoring of a slider's flying stability in track seeking operations will be of great importance to tribology performance testing and characterisation.

The concept of using the capacitance between a slider and a disk surface to detect the slider's flying height has been used for more than twenty years. Old techniques used a small probe formed on the slider's surface. The slider was developed specifically for this purpose. However, this technology is not suitable to be used in production level testing and characterisation for there is no such probe on a normal slider.

There is also the possibility of using the magnetic transducer head of a slider as a transducer to measure the slider's flying characteristics at the drive level. This technique cannot be used for the characterisation of flying height and stability during the slider take-off and landing process as the head velocity is too small in these conditions.

U.S. Patent No. 4,931,887 of Hegde, S. G. et al, describes a method and a means for measuring head-disk spacing by the capacitance between

conductive slider rails and a disk with an electrically conductive pattern on it. By measuring the electrical capacitance between the slider and the pattern on the disk, and by processing the electrical capacitance signal, a vertical spacing signal proportional to the vertical spacing between the disk and the slider is obtained. This technique uses a specially prepared disk with an electrically conductive pattern on it. Electronic circuitry measures the capacitance directly.

U.S. Patent No. 4,605,977 of Hugh, B. et al, uses a capacitive proximity sensor coupled to the magnetic head for sensing the flying height of the head above the disk, and compares the result with a reference flying height in order to maintain the head at a constant predetermined height above the disk. The device contains a specifically developed capacitive sensor to measure the flying height.

U.S. Patent No. 4,479,090 of Frater, N. K. et al, describes a circuit to detect triboelectric charges generated by intermittent contact between the head and the disk and also to detect variations in the spacing between the head and the disk surface when the two are not in contact. Triboelectric charges are generated when two materials are rubbed together. The measurement of the triboelectric charge is good enough for the detection of two bodies impacting but is not good enough for the contact process.

An object of this invention is to seek to provide a method and device for monitoring the flying height and stability of a slider and the performance of a slider-disk interface without making any modification to the slider or the disk surface such that the method and device can be used in production line disk drive assemblies to measure and monitor the flying

height and stability of the slider and the performance of the slider-disk interface during actual drive working conditions.

Another aspect of the invention seeks to provide a method and device to suppress the noise from a grounded drive motor to obtain a high signal to noise ratio for a flying height variation signal.

As well as monitoring the flying height and stability of a slider and the performance of a slider-disk interface without making any modification to the slider or the disk surface, this invention also relates to a method of monitoring the drive level slider contact start and stop process directly from an oscilloscope or similar visual display. Similarly, embodiments of the method are also suitable for monitoring drive level slider-disk impacts phenomenon and contact recording under real disk drive working conditions.

Accordingly, one aspect of the present invention provides a flying height monitoring device for monitoring the flying height of a slider above a rotatable disk, which device comprises: a flying height transducer for producing a signal indicative of the flying height of the slider above the disk, one pole of the transducer comprising the slider and the other pole of the transducer comprising a surface of the disk, the slider and the disk being conductive; and a noise suppression device to obtain a high signal to noise ratio for the signal indicative of the flying height.

A further aspect of the present invention provides a slider and disk interface of a magnetic head slider assembly for use with a disk drive assembly including a rotatable disk, a slider comprising: a slider body having means to generate, during rotation of the disk, an air bearing between the slider

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body and the rotatable disk, the air bearing holding the slider above the disk by a flying height, the slider and the disk being conductive, the slider and the disk forming an electrical transducer to provide a flying height signal without modifying the structure of the slider or disk and a noise suppression device to obtain a high signal to noise ratio for the signal indicative of the flying height.

Another aspect of the present invention provides a method of monitoring the flying height of a slider above a rotatable disk, comprising the step of producing a flying height signal indicative of the flying height from a transducer, one pole of the transducer comprising a conductive slider and the other pole of the transducer comprising a surface of a conductive disk, the method including the step of suppressing noise to obtain a high signal to noise ratio for the signal indicative of the flying height.

In order that the present invention may be more readily understood, embodiments thereof will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram of a flying height monitoring system embodying the present invention;

Figure 2 is a schematic diagram of transducer coupling noise suppression electronics;

Figure 3 is a schematic diagram of electronic circuitry for use with the flying height monitoring system of Figure 2;

Figure 4 is a schematic diagram of a dual slider noise suppression system embodying the present invention;

Figure 5 is a schematic diagram of a further flying height monitoring system embodying the present invention;

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Figure 6(a) is a perspective view of the flying attitude of a slider;

Figure 6(b) is a side view of the slider shown in Figure 6(a);

Figure 6(c) is view from the front of the slider of Figure 6(a);

Figure 7 is a bottom view of a slider;

Figure 8 is a three-dimensional graph showing the relationship between slider-disk normalised capacitance, the pitch angle of the slider and the roll angle of the slider;

Figure 9 is a three-dimensional graph showing the relationship between slider-disk normalised capacitance, the pitch angle of the slider and the flying height of the slider;

Figure 10 is a graph showing the experimental results of the flying height variation of a slider whilst track seeking between track 100 and track 3800, which is obtained by this invention at the drive level for a 50% tri-pad slider;

Figure 11 is a graph showing experimental results using a resistance arc-over method to detect the slider flying weakness point at the drive level whilst the head seeks back and forth between track 100 and track 3000;

Figure 12 is a graph showing the experimental results of the flying height variation of a slider during head start flying, which is obtained by this invention at the drive level for a 50% tri-pad slider; and

Figure 13 is a graph showing the experimental results of the flying height variation of a slider during a Contact Start Stop (CSS) test with 3 seconds acceleration, 2 seconds constant velocity and 3 seconds deceleration.

Referring to Figure 1, a disk drive assembly comprises a rotatable disk 10 mounted on a central spindle 51 driven by a motor 50. A slider 20 is connected to one end of a suspension 31 above the disk 10. The other end of the suspension 31 is mounted to a voice coil motor (VCM) arm 30. The VCM arm 30 is connected to a collar 40 of a voice coil motor which is controllable to move the slider 20 radially across the disk 10. The collar 40 is seated on an axle 41 of the VCM. The disk 10, spindle 51, motor 50, slider 20, suspension 31, VCM arm 30 and the axle 41 of the VCM are all conductive. The motor 50 is grounded. The disk 10, spindle 51 and motor 50 are all ohmically connected to one another. Similarly, the slider 20, suspension 31 and VCM arm are all ohmically connected to one another. The collar 40 can be either conductive or non-conductive. In the present embodiment, the collar 40 is non-conductive. Embodiments of the invention benefit from the high conductivity of present sliders, compared with previously non-conductive sliders.

The slider 20 has means to generate, during rotation of the disk 10, an air bearing between the slider 20 and the rotatable disk 10. The air bearing holds the slider 20 above the disk by a flying height h. The slider body 20 is made of conductive material and comprises a substantially

rectangular and elongate block having two rails 22 raised proud of a main surface 21 of the slider 20. The raised rails 22 define therebetween a bleed slot 24. The leading edge of the rails 22 are each provided with a sloped ramp surface 23 to promote the creation of an air bearing between the disk surface 10 and the slider 20. The main surface 21 is shown in detail in Figure 7.

In combination, the rails 22 and the ramp surfaces 23 comprise the means which generate the air bearing. Typically, and as seen in Figures 6a, 6b and 6c, the main surface 21 of the slider 20 is not parallel with the disk surface but is angled slightly thereto, at an attitude, such that the trailing edge of the slider 20 is closest to the disk surface and the leading edge is furthest away from the disk surface. As shown in Figure 7, the rails 22 each have an effective length L and a width W. The bleed slot 24 separates the rails 22 by a gap having a width W_1.

The interface between the slider 20 and the disk 10 provides an electrical flying height transducer which is created by connecting a first wire to the arm 30 and a second wire to the grounded motor 50, the signals received from the first and second wires being representative of the flying height of the slider 20 above the disk 10.

The conductive slider itself is used as one-pole of the flying height transducer which may be, in accordance with different embodiments of the invention, a capacitive transducer, a resistive transducer, or an impedance transducer. No modification of the slider is necessary to perform this function, the slider being prepared in a conventional manner. The other pole of the flying height transducer comprises the conductive disk.

A number of techniques are used for interpreting the signals provided by the flying height transducer: a capacitive technique; a resistive technique; and an impedance technique. If the surface layer of the disk 10 is non-conductive, then the slider-disk interface may only be used as a capacitance transducer. If the disk surface is conductive, the slider-disk interface can be used as a resistance transducer or an impedance transducer.

Referring to Figure 2, the transducer coupling noise suppression electronics embodying the present invention comprises a signal generator 70 which supplies its signal to the slider 20 in order to obtain a capacitive impedance variation signal from the slider-disk interface transducer. An R-C circuit 71, comprising a resistor R1 and a variable capacitor C, is connected in series between the signal generator 70 and ground, to which the motor 50 is also connected. Another resistor R2 is connected between the slider 20 and the signal generator 70. Thus, the circuitry comprises two branches, the resistor R2, slider-disk branch and the R-C circuit branch. The two branches are balanced by adjusting the variable capacitor C, the values of R1 and R2 being substantially the same.

There is a certain amount of noise associated with the disk drive assembly and, in particular, with the grounded motor 50. Thus, the output of the circuitry of Figure 2 includes not only the flying height variation signal but also an additional noise signal corresponding to the grounded motor noise. The junction of the resistor R1 and the variable capacitor C is tapped to provide a pure noise signal. By properly adjusting the bridge such that the two branches of the circuitry are balanced, the noise signal from the R-C circuit can be subtracted from the flying height variation

signal which includes noise to yield a substantially clean flying height variation signal having a high signal to noise ratio. This can be done, for example, by an operational amplifier 80 as shown in Figure 3. The resultant clean flying height variation signal is then demodulated by demodulation electronics 60 and can be monitored from an oscilloscope 71, or the like, directly.

In another embodiment shown in Figure 4, an extra slider-suspension assembly 20',31',30' similar to the slider 20, suspension 31 and VCM arm 30 previously described is provided in place of the variable capacitor C to filter out the grounded motor noise. The extra slider-suspension assembly 20',31',30' is fixed at a predetermined position on the disk surface and, whilst the slider-suspension assembly 20,31,30 is doing the track seeking process, the flying height due to the track seeking can be measured through this scheme accurately.

In a further embodiment shown in Figure 5, the disk drive assembly comprises two disks 10,10' mounted on a common spindle 51. A head stack assembly is provided which comprises a pair of slider-suspension assemblies 20,31,30 for each disk, one slider-suspension assembly for each disk surface. The signal input from the four sliders 20 to the operational amplifier is gated through a surface selector 90 which selects which of the sliders 20 is to be used to provide a disk-slider interface transducer to measure that slider's flying height using the same noise reduction method described in relation to Figure 4.

The first technique for flying height measurement is the capacitance method. In this method, the demodulation electronics detects the impedance of the capacitance of the transducer created by the slider-disk

interface. The output signal is proportional to the impedance of the capacitance when only considering the capacitive part, Z_c, of the transducer.

$$Z_c = \frac{1}{j\omega C} = \frac{h}{j\omega\varepsilon_0 A}$$

where A is the area of the rails 22 and h is the flying height, i.e. the distance between the slider and the disk surface and j, w and e_0 have their normal meanings. The impedance output signal is proportional to the flying height if the attitude of the slider remains the same.

Figures 6a, 6b and 6c show the flying attitude of a slider 20 including its pitch θ and roll β. Figure 7 shows the relative dimensions of the slider 20. The rails 22 of the slider 20 contribute almost the whole capacitance value of the slider-disk interface transducer because the flying height is small compared to the depth of the bleed slot 24 below the rails 22. Therefore, it is reasonable to only consider the rails 22 of the slider 20 and neglect the other parts of the slider 20 when calculating the transducer capacitance. The capacitance of the interface between the slider and the disk surface, when considering pitch and roll, is:

$$C/\varepsilon_0 = h\,\mathrm{ctg}\beta\,\mathrm{ctg}\theta \ln\frac{h}{h+L\sin\theta} - L\cos\theta\,\mathrm{ctg}\beta \ln\frac{h+L\sin\theta}{h+\mathrm{W}\sin\beta+L\sin\theta}$$
$$-L\cos\theta\,\mathrm{ctg}\beta \ln\frac{h+(W+W_1)\sin\beta+L\sin\theta}{h+(W+2W_1)\sin\beta+L\sin\theta} - \mathrm{ctg}\beta\,\mathrm{ctg}\theta(h+W\sin\beta)\ln\frac{h+W\sin\beta}{h+W\sin\beta+L\sin\theta}$$
$$+\mathrm{ctg}\beta\,\mathrm{ctg}\theta(h+W\sin\beta+W_1\sin\beta)\ln\frac{h+(W+W_1)\sin\beta}{h+(W+W_1)\sin\beta+L\sin\theta}$$
$$-\mathrm{ctg}\beta\,\mathrm{ctg}\theta(h+2W\sin\beta+W_1\sin\beta)\ln\frac{h+(2W+W_1)\sin\beta}{h+(2W+W_1)\sin\beta+L\sin\theta}$$

where:

W is the width of each slider rail 22;

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L is the length of each slider rail 22;

W_1 is the distance between the two rails 22;

h is the flying height;

θ is the pitch of the slider; and

β is the roll of the slider.

The normalised capacitance variation with pitch, roll and the flying height for a Tri-pad 50% slider are shown in Figures 8 and 9. Considering the actual disk drive working condition, the range of variation of the slider's pitch, roll and flying height are 7.6 to 10.4 μin, 0.4 to 1 μin and 10 - 40 nm, respectively.

From Figures 8 and 9, it can be seen that the capacitance is more sensitive to the pitch and the flying height than to roll. Furthermore, the pitch sensitivity becomes higher when the flying height becomes lower. The quantitative results of Figure 8 show that the pitch affects the relative capacitance by less than 15%, and roll affects the relative capacitance by less than 5%. The quantitative results of Figure 9 show that small pitch angles increase the flying height variation effects on the capacitance, and that high flying heights will decrease the effect that pitch has on the capacitance. It should be noted that higher speeds of rotation of the disk will result in higher flying heights and a larger pitch angle, and vice versa so that the amount by which the pitch angle affects the capacitance is much smaller than might first seem the case. Therefore, the main capacitance variation is due to changes in the flying height.

Figure 10 shows the experimental results of the slider flying height variation while the head is seeking from track 100 to track 3800 back and forth measured by a flying performance measurement system embodying

the present invention using the capacitance method. The top trace shows the slider flying height variation, and the bottom trace shows the driving current of the voice coiled motor (VCM) which drives the head to seek radially in and out over the tracks on the disk surface. The leading edge of the rectangular positive pulse in the bottom trace marks the beginning of head seeking from the outer diameter to the inner diameter, and the leading edge of the rectangular negative pulse (occurring after approximately two divisions) marks the beginning of head seeking from the inner diameter to the outer diameter. The rectangular pulses represent the acceleration of the VCM, the flat line after each pulse represents the constant velocity of the VCM, and the triangular pulses represent the deceleration of the VCM. The VCM driving current trace is synchronised with the slider flying height variation trace so it is possible to determine variations in flying height during and possibly as a consequence of the track seeking process. The results obtained indicate that a negative current or driving force towards the outer diameter from the inner diameter reduces the flying height, whilst a positive current or a driving force towards the inner diameter from the outer diameter increases the flying height. Furthermore, accelerations towards the inner and the outer diameters, as represented by the rectangular pulses, creates the most significant changes in the flying height in that track seeking process. Accelerations toward the inner diameter increase the flying height, whilst accelerations toward the outer diameter decrease the flying height. During periods of constant seeking speed, the slider adjusts its flying height to the steady height defined by the point at which the lift force created by the air-bearing balances with the loading force provided by the suspension.

In the resistance method, the output signal comprises the contact resistance between the slider 20 and the disk surface. This method is used to indicate when the slider is in contact with the disk surface and when a crash or impact onto the disk surface occurs.

When a voltage between two conductive bodies becomes high enough, the air between them becomes a plasma causing an electrical arc-over effect. The potential difference between the two bodies is greatly reduced during arc-over. Because the distance between the flying slider and the disk surface is in the magnitude of 10nm, the arc-over voltage between the two conductive surfaces is very small. A new method, the resistance arc-over method, takes advantage of this property to detect the weakness point of the flying slider. The principle of the arc-over voltage method is to choose a critical arc-over DC voltage corresponding to a certain flying height h_c such that if the actual flying height h is less than the critical flying height h_c, then there is an arc-over between the disk and the slider, and the potential difference between the two will greatly decrease. If, however, the flying height h is greater than the critical flying height h_c, then the potential difference will remain at the normal level. This method can be used to detect the flying height weakness area, i.e. the area in which a slider-disk crash is most likely to occur.

Figure 11 shows the waveforms captured by an oscilloscope in accordance with the resistance arc-over method at the drive level whilst the head seeks back and forth between track 100 and track 3000. The top trace represents the DC voltage across the resistance between the slider and the disk. The bottom trace represents the driving current waveform for the VCM, which is the drive level test. The DC voltage value should be chosen as the critical value between the arc-over voltage and not the

voltage at the normal slider flying height. Under normal slider working conditions, the flying height is high enough and the voltage across the slider and disk keeps constant enough that there is no arc-over between the slider and the disk, the air resistance between the slider and the disk keeping the voltage substantially constant. However, if there is a loss in flying height below the critical flying height h_c (determined by the DC voltage value), then an arc-over voltage occurs and the voltage between the slider and the disk will decrease dramatically. This enables detection of a low flying height point, which may be a flying weakness point.

Since different DC voltage values result in different critical flying heights h_c, properly selected DC voltage values can be used to find out the flying weakness point for selected flying heights. Using this method and performing a series of experiments the same as shown in Figure 11 but with different DC voltage values and hence different critical flying heights h_c, it has been found that the beginning of a deceleration from an outer diameter region to an inner diameter region whilst seeking corresponds to a location where a minimum slider-disk spacing is very likely to occur. Similarly, it has been found that the second half of an acceleration from an inner diameter region to an outer diameter region during seeking also corresponds to a location where a minimum slider-disk spacing is very likely to occur.

Referring to Figure 12, the experimental results measured by a flying performance measuring system embodying the present invention using the impedance method can be seen. The results show the flying height variation of the slider during the head start flying at the drive level. The first two divisions of Figure 12 show that the head is still substantially in contact with the disk surface. The next four divisions

show the flying height of the slider increasing as it reaches its steady height which is achieved when the spindle is at its standard operating speed. The last four divisions show the slider going from the inner diameter to the outer diameter of the disk surface, and back to the inner diameter, then to the outer diameter again before the head is ready to work.

In the impedance method, the output signal comprises the impedance between the slider 20 and the disk surface. Figure 13 is a typical experimental result of the impedance method, which consists of a combination of the capacitance method and the resistance method. The results of the experiment shown in Figure 13 are based upon a Contact Start-Stop (CSS) Test, the cycle of the CSS being 3 seconds acceleration, 2 seconds constant velocity at 5400rpm and 3 seconds deceleration for a 50% Tri-pad slider.

The results identify two clear regions: a resistance region in which the slider is in contact with the disk; and a capacitance region in which the slider is flying above the disk surface. A boundary line splits the capacitance region and the resistance region, the part above the line being the resistance region which can be used to monitor the slider-disk contact process or any slider-disk crashes, while the part below the line is the capacitance region which relates to the slider's flying performance monitoring issues. The sharp peak which jumps into the resistance region from the capacitance region represents a slider likely impact on the disk surface.

If the surface of the disk 10 is conductive, the resistance part of the impedance has to be considered when measuring the impedance of the

slider-disk transducer. The resistance of the slider-disk transducer consists of a contact resistance which occurs when the slider is in contact with the disk, which is the condition when the slider takes off or lands on the disk surface and air resistance which occurs when there is no contact between the slider and the disk surface, the slider flying over the disk surface. The value of the air resistance is in the order of several million Ohms whereas the value of the contact resistance is in the order of several tens of Ohms.

The impedance of the capacitance depends upon the applied frequency from the signal generator. Using the impedance method it is possible to choose an appropriate frequency from the signal generator 70 to control the impedance value of the transducer capacitance to be much greater than the contact resistance and much smaller than the air resistance. The transducer comprising the interface between the disk and the slider is equivalent to a capacitor and a resistor in parallel, the capacitor having an impedance of Z_c and the resistor having an impedance of Z_r, the total impedance Z_t being:

$$Z_t = \frac{Z_c Z_r}{Z_c + Z_r}$$

When the slider is in contact with the disk, $Z_t \approx Z_r$ with $Z_c >> Z_r$ and when the slider is flying above the disk surface, then $Z_t \approx Z_c$ with $Z_c << Z_r$. Therefore, the contact process of the slider on the disk can be monitored by the contact resistance part of the impedance without taking into account the effects of the capacitance, and the flying performance of the slider can be monitored by observing the capacitance part without considering the air resistance.

CLAIMS:

1. A flying height monitoring device for monitoring the flying height of a slider above a rotatable disk, which device comprises: a flying height transducer for producing a signal indicative of the flying height of the slider above the disk, one pole of the transducer comprising the slider and the other pole of the transducer comprising a surface of the disk, the slider and the disk being conductive; and a noise suppression device to obtain a high signal to noise ratio for the signal indicative of the flying height.

2. A device according to Claim 1, wherein the surface of the disk is conductive.

3. A device according to Claim 1 or 2, wherein the disk is mounted on a spindle driven by a motor which is grounded, the disk, spindle and motor being conductive and ohmically connected to one another.

4. A device according to any preceding claim, wherein the slider is connected to one end of a suspension, the other end of the suspension being mounted to a voice coil motor arm, the slider, suspension and voice coil motor arm all being conductive and ohmically connected to one another.

5. A device according to any preceding claim, wherein the voice coil motor arm is mounted on a collar of the voice coil motor.

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6. A device according to Claim 5, wherein the collar is non-conductive.

7. A device according to Claim 6, wherein the slider, suspension and voice coil motor arm are insulated from the voice coil motor by the collar.

8. A device according to any preceding claim, wherein the noise suppression device comprises an R-C circuit connected in parallel beside a resistor and slider-disk branch, the capacitor and the disk being grounded, the junction between the resistor and the capacitor being tapped to provide a pure noise signal.

9. A device according to any one of claims 1 to 7, wherein the noise suppression device comprises an extra slider supported above the disk by one end of an extra suspension, the extra slider being tapped to provide a pure noise signal.

10. A device according to Claim 9, wherein the extra slider is located at a predetermined position on the disk surface so as to provide a relative flying height variation signal with respect to the slider.

11. A device according to any one of Claims 8, 9 or 10, wherein a signal generator is provided which produces a first signal which is modified by the transducer to produce a flying height signal, the output of the transducer comprising a combination of the flying height signal and noise.

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12. A device according to Claim 11, wherein subtraction means are provided to subtract the pure noise signal from the flying height signal and noise to filter out the noise component and produce a flying height signal with a high signal to noise ratio.

13. A device according to Claim 12, wherein a plurality of separate transducers are provided, one for each surface of a disk, the plurality of transducers being connected to the subtraction means through a surface selector for selecting which of the transducers associated with a particular disk surface is to be operatively connected to the subtraction means.

14. A device according to any preceding claim, wherein the or each transducer is a capacitive transducer, the output signal of the transducer being indicative of the capacitance between the or each slider and the or each disk surface.

15. A device according to any one of Claims 1 to 13, wherein the or each transducer is a resistive transducer, the output signal of the transducer being indicative of the resistance between the or each slider and the or each disk surface.

16. A device according to any one of Claims 1 to 13, wherein the or each transducer is an arc-over transducer, the output signal of the transducer being indicative of whether the or each slider is below a predetermined flying height above a respective disk surface.

17. A device according to any one of Claims 1 to 13, wherein the or each transducer is an impedance transducer, the output signal of the

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transducer being indicative of the impedance between the or each slider and the or each disk surface.

18. A device according to any preceding claim, wherein the impedance of the capacitance between the or each slider and the or each disk surface is proportional to the flying height between the slider and the rotation disk, the flying height signal from the transducer reflecting the flying height directly, not the inverse relationship obtained by measuring the capacitive value.

19. A device according to any preceding claim, wherein the slider is a conventional conductive slider and the disk is a conventional conductive disk.

20. A slider and disk interface of a magnetic head slider assembly for use with a disk drive assembly including a rotatable disk, a slider comprising: a slider body having means to generate, during rotation of the disk, an air bearing between the slider body and the rotatable disk, the air bearing holding the slider above the disk by a flying height, the slider and the disk being conductive, the slider and the disk forming an electrical transducer to provide a flying height signal without modifying the structure of the slider or disk and a noise suppression device to obtain a high signal to noise ratio for the signal indicative of the flying height.

21. A method of monitoring the flying height of a slider above a rotatable disk, comprising the step of producing a flying height signal indicative of the flying height from a transducer, one pole of the transducer comprising a conductive slider and the other pole of the

transducer comprising a surface of a conductive disk, the method including the step of suppressing noise to obtain a high signal to noise ratio for the signal indicative of the flying height.

22. A method according to Claim 21, wherein a signal generator produces a first signal at a predetermined frequency, which signal is modified by the transducer to produce a flying height signal.

23. A method according to Claim 22, wherein the flying height signal is indicative of the impedance between the slider and the disk surface.

24. A method according to Claim 23, wherein the impedance comprises a resistance component and a capacitive component, the resistance between the conductive disk surface and the conductive slider comprising contact resistance when the slider is in contact with the disk and air resistance when the slider is flying above the disk, the air resistance being several magnitudes greater than the contact resistance, the frequency of the first signal from the signal generator being selected such that the capacitive component of the impedance is much greater than the contact resistance component of the impedance and much smaller than the air resistance component of the impedance.

25. A method according to Claim 24, wherein the capacitive component of the impedance is used to monitor the flying height whilst the slider is flying above the disk and the resistance component of the impedance is used to monitor the slider and disk when in contact with one another.

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26. A method according to Claim 21, wherein a critical flying height is selected and an appropriate DC voltage is applied across the transducer to create an arc-over between the slider and the disk surface if the flying height of the transducer is below the critical flying height.

27. A method according to Claim 26, wherein the voltage across the transducer greatly reduces when there is an arc-over thereby providing an indication of the slider flying below the critical flying height and thereby detecting a flying height weakness point above the disk.

28. A method according to Claim 26 or 27, wherein a plurality of tests are conducted at various critical flying heights to determine flying height weakness points above the disk at different flying heights.

29. A method according to Claim 22, wherein the flying height signal is indicative of the capacitive impedance between the slider and the disk surface.

30. A method according to Claim 22, wherein the slider-disk contact process is indicative of the resistance between the slider and the disk surface.

31. An instrument incorporating a device according to any one of Claims 1 to 20, wherein the instrument is a SpinStand, CSS Tester or a Servo Writer to measure and calibrate the properties of the slider-disk interface.

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