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TITLE OF THE INVENTION

DISK DRIVE WITH CONTROL OF READ AND WRITE GATE SIGNALS
FOR READ AND WRITE OPERATION

BACKGROUND OF THE INVENTION

5 This invention generally relates to the field
of a disk drive to be used with the perpendicular
magnetic recording method, and more particularly, to
control of read/write gate signals for regulating the
timing of a read/write operation.

10 In recent years, the perpendicular magnetic
recording method has been attracting attention as
technique for overpassing the recording density limit
of the conventional longitudinal magnetic recording
method in the technological field of disk drives
15 including hard disk drives. Perpendicular magnetic
recording method can realize a high surface recording
density because it provides a relatively high signal
resolution and small signal amplitude attenuation for
a high linear recording density.

20 As is the same basic structure of the longitudi-
nal magnetic recording method, a magnetic head unit
having a read head and a write head mounted separately
on a slider is used in a disk drive that is adapted to
the perpendicular magnetic recording method. The read
25 head normally comprises a GMR (giant magnetoresistive)
element, whereas the write head is typically an SPT
(single pole type) head. When such a magnetic head is

designed to be used with the perpendicular magnetic recording method, the read head and the write head are separated from each other by a large gap greater than its counterpart of the longitudinal magnetic recording method in the circumferential direction of the disk. More specifically, the gap separating the read head and the write head of a magnetic head unit to be used with the perpendicular magnetic recording method is about 7 to 8 μm . On the other hand, the gap separating the read head and the write head of a magnetic head unit to be used with the longitudinal magnetic recording method is about 3 to 4 μm .

With a disk drive using such a separate type magnetic head unit, the timing of reading operation of the read head and that of writing operation of the write head have to be regulated relative to each other. Now, this will be described in greater detail below.

FIG. 7 of the accompanying drawing is a schematic block diagram of a conventional disk drive, illustrating a principal part thereof. Referring to FIG. 7, the disk drive comprises a separate type magnetic head unit 2, a preamp circuit 7, a read/write (R/W) channel 8, a disk controller (HDC) 9 and a microprocessor (CPU) 10.

The preamp circuit 7 has a read amp for amplifying the read signal output from the read head

of the magnetic head unit 2 and a write amp for
converting the write data signal into a write electric
signal. The R/W channel 8 is a signal processing IC
adapted to process a read/write data signal (including
5 a servo data signal) and has a function of generating
a servo sector pulse SSP out of a servo data signal as
will be described hereinafter.

The HDC 9 operates as interface for the drive
and the host system (not shown) and has a read/write
10 gate generator 90 for generating read/write signals
(RG, WG). The CPU 10 is a main control unit for the
drive and controls the read/write gate generator 90.

The disk provided in the disk drive has a number
of data regions referred to as data tracks and
15 arranged radially on the surface. Each data track has
a data format as shown in FIG. 5B of the accompanying
drawing. Referring to FIG. 5B, the data format
provides servo areas 50 arranged circumferentially at
regular intervals and data areas 51 each of which is
20 arranged between two adjacent servo areas. A servo
data signal is recorded in each servo area 50 in the
manufacturing process of the drive by a dedicated
device referred to as a servo track writer. The servo
area 50 is a region which is prohibited the operation
25 of recording data during the normal operation of
reading and writing data. The servo data signal
provides servo information that is used (by the CPU

10) to control the positioning of the magnetic head unit 2.

On the other hand, each data area 51 is divided into a number of data sectors where user data (DATA) are recorded on it. Additionally, note that the data area 51 has a length that is not necessarily equal to the length of a data sector multiplied by an integer. A data sector may be divided into two sectors with a servo area 50 interposed between them.

Each data sector has a gap 52, a PLL synchronizing signal (PLL) 53, a sync byte (SB) 54, a user data (DATA) 55, EC (error correction) related information 56 and a pad 57 as shown in FIG. 6.

Referring still to FIG. 6, gap 52 is a region for absorbing fluctuations in the rotational movement of the disk. The gap 52 is recorded by the write head during the operation of writing data in the data area 51. Then, a PLL synchronizing signal (PLL) 53 is recorded immediately after the recording of the gap 52. The PLL 53 provides a synchronizing signal pattern for synchronizing the read clock to be used for a read operation (data reproducing operation) with the data that is recorded there. Then, a synchronizing byte (sync byte SB) 54 for detecting the starting point of user data is recorded. Subsequently, user data (DATA) is recorded.

Referring now to FIG. 8C, a read operation is

executed as the HDC 9 activates the read gate signal RG for the R/W channel 8. The read/write gate generator 90 comprises a data sector pulse (DSP) generator 91 and a delay circuit 92. The read/write generator 90 generates a read gate signal RG and a write gate signal WG by referring to the DSP generated by the DSP generator 91 as shown in FIG. 8B. The DSP generator 91 generates a data sector pulse (DSP) by referring to the servo sector pulse (SSP) output from the R/W channel 8 as shown in FIG. 8A. The servo sector pulse (SSP) is generated at the timing of the servo gate signal (SG) output from the HDC 9.

In the write operation, the write gate signal WG is activated by the data sector pulse (DSP) as shown in FIG. 8D. Immediately after the servo area 50, the data sector pulse (DSP) is generated with a delay equal to the time period corresponding to the gap (GN) between the read/write heads, starting from the timing of the end of the servo area 50 (see FIG. 8E). The delay is necessary because, when the end of the servo area 50 is detected by referring to the read head, the write head is still located within the servo area 50 and therefore the servo data signal recorded in the servo area 50 will be destroyed if any data is written at that time. The delay is provided to avoid this problem.

In the read operation, on the other hand, the

read gate signal RG needs to be activated at the middle of the rotary movement fluctuations absorbing gap 52 (the boundary of the parts PA1 and PA2) (see FIG. 8C). Therefore, the delay circuit 92 activates
5 the read gate signal RG at the timing obtained by a delay of a predetermined time period DT from the data sector pulse (DSP). The delay time DT is defined by the CPU 10. As a result, the read head can reliably read the PLL synchronizing signal (PLL) 53
10 if the rotary movement of the disk fluctuates in the read/write operation. Note that a PLL synchronizing signal is recorded in the rotary movement fluctuations absorbing gap 52. In other words, the PLL region 53 is an area for securing a necessary minimal PLL
15 synchronizing signal.

With the longitudinal magnetic recording method, the gap separating the read/write heads is about 3 μm as pointed out earlier. If the disk rotates at a rate of 4,200 rpm $\pm$ 0.2%, the time period
20 (GN) corresponding to the gap varies depending on the position of the head unit 2 on the disk. More specifically, the time period (GN) is about 0.32 μs on the outer periphery of the disk and about 0.64 μs on the inner periphery of the disk. Therefore,
25 normally, the CPU 10 defines a delay time (GN) for each zone on the disk and gives it to the DSP generator 91. The zones of the disk are produced by

dividing the total number of tracks on the disk by a given number.

On the other hand, each rotary movement fluctuations absorbing gap 52 (PA1 and PA2) has
5 a constant length regardless of the position on the disk. If the accuracy of rotary movement is $\pm 0.2\%$, the time period corresponding to the rotary movement fluctuations absorbing gap 52 is about $1.27 \mu s$.
Then, the delay time DT of the read gate signal RG is
10 " $(1.27 / 2 - 0.32) = 0.315 \mu s$ " on the outer periphery and substantially equal to 0 on the inner periphery.

As pointed out above, the magnetic head unit 2 of the perpendicular magnetic recording method has a gap between the read/write heads greater than its
15 counterpart of the longitudinal magnetic recording method. Therefore, the timing of generating the data sector pulse (DSP) needs to be relatively delayed as shown in FIG. 9A. If the delay time is reduced to nil, the timing of activating the read gate signal RG
20 comes closer to the PLL region 53 from the boundary of the two parts (PA1 and PA2) of the rotary movement fluctuations absorbing gap 52 as shown in FIG. 9B. Under this condition, there may be cases where the PLL synchronizing signal is not properly read out from
25 the PLL region 53 by the read head at the timing of activating the read gate signal RG because of fluctuations in the rotary movement of the disk.

Therefore, it is necessary to absorb fluctuations in the rotary movement of the disk by increasing the region of the rotary movement fluctuations absorbing gap 52 (by PA3 for the PA1) as shown in FIG. 9E.

5 However, the efficiency of the data format is reduced as the region of the rotary movement fluctuations absorbing gap 52 that is not the data recording region of the disk increases.

Now, how the efficiency of the data format is
10 reduced will be described more specifically.

Assume that the gap separating the read/write heads is 8 μm and the disk is driven to rotate at a rate of 4,200 rpm $\pm$ 0.2%. The time period (GN) that corresponds to the gap varies depending on the
15 position of the head unit 2. To be accurate, the time period is about 0.86 μs on the outer periphery and about 1.71 μs on the inner periphery of the disk.

As for the length of the pairs of rotary movement fluctuations absorbing gap 52, the PA1 needs to
20 be increased by a part (PA3) that corresponds to 0.225 μs on the outer periphery and 1.075 μs on the inner periphery, provided that the accuracy of rotary movement is $\pm$ 0.2% and the delay time DT of the read gate signal is 0. These time periods correspond
25 respectively to 8.4 bytes and 20.1 bytes in terms of a disk drive having a transfer rate of 300 Mbps. In other words, the rotary movement fluctuations

absorbing gap 52 has a length equal to 1.3% to 3.2% of a data sector on the disk. Therefore, the efficiency of the data format is reduced by these percentage figures.

5 Disk drives adapted to delay the operation of recording the data to be written by a time period corresponding to the gap (distance) separating the read/write heads so that the read head may properly reproduce the recorded data (see, inter alia, Jpn. Pat. Appln. KOKAI Publication No. 6-176486 and U.S. 10 Patent No. 5,600,501). However, the problem of reduced efficiency of the data format cannot be resolved simply by delaying the operation of recording the data to be written on the disk.

15 BRIEF SUMMARY OF THE INVENTION

 Therefore, the object of the present invention is to provide a disk drive that is to be used with the perpendicular magnetic recording method can properly read a PLL signal on a disk and avoid the problem of 20 efficiency reduction of the data format.

 In accordance with an aspect of the present invention, there is provided a disk drive including facilities to control a read gate signal and a write gate signal in accordance with the space between the 25 read head and the write head of a magnetic head unit and the data format on the disk in the disk drive.

 The disk drive comprises:

a disk operating as recording medium and adapted to record data signals by perpendicular magnetic recording;

5 a magnetic head unit having a write head for writing a data signal onto and a read head for reading a data signal from the disk;

a gate generator for generating a write gate signal for determining the timing of the write operation of the write head and a read gate signal
10 for determining the timing of the read operation of the read head;

the gate generator being adapted to regulate the timing of outputting the write gate signal and that of outputting the read gate signal on the basis of the
15 gap between the write head and the read head in the circumferential direction of the disk and the data format on the disk; and

a read/write device for executing the write operation at the timing of outputting the write gate
20 signal and the read operation at the timing of outputting the read gate signal.

Additional objects and advantages of the invention will be set forth in the description which follows, and in part will be obvious from the
25 description, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and obtained by means of the

instrumentalities and combinations particularly pointed out hereinafter.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

The accompanying drawings, which are incorporated
5 in and constitute a part of the specification,
illustrate embodiments of the invention, and together
with the general description given above and the
detailed description of the embodiments given below,
serve to explain the principles of the invention.

10 FIG. 1 is a schematic block diagram of the
read/write gate generator of an embodiment of disk
drive according to the invention, illustrating
a principal part thereof;

FIG. 2 is a schematic block diagram of the
15 embodiment of disk drive of FIG. 1, illustrating
a principal part thereof;

FIGS. 3A through 3D are timing charts
illustrating the operation of the read/write gate
generator of FIG. 1;

20 FIG. 3E is a schematic illustration of the data
format, illustrating the operation of the read/write
gate generator of FIG. 1;

FIG. 4 is a schematic block diagram of an
embodiment obtained by modifying the embodiment of
25 FIG. 1;

FIGS. 5A through 5C are schematic illustrations
of the configuration of a disk to be used with the

modified embodiment of FIG. 4;

FIG. 6 is a schematic illustration of the data format on the disk of FIGS. 5A through 5C;

FIG. 7 is a schematic block diagram of a known disk drive, illustrating a principal part thereof;

FIGS. 8A through 8D are timing charts illustrating the operation of the read/write gate generator of FIG. 7;

FIG. 8E is a schematic illustration of a data format that can be used for the operation of the known disk drive of FIG. 7;

FIGS. 9A through 9C are timing charts also illustrating the operation of the read/write gate generator of FIG. 7; and

FIGS. 9D and 9E are schematic illustrations of data formats that can be used for the operation of the known disk drive of FIG. 7.

DETAILED DESCRIPTION OF THE INVENTION

Now, the present invention will be described in greater detail by referring to the accompanying drawing that illustrates a preferred embodiment of the invention.

(configuration of disk drive)

This embodiment of disk drive according to the invention is adapted to be used with the perpendicular magnetic recording method. Referring to FIG. 2, the disk drive comprises a disk 1 operating as data

recording medium and a magnetic head unit 2 for
reading data from and writing data onto the disk 1.
The disk 1 is driven by a spindle motor (SPM) 3.
As shown in FIG. 5A, a number of tracks (TR0 through
5 TRn) are formed concentrically on the disk 1.

The magnetic head unit 2 includes a read head
that is normally a GMR element and a write head that
is normally a SPT head, the read head and the write
head being separated from each other and mounted on a
10 slider. As pointed out earlier, the read/write heads
of the magnetic head unit 2 are circumferentially
separated from each other by a gap (distance) of about
7 to 8 μm . Therefore, the gap is larger than that of
a magnetic head unit adapted to be used with the
15 longitudinal magnetic recording method.

The magnetic head 2 is mounted on an actuator 4.
The actuator 4 moves the head unit 2 of the disk in
a radial direction of the disk 1 by the drive force of
a voice coil motor (VCM) 5. The VCM 5 is the object
20 of control (plant) of a head positioning control
system (servo system) in a narrow sense of the word
and fed with a drive current by means of a VCM driver
6A that is included in motor driver IC 6. The motor
driver IC 6 includes the VCM driver 6A and an SPM
25 driver 6B for feeding the SPM 3 with a drive current
and is controlled by CPU 10.

Besides the above described head disk assembly,

the disk drive comprises a circuit system having a preamp circuit 7, a R/W channel 8, a disk controller (HDC) 9, a CPU 10 and memories 11.

5 The preamp circuit 7 includes a read amp for amplifying the read signal output from the read head and a write amp for converting a write data signal into a write current signal. The R/W channel 8 is a signal processing IC for processing read/write signals (including servo signals) and also has a
10 function of generating a servo sector pulse SSP out of the servo data signal read out from by the read head.

 The HDC 9 operates as interface of the disk drive and the host system (not shown) and includes a read/write gate generator 100 for generating
15 read/write gate signals (RG, WG). The CPU 10 is the main control unit of the disk drive and controls the read/write generator 100. The memories 11 includes a flash EEPROM, a RAM and a ROM and is adapted to store various programs and data necessary for the
20 operation of the CPU 10.

(configuration of read/write gate generator)

 As shown in FIG. 1, the HDC 9 comprises a DSP generator 91 and a read/write gate generator 100 having delay circuits 101, 102. The respective delay
25 times Da through Dc of the DSP generator 91 and the delay circuits 101, 102 are defined by the CPU 10. The DSP generator 91 generates a data sector pulse

(DSP) by referring to the servo sector pulse (SSP) output from the R/W channel 8.

5 The R/W channel 8 detects a servo sector mark 501 from the read signal output from the read head when the servo gate signal (SG) output from the HDC 9 becomes active. A servo sector mark 501 is a signal to be used for detecting a servo area 50 as it is contained in the servo area 50. In addition to the mark 501, an AGC pattern 500 and a track address code 10 502 and a servo burst signal that are servo data in a narrow sense of the word are also recorded in the servo area 50. The R/W channel 8 generates a servo sector pulse (SSP) in response to the detection of a servo sector mark 501 and transmits it to the HDC 9 (notification of detection of a servo sector mark). 15

 The delay circuits 101, 102 respectively output a read gate signal RG and a write gate signal WG to the R/W channel 8 at respective timings that are determined according to the delays Db, Dc given by the CPU 10 (see FIGS. 1 and 2). The R/W channel 8 carries 20 out a read operation (of processing a read signal) at the timing of the read gate signal RG and a write operation (of processing a write signal) at the timing of the write gate signal WG.

25 (data format)

 As shown in FIG. 5A, a number of tracks (TR0 through TRn) are concentrically formed on the disk 1.

Each track has servo areas 50 arranged circumferentially at regular intervals and data areas 51 each of which is arranged between two adjacent servo areas as shown in FIG. 5B. Each data area 51 is divided into a number of data sectors for recording user data (DATA). Note that the data area 51 has a length that is not necessarily equal to the length of a data sector multiplied by an integer. As shown in FIG. 5B, a data sector (sector No. 3 in FIG. 5B) may be divided into two sectors with a servo area 50 interposed between them.

As shown in FIG. 5C, the servo area 50 stores a servo sector mark 501, an AGC pattern 500, a track address code 502 and a servo burst signal 503 that are recorded on it.

Additionally, each data sector has a gap 52, a PLL synchronizing signal (PLL) 53, a sync byte (SB) 54, a user data (DATA) 55, ECC (error correction) related information 56 and a pad 57 also recorded on it.

The gap 52 is a region for absorbing fluctuations in the rotation movement of the disk 1. The gap 52 is recorded by the write head during the operation of writing data in the data area 51. Then, a PLL synchronizing signal (PLL) 53 is recorded immediately after the recording of the gap 52. The PLL 53 provides a synchronizing signal pattern for

synchronizing the read clock to be used for a read operation (data reproducing operation) with the data that is recorded there. Then, a sync byte (SB) 54 for detecting the starting point of user data (DATA) is recorded. Subsequently, user data (DATA) is recorded. The pad 57 is a region for a write path delay.
(operation of generating read/write gate signals)

The disk drive executes a read operation in the data area 51 when HDC 9 activates the read gate signal RG for the R/W channel 8. In the read operation, the R/W channel 8 processes the read signal read out by the read head and reproduces (decodes) the user data. At this time, it is necessary to reliably read the PLL synchronizing signal from the PLL region 53 in order to obtain a synchronizing pulse necessary for the read operation. On the other hand, the disk drive executes a write operation in the data area 51 when the HDC 9 activates the write gate signal WG for the R/W channel 8. In the write operation, the R/W channel 8 processes a write data signal and transmits it to the preamp circuit 7 in order to supply a write signal to the write head. At this time, the timing of the data writing operation needs to be so regulated that it may not carried out in the servo area 51.

Now, the operation of generating read/write gate signals of the embodiment will be described by referring to FIGS. 3A through 3E.

As shown in FIG. 3A, the R/W channel 8 outputs a servo sector pulse (SSP) to the HDC 9 in response to the detection of a servo area 50 (and a servo mark 501). Then, the DSP generator 91 generates a data sector pulse (DSP) that indicates the starting point of the data sector as shown in FIG. 3B. At this time, the DSP generator 91 generates the data sector pulse (DSP) at the timing corresponding to a predetermined delay time (T2) from the end of the servo area 50 (and hence the head of the data sector) according to the delay (Da) defined by the CPU 10 (see FIG. 3E).

Furthermore, the DSP generator 91 generates a plurality of data sector pulses (DSPs) at regular time intervals starting from the first data sector pulse (DSP), the number of data sector pulses corresponding to the number of data sectors. In short, the DSP generator 91 generates a data sector pulse (DSP) at the timing of the leading region of each of the data sectors contained in the data area 51 on the basis of the three parameters defined by the CPU 10. The three parameters includes the time (T2) from the end of the servo area 50 (the head of the data sector) to the first data sector pulse (DSP), the length of each data sector and the number of data sectors corresponding to a single servo area 50.

Then, in the write operation, the read/write gate generator 100 generates a write gate signal WG at the

timing corresponding to a predetermined delay time
(T3) from the DSP according to the delay (Dc) defined
by the CPU 10 for the delay circuit 102 (see FIGS. 3D
and 3E). The time from the end of the servo area 50
5 (the head of the data sector) to the generation of the
write gate signal WG is expressed by " $T1 = T2 + T3$ ",
which is a delay time corresponding to the gap between
the read head and the write head (the distance of
about 7 to 8 μm).

10 On the other hand, in the read operation, the
read/write gate generator 100 generates a read gate
signal RG at the timing corresponding to a predeter-
mined delay time from the data sector pulse (DSP)
according to the delay (Db) defined by the CPU 10 for
15 the delay circuit 101. The timing of generating the
read gate signal RG is so selected that it comes at
the middle of the gap 52 (the boundary of the parts
PA1 and PA2) (see FIG. 3E).

As described above, the read/write gate generator
20 100 of this embodiment generates a write gate signal
WG at the timing corresponding to a predetermined
delay time (T3) from the data sector pulse (DSP) in
the write operation. In other words, the generator
100 generates a write gate signal WG at the timing
25 corresponding to the delay time (T1), which by turn
corresponds to the gap (distance of about 7 to 8 μm)
between the read head and the write head, from the end

of the servo area 50. At this time, the DSP generator 91 generates a data sector pulse (DSP) at the timing corresponding to the delay time (T2) that is shorter than the delay time (T1) corresponding to the gap (distance of about 7 to 8 μm) between the read head and the write head.

Therefore, the timing of the start of the write operation corresponds to an area that by turn corresponds to the gap 52 as shown in FIG. 3E so that any error of writing data in the servo area 50 is reliably avoided. In the read operation, on the other hand, the generator 100 generates a read gate signal RG at the timing corresponding to a predetermined delay time from the data sector pulse (DSP). Therefore, the read operation starts from the middle of the gap 52 (the boundary of PA1 and PA2) as shown in FIG. 3E. Thus, the PLL synchronizing signal can be read properly from the PLL region 53 without expanding the area of the gap 52. As a result, it is possible to avoid any reduction in the efficiency of the data format that may arise when the area of the gap 52 is increased.

As specific example, when the time (T2) from the end of the servo area 50 to the generation of the data sector pulse (DSP) is 0.4 μs , preferably the delay time of the read gate signal RG is made equal to 0.235 μs . It is also preferable to make the delay

time (T3) of the write gate signal WG to be equal to 0.46 μ s at the outer periphery and equal to 1.31 μ s at the inner periphery of the disk 1. In short, preferably, delays (Da, Db, Dc) for the read/write gate generator 100 are regulated at each zone on the disk 1 under the control of the CPU 10 during the read/write operation.

Thus, with this embodiment of the invention, when a read gate signal and a write gate signal are generated by referring to the generation of a data sector pulse (DSP), the delay times selected by referring to the DSP are so regulated that the read gate signal always precedes the write gate signal. Additionally, the write gate signal is generated with a delay of a predetermined time period after the generation of the DSP. In the read operation, the delay of a predetermined time period as defined by referring to the DSP is regulated for the generation of the read gate signal. In short, the read head can properly read a PLL synchronizing signal from a PLL area without expanding the area of the related gap on the data format. In the write operation, the write head can effectively avoid erroneously writing data in the servo area.

(modified embodiment)

FIG. 4 is a schematic block diagram of the read/write gate generator of an embodiment obtained by

modifying the embodiment of FIG. 1.

Referring to FIG. 4, the read/write gate generator comprises a DSP generator 91, a delay circuit 103 and switches 104, 105. The switches 104, 105 are controlled by the CPU 10.

The above of FIG. 4 of this modified embodiment operates in such a way that the delay circuit 103 is used only for generating a write gate signal WG when the delay time ($T1$) corresponding to the gap (distance of about 7 to 8 μm) between the read head and the write head and the time ($T4$) corresponding to the gap 52 satisfies the requirement of " $T1 > T4 / 2$ ". The time " $T4 / 2$ " corresponds to the middle of the gap 52 (the boundary of PA1 and PA2).

More specifically, the read/write gate generator activates a read gate signal RG at the timing substantially equal to the timing of generation of a DSP and generates a write gate signal WG at the timing that corresponds to the delay time of the delay circuit 103 by using the switches 104, 105 under the control of the CPU 10. At this time, the DSP generator 91 generates the DSP at the timing corresponding to the middle of the gap 52 according to the delay (D_a) defined by the CPU 10. When the above requirement is not met and hence the relationships of " $T1 < T4 / 2$ " and " $T1 > T4 / 2$ " hold true respectively at the outer periphery and the inner periphery of

the disk 1, the delay circuit 103 is used for the operation of generating a read gate signal RG at the outer periphery by means of the switches 104, 105 under the control of the CPU 10. On the other hand,
5 the delay circuit 103 is used for the operation of generating a write gate signal WG at the inner periphery as in the case of the above embodiment.

Thus, in this modified embodiment, a same delay circuit 103 is used commonly for generating read/write
10 gate signals under the control of the CPU 10. In other words, this modified embodiment has a reduced circuit configuration if compared with the above embodiment.

As described above in detail, the magnetic head
15 unit of a disk drive according to the invention that is adapted to be used with the perpendicular magnetic recording method and having the read head and the write head separated from each other by a relatively large gap can regulate the generation of read/write
20 gate signals for respectively determining the timings of read/write operations. Then, it is always possible to properly read the corresponding PLL synchronizing signal that is needed for the read operation and avoid any increase of the area of the gaps on the disk and
25 hence any reduction of the efficiency of the data format. Thus, a disk drive comprising such a magnetic head unit can be effectively used to realize a high

recording density particularly by means of the
perpendicular magnetic recording method.

Additional advantages and modifications will
readily occur to those skilled in the art. Therefore,
5 the invention in its broader aspects is not limited to
the specific details and representative embodiments
shown and described herein. Accordingly, various
modifications may be made without departing from the
spirit or scope of the general inventive concept as
10 defined by the appended claims and their equivalents.

WHAT IS CLAIMED IS:

1. A disk drive comprising:

a disk operating as recording medium and adapted
to record data signals by perpendicular magnetic
5 recording;

a magnetic head unit having a write head for
writing a data signal onto and a read head for reading
a data signal from the disk;

a gate generator which generates a write gate
10 signal for determining the timing of the write
operation of said write head and a read gate signal
for determining the timing of the read operation of
said read head;

said gate generator being adapted to regulate the
15 timing of outputting said write gate signal and that
of outputting said read gate signal on the basis of
the gap between said write head and said read head in
the peripheral direction of said disk and the data
format on said disk; and

20 a read/write device which executes the write
operation at the timing of outputting said write
gate signal and the read operation at the timing of
outputting said read gate signal.

2. The disk drive according to claim 1, wherein

25 a plurality of tracks, each having a plurality of
data sectors, are formed on said disk and each of said
data sectors is provided with said data format and

includes a gap region and a PLL region located at the head of the data recording region thereof;

the disk drive further comprising:

a DSP generator for generating a data sector pulse to be used for detecting the head of each data sector;

said gate generator being adapted to generate said read gate signal at the timing corresponding to said gap region by referring to the timing of generation of said data sector pulse and said write gate signal at the timing coming behind the timing of generation of said read gate signal and defined by the gap separating said write head and said read head.

3. The disk drive according to claim 2, wherein said gate generator is adapted to generate said read gate signal at the timing substantially corresponding to the middle of said gap region by referring to the timing of generation of said data sector pulse and said write gate signal at the timing as defined in terms of the distance from the head of said gap region on the basis of the gap between said write head and said read head.

4. The disk drive according to claim 2, wherein said DSP generator is adapted to generate a data sector pulse (DSP) at the timing of a delay time shorter than the delay time corresponding to the gap between said read head and said write head, said

timing being defined in terms of the distance from the head of said data sector.

5 5. The disk drive according to claim 1, wherein
a plurality of tracks, each having a plurality of
servo areas and a plurality of data sectors, are
formed on said disk and each of said servo areas is
arranged between two adjacent data sectors, each of
said data sectors being provided with said data format
and includes a gap region and a PLL region located at
10 the head of the data recording region thereof;

the disk drive further comprising:

15 a DSP generator adapted to generate a data sector
pulse for detecting the head of each data sector by
referring to the servo sector pulse from said servo
area;

20 said gate generator being adapted to generate
said read gate signal at the timing corresponding
to said gap region by referring to the timing of
generation of said data sector pulse and said write
gate signal at the timing coming behind the timing of
generation of said read gate signal with a delay time
corresponding to the gap separating said write head
and said read head as defined from the end of said
servo area.

25 6. The disk drive according to claim 1, wherein
said gate generator is adapted to generate said
read gate signal at the timing coming before the

timing of said write gate signal in a read operation.

7. The disk drive according to claim 1, wherein
a plurality of tracks, each having a plurality of
data sectors, are formed concentrically on said disk
and each of the tracks is divided into zones defined
in a radial direction for control purposes;

said gate generator being adapted to regulate the
timing of outputting said write gate signal and that
of outputting said read gate signal for each zone.

8. The disk drive according to claim 2, wherein
a plurality of tracks are formed concentrically
on said disk and each of the tracks is divided into
zones defined in a radial direction for control
purposes;

said gate generator being adapted to regulate the
timing of outputting said write gate signal and that
of outputting said read gate signal for each zone.

9. The disk drive according to claim 2, wherein
said DSP generator and said gate generator are
included in a disk controller operating as interface
of the disk drive and an external system.

10. The disk drive according to claim 5, further
comprising:

a read/write channel for processing the read
signal read out from said servo area or said data
sector by means of said read head and a disk
controller operating as interface of the disk drive

and an external system;

said read/write channel being adapted to generate said servo sector pulse out of the read signal read out from said servo area;

5 said disk controller including said DSP generator and said gate generator and being adapted to input said servo sector pulse output from said read/write channel to said DSP generator.

11. A method of generating a read gate signal for
10 a read operation and a write gate signal for a write operation in a disk drive by perpendicular magnetic recording, said disk drive having a disk, a read head and a write head, said method comprising:

generating said read gate signal for said read
15 operation and said write gate signal for said write operation at the respective timings regulated on the basis of the peripheral gap between said read head and said write head on the disk; and

executing said write operation at the timing of
20 the output of said write gate signal and said read operation at the timing of the output of said read gate signal.

12. The method according to claim 11, further comprising:

25 generating a data sector pulse for detecting the head of each data sector formed on said disk; and

generating said read gate signal by referring to

the timing of generation said data sector pulse and said write gate signal at the timing coming behind said read gate signal and defined on the basis of the gap between said read head and said write head.

5 13. The method according to claim 11, further comprising:

generating a data sector pulse for detecting the head of each data sector formed on said disk; and

generating said read gate signal at the timing
10 corresponding to the head of each data sector by referring to the timing of generation said data sector pulse and said write gate signal at the timing coming behind said read gate signal and defined on the basis of the gap between said read head and said write head
15 from said head of data sector.

14. The method according to claim 11, further comprising:

generating a servo sector pulse out of the read signal read out from a servo area formed on said disk
20 by means of said read head;

generating a data sector pulse for detecting the head of each data sector by referring to said servo sector pulse;

generating said read gate signal at the timing
25 corresponding to the head of each data sector by referring to the timing of generation of said data sector pulse; and

generating said write gate signal at the timing coming behind the read gate signal and defined on the basis of the gap between said read head and said write head from said head of data sector.