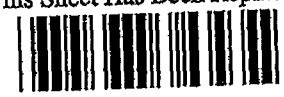
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CD/DVD RADIAL RUNOUT CALIBRATION

FIELD OF THE INVENTION

The present invention relates to sensing signals recorded on a disk, applying the sensed signals as an indication of track crossing and particularly for sensing signals recorded on an optical disk.

BACKGROUND OF THE INVENTION

Disk recorders of either the magnetic or optic type employ transducer positioning systems. Such transducer positioning system often use a velocity servo system for long transducer radial motions, termed seeks. Upon reaching a target track after leaving an origin track, the operation of the positioning system switches from a velocity seek mode to a track following mode. Such a track following control may be favorable compared to a stop-lock positioning control in other positioning applications. In a subsequent seek operation, the track following position mode is interrupted to return a velocity loop control or a second in positioning loop of another form.

One of the difficulties in track following arises from the eccentricity in disk rotation combined with 1 micro intertrack spacing. Such so-called repeatable "runout" or "eccentricity of

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rotation" causes false direction of motion indications between a track being crossed and the absolute motion of the transducer.

When starting to play back a disk, optical disk players, such as CD players or DVD player, read and store beforehand TOC (Table of Contents) data from a read-in area of the currently set disk. Upon access to a desired track based on a search command, the micro-processor in the optical disk player first calculates the currently read sub-code Q-data to find the current track number and then the number desired tracks. The difference between the two track numbers allows the microcomputer to find the number of tracks to be jumped. Accordingly, the microcomputer drives the optical system of the player to jump the calculated number of tracks in order to reach the target track. With the spreading use of optical disk drives units as an external storage for computers, the demand for a compact and high speed unit has increased.

Data storing disks employ circular or spiral tracks on which data is recorded. Transducers such as magnetic read/write heads, laser read/write assemblies, and the like, must maintain registry with those tracks within relatively close tolerances.

The ideal data storage disk contains a plurality of concentric data tracks that are perfectly circular or spiral in character when

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established and remained that way indefinitely. Such ideal data tracks are rarely created in disk manufacture and even more rarely remain circular in contemporary operating environment.

The lack of circularity in the data tracks is known in the industry as runout or radial runout. If it is too great, the transducer controlling servo system may not have adequate reacting capability to response so as to maintain data interfacing registry. Further even though the disk itself may rotate at a constant velocity, the runout forces the servo system to accelerate and decelerate rapidly to compensate for the runout.

There is a need for apparatus, which is part of the servo system to actual detect and compensate for radial runout.

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SUMMARY OF THE INVENTION

The present invention provides a method and apparatus for detecting and accurately measuring the amount and direction of radial runout by employing signals indicating the track crossings. These track crossings may be represented by either TZC signals or MIRR signals.

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BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 illustrates a diagram of the present invention;

Fig. 2 illustrates a circuit diagram of the present invention;

Fig. 3 illustrates another circuit diagram of the present invention;

Fig. 4 (a-i) Illustrates waveforms of the present invention;

Fig. 5 illustrates a waveform of the radial runout.

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DETAILED DESCRIPTION OF THE INVENTION

The present invention measures both direction and magnitude of the radial runout.

As illustrated in Fig. 1, a track 110 is centered about a track center 120. The offset of track 110 is due to eccentricity. The track 110 is offset from the center of the disk 130 by an amount of the radial runout A.

Fig. 1 is a block diagram of a tracking servo system for controlling jump or tracking operation.

In Fig. 1, the information recorded on disk 200 is read by pickup device 260 as an information signal. The pickup device 260 as a result of the read operation and in response to the information signal generates an RF signal which is input to the RF amplifier 210. Additionally, the pickup 260 sends the information signal on disk 200 to the TE signal generating circuit 270. The tracking error generating circuit 270 generates a tracking error (TE) signals based on the output of pickup 260. The TE signal has sinusoidal characteristic during track crossing such as shown in Fig. 4c. The TE signal is input to the track traverse detecting circuit 220. Additionally, the RF signal is output from the RF amplifier 210 is

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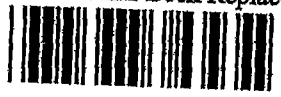
input to the track traverse detecting circuit 220. Output from the track traversed detecting circuit 220 are TZC and MIRR signals which are input to DSP 230. Accordingly, the DSP 230 operates a tracking actuator 250 to move the pickup 260 across the disk 200. Fig. 4 illustrates the RF signal and the TE signal sent to the MIRR generating circuit 320 and the TZC generating circuit 350, respectively.

The mirror signal generating circuit 320 generates an heightened level signal as illustrates in Fig. 4b by detecting a mirror face between tracks (pit area) on the disk 200. The MIRR signal is a signal that goes high when the optical spot is irradiated at the disk mirror face (area between tracks or pit arrays) and which goes low when the optical spot is irradiated at a track. The TZC signal as illustrated in Fig. 4d is generated as the sine signal of the TE signal is captured, the TE represents the deviation of the optical spot from any of the tracks or from any mirror area therebetween. When the TE signal is zero, for example, when the optical spot is located precisely on a track or on a mirror face, the TZC signal goes from high to low or vice versa.

Figs. 1a and 16 illustrate the radial motion of the track near the beam spot 100. The radial motion or radial runout can be

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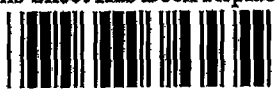


modeled as simple harmonic motion where $y = A \sin(\theta + \theta)$ and the velocity, $v = dy/dt = (2\pi/T) A \cos\theta$ where y is the radial displacement from the center of motion or the lens, v = radial velocity, T = period of rotation of the disk and A = ½ of the peak to peak runout magnitude. θ equals the angle of rotation of the center of the circular or spiral track away from the orientation pointing from the center of rotation to the pickup beam spot 100. θ = the angle of rotation of the center of the circular or spiral track at time zero.

In actuality, θ can be measured from a center of the motor driving the disk. The motor shaft typically includes hall sensors, for example three hall sensors, located around the shaft at equal spacing between successively north poles. Typically, there is 6 north poles on the circular permanent magnet. Thus, each hall sensor generates 6 pulses per motor rotation resulting in 18 total pulses per motor rotation or $360/18 = 20°$ between pulses. Additionally, a clock generator used with the hall sensors may be used to determine a more precise location of the shaft and may be set to generate 360 clock pulses for a given complete revolution of the mot or and disk. In this case, each clock pulse would correspond to 1° of θ. Typically, a higher number of pulses would be used for greater accuracy in

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determining shaft position or θ, 2 hall sensor pulses, followed by 5 clock generator pulses, θ = 45°. Thus, θ can be accurately measured.

The magnitude of the radial runout can be determined by rotating the disk at a constant angular velocity. The pickup device 260 remains stationary in the radial direction, and the magnitude of the radial runout can be measured by either using the TZC signal or the MIRR signal or both. A count pulsing circuit or a DSP circuit can be used to count the number of high pulses of the TZC signal per disk rotation and the radial runout magnitude is equal to (half) ½ the number. Alternatively, a pulse counting or DSP could count the number of MIRR pulses from the MIRR signal per disk rotation and again the radial runout magnitude would be half this number. A pulse counting circuit or DSP could count the number of TZC high pulses or, but not both, MIRR high pulses that occur between the direction reversal of track crossings and divide by 2. Direction reversal of track crossing is detected by observing the phase lag/lead of TZC signal with respect to MIRR signal.

Alternatively, a circuit or DSP could measure the period of time between successive track crossings. The period should vary in a periodic fashion reaching maximum twice per disk rotation and additionally reaching minimum twice per disk rotation. The DSP then counts the number of track crossings between successive

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maximum or between successive minimum, This number is twice the radial runout peak magnitude. Thus, to determine the radial runout magnitude, this number is divided by 2. Alternatively, a track count circuit that counts up or down depending on the inward/outward track crossings the DSP or an appropriate hardware circuit detects the maximum and minimum of track count. The difference between the maximum and minimum is twice the radial runout magnitude. Consequently, the difference between the maximum and minimum is divided by 2 to obtain the radial runout magnitude.

The solid line represents first possible radial runout and the second is a second possible radial runout, 180° out of phase with the first possible radial runout. The solid line has the outer period minimum arrives at point 525 and the inner period maximum arrives at point 527. The second possible radial runout is the inner period minimum at point 529 and the outer period maximum at point 531. The true solid runout can only be the first possible radial runout or the second possible radial runout. The true radial runout must be identified. The radial actuator is activated to follow the first possible radial runout. The runout magnitude determined by comparing with the actual runout magnitude. If the magnitude is less than the actual runout magnitude then the true radial runout is the first possible radial runout. If the magnitude is greater than the

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actual runout magnitude then the true radial runout is the second possible radial runout.

Using the transfer function of the radial actuator from the manufacture, calculate the magnitude of a sinusoidal voltage signal to be input into the radial actuator to move the radial actuator in a radial direction a distance, A/2. (A is the magnitude of the actual radial runout.) While A/2 is chosen for the present invention, any fraction of A could be chosen. This is magnitude B(B = A/2). As illustrated in Fig. 9, the phase is adjusted by moving curve 900 to the position of curve 920 and then to the position of the curve 930.

These and other objects features an advantage that the invention that will be come apparent upon reading of the following description and appended drawings.

While the exemplary preferred embodiments of the present invention are described herein, with particularity, those have normal skill in the art will recognize various changes, modification, additions and applications, other than those specifically mentioned and without departing from the spirit of this invention.

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CLAIMS

1. A circuit to determine radial runout, comprising:

a disk to rotate to be subject to said radial runout and to have at least one track;

a circuit to detect track crossing of said at least one track;

a circuit to detect a characteristic of said radial runout based on said track crossing.

2. A circuit to determine radial runout as in Claim 1, whereas, said circuit to detect track crossing details said track crossing based on a TZC signal.

3. A circuit to determine radial runout as in Claim 1, whereas, said circuit to detect track crossing detects said track crossed based on a MIRR signal.

4. A circuit to determine radial runout as in Claim 1, whereas said circuit to detect a characteristic detects a magnitude of the radial runout.

5. A circuit to determine radial runout as in Claim 1, whereas said circuit to detect to a characteristic detects a direction of the radial runout.

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6. A method to determine radial runout, comprising the steps of:

rotating a disk to be subject to the radial runout and having at least one track;

detecting track crossings of at least one track;

detecting a characteristic of the radial runout based on the track crossing;

7. Wherein said detecting a method to determine radial runout as in Claim 5.

8. Wherein the track crossings are based upon a TZC signal.

9. A method to determine radial runout, wherein:

the step to detect the track crossings, detects the track crossings based on MIRR signal.

10. A circuit to determine radial runout as in Claim 6, wherein:

the step of detecting the characteristics detects a magnitude of the radial runout.

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5 11. Wherein the circuit wherein:

the step to detect the characteristic detects a direction of the radial runout.

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