PERTEC Application Notes

Hard-Sector Formatting For PERTEC Flexible Disk Drives

FOREWORD

This Application Note provides the reader with a method of configuring a hard-sectored format for PERTEC flexible disk drives. The parameters which contribute to sector format considerations are described. Additionally, a typical example is worked out as an aid to understanding the steps involved in calculating a format for flexible disk drives.

PERTEC

TABLE OF CONTENTS

PERTEC

NOTES

I. INTRODUCTION

The PERTEC flexible disk drive is a compact disk memory device used for random-access data storage. The recording medium employed is a circular flexible mylar disk referred to as a diskette.

The standard diskette is designed for use with a format in which sector mark information is pre-recorded. In this case, a single hole on the disk serves as a reference point. The detection of this hole is accomplished by a transducer consisting of a phototransistor/ LED combination. This Application Note, however, is concerned with a diskette designed with multiple holes which provide sector information.

The term *hard sectored* identifies a diskette that has fixed sector holes on the same radius as the index hole. Sector timing is accomplished by sensing the holes provided on the hard-sectored diskette. This configuration is shown in Figure 1 along with a timing diagram which compares the hard-sectored and the single-hole diskettes.

The paragraphs that follow will aid the user to configure hard-sectored formats for his specific application.

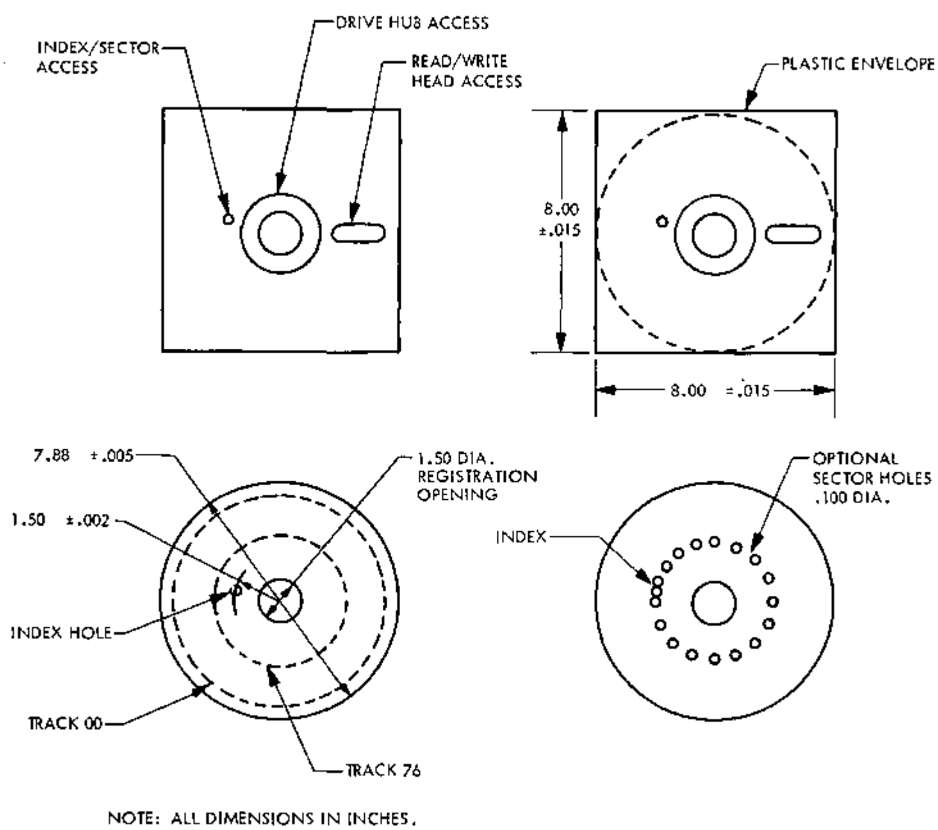
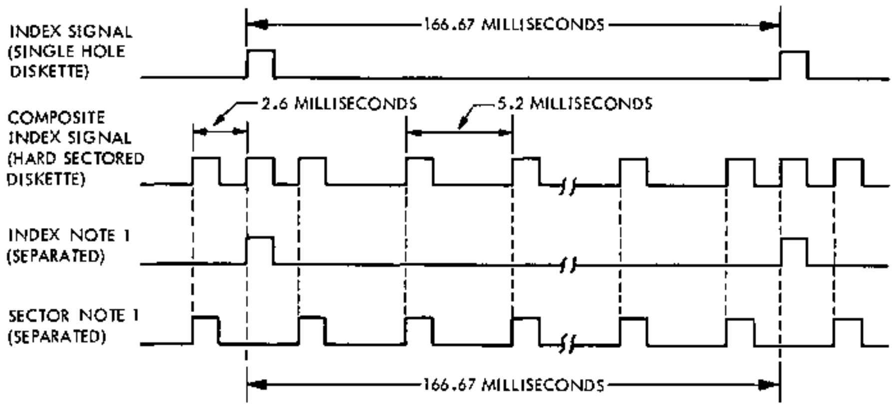


Figure 1A. Diskette Comparison



NOTE: 1. USER SYSTEM SEPARATES INDEX AND SECTOR PULSES.

Figure 1B. Diskette Comparison (Timing)

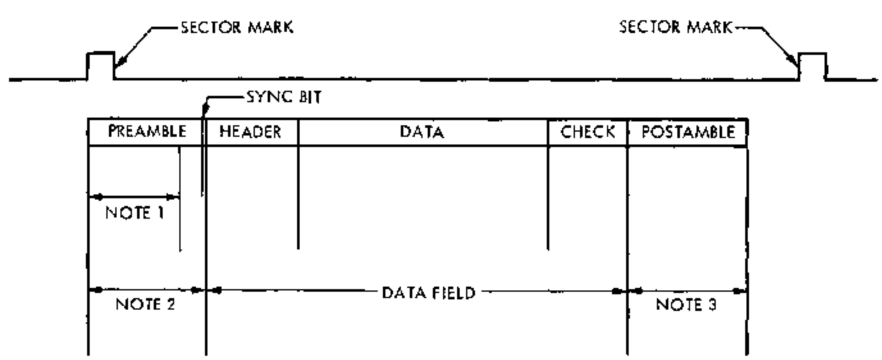
II. TIMING CONSIDERATIONS

The basic parameters used to configure a hard-sectored format for a single density flexible disk drive are as follows:

Number of Sectors	1 — 32
Number of Tracks	76
Rotation Rate	360 rpm
Data Transfer Rate	250,000 bits per second
Nominal Density	3268 bpi (bits per inch, inside track)

Using these parameters a variable header format (shown in Figure 2) can be recommended which consists of the following.

- Preamble — A burst of *zero* bits required for sector tolerancing and to allow the read electronics to acquire data.
- Sync Bit — A single *one* bit which flags the beginning of useful data.
- Data Field — Consists of:
  - Header — Two bytes which contain the track and sector address of the current sector. This is compared against the expected address before a data transfer takes place.
  - Data — n bytes of data; the value of n depends on the formatter configuration.
  - Check — Two bytes of Cyclic Redundancy Check (CRC) character information for the Header and Data. When reading from disk, these bytes are compared against a recomputed CRC.
- Postamble — A burst of *zero* bits which allows the erase head to complete the erasure of the CRC field before write current is switched off.



NOTES:
1. READ PREAMBLE DELAY
2. WRITE PREAMBLE DELAY
3. WRITE POSTAMBLE DELAY

Figure 2. Basic Format

The number of sectors on a disk surface is normally specified by the user. If S is the disk speed in rpm, the time T_{REV} in microseconds (µsec) for one revolution is:

$$T_{REV} = \frac{60 \cdot 10^6}{S} \ \mu sec \qquad (1)$$

The time T_S (in µsec) for one sector can be obtained by dividing T_{REV} by the number of sectors for one revolution, N. Therefore, the time T_S is given by:

$$T_S = \frac{T_{REV}}{N}$$

Therefore, substituting, we get

$$T_S = \frac{60 \cdot 10^6}{S \cdot N} \ \mu sec \qquad (2)$$

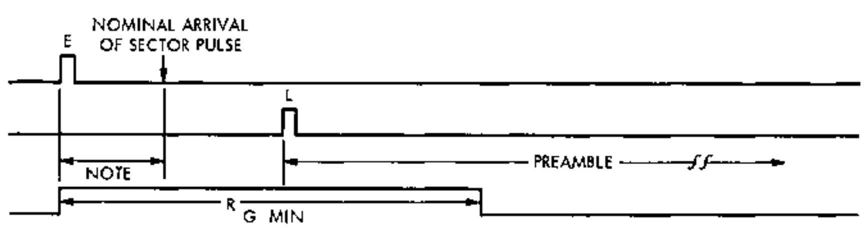
We can assume at this point that the disk surface is divided into sectors by the 32 equally spaced holes. In addition, an index hole is provided (on the same radius) centrally spaced between two selected sector holes to establish a point of reference and to indicate that the next sector hole detected is the beginning of the first sector. Each sector must then provide sufficient space to contain a group of bytes which comprises one record of data.

The nominal Sector Time obtained in Equation (2) establishes the nominal arrival time for a sector pulse. However, due to factors such as transducer alignment, transducer response, positioner linearity, and sector amplifier response, the actual arrival time of a sector pulse deviates from the nominal. The maximum deviation from this nominal value is defined as electronic sector jitter (ESJ) which is discussed in Paragraph 2.1.

2.1 READ PREAMBLE DELAY

Read preamble delay is defined as the gate delay from the sector mark to the beginning of *reading*. However, the read gate must take into account the electronic sector jitter (ESJ) due to the mechanical tolerances in sector holes, sector transducer alignment, and the sector amplifier response.

Figure 3 illustrates a situation in which the preamble is *written* from the late sector (L) and read from early sector (E). This represents the worst-case condition in which the ESJ is maximum.



NOTE: MAXIMUM ELECTRONIC SECTOR JITTER (ESJ)

Figure 3. Read-Gate Timing

The read-gate delay provides the necessary timing delay before a read operation can begin; but, the minimum read gate time should at least equal the total worst-case maximum ESJ plus the acquisition time (τ) for the read recovery circuit. The total maximum ESJ including the effects of disk speed variation, is calculated for a typical PERTEC flexible disk drive as follows.

Sector Amplifier Response	=	±1 μsec
Transducer Alignment	=	±40 μsec
Transducer Response	=	±5 μsec
Positioner Linearity	=	±20 μsec
Total Electronic Sector Jitter	=	±66 μsec

Using these figures we find that the minimum read-gate time is:

$$R_{G\,min} = (2\,ESJ + \tau)\,\mu sec \quad (3)$$

where

τ = acquisition time for the read recovery circuit.

The acquisition times are typically 100 μsec for the recommended PERTEC Phase-Lock Loop data separator, and 10 μsec for a single-shot separator.

2.2 WRITE PREAMBLE DELAY

The write preamble must be long enough to allow the read gate to go *false* before the end of the preamble in the worst-case condition. This condition is illustrated in Figure 4.

Figure 4 also illustrates the worst-case condition in which the preamble is *written* from the early sector mark (E) and *read* from the late sector mark (L). Therefore, we have the minimum preamble ($T_{pr\,min}$), whose equation is

$$T_{pr\,min} = 2\,ESJ + R_{G\,min} \quad (4)$$

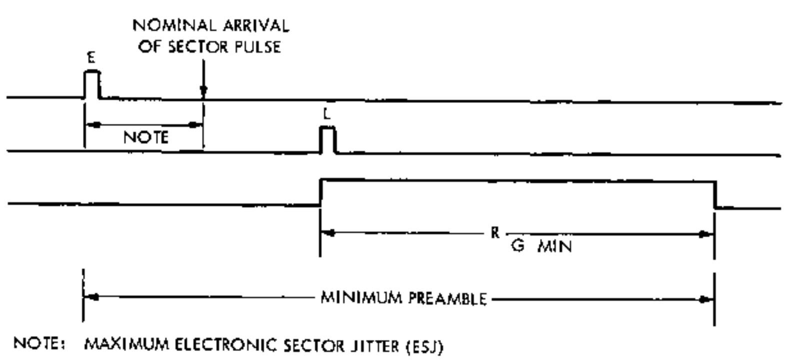


Figure 4. Preamble Timing

2.3 POSTAMBLE DELAY

A postamble delay (burst of *zero* bits) is injected to allow the erase head to complete the erasure of the check field before the write current is switched off. The postamble delay should be at least equal to the time it takes a point to traverse the erase gap. To calculate this, let S be the disk speed (in rpm) and let percentage variation in the disk speed be ±X%. The time to traverse the erase gap should be calculated for the innermost track where the linear speed is minimum. This represents the worst-case condition for the minimum postamble length. Also, let R_{in} be the radius of the innermost track on the disk expressed in inches; therefore, the linear speed for the innermost track V_{min} will be:

$$V_{min} = \frac{2\pi \cdot S \cdot R_{in}}{60\,(1 + X/100)} \quad \text{inches per second (ips)}$$

$$= \frac{2\pi \cdot S \cdot R_{in} \cdot 10^3}{60\,(1 + X/100) \cdot 10^6} \quad \text{mils per microsecond (mils/}\mu\text{sec)}$$

$$V_{min} = \frac{2\pi \cdot S \cdot R_{in}}{6 \cdot 10^4\,(1 + X/100)} \quad \text{mils/}\mu\text{sec} \qquad (5)$$

Further, let L_{EG} be the length of the erase gap (in mils) and T_{EG} be the time (in µsec) to traverse the erase gap. Therefore, the equation becomes

$$T_{EG} = \frac{L_{EG}}{V_{min}} \quad \mu\text{sec}$$

Next, substituting for V_{min} in Equation (5), we find that

$$T_{EG} = \frac{6 \cdot 10^4 \cdot L_{EG} \cdot (1 + X/100)}{2\pi \cdot S \cdot R_{in}} \quad \mu\text{sec} \qquad (6)$$

2.4 SECTOR TOLERANCE

Another tolerance factor for the uncertainty in a sector-hole location can be calculated as follows.

Let the mechanical tolerance in the location of a sector hole be ±SL minutes of arc. The equivalent tolerance, T_{SL}, (in µsec) for a sector-hole location with a disk speed of S (in rpm) and the speed variation of ±X% is:

$$T_{SL} = \frac{60 \cdot 10^6}{360 \cdot S} \cdot \frac{2 \cdot SL}{60} \cdot (1 + X/100)\,\mu\text{sec}$$

$$T_{SL} = \frac{SL\,(1 + X/100) \cdot 10^6}{180 \cdot S} \quad \mu\text{sec} \qquad (7)$$

2.5 SPEED TOLERANCE

Let the tolerance due to the speed variation be T_X. Then T_X (in μsec) can be expressed as:

$$T_X = \frac{60 \cdot 10^6}{S} \cdot \frac{1}{N} \cdot \frac{X}{100}$$

$$T_X = \frac{60 \cdot X \cdot 10^4}{S \cdot N} \mu sec \qquad (8)$$

where

N = Number of sectors per revolution
S = Disk Speed
X = Speed Variation (%)

2.6 DATA FIELD

The space available for the data field in a sector is calculated by allowing for the mechanical tolerance in the position of a sector hole, a write preamble delay, an erase gap, and the speed variation. Figure 5 illustrates the tolerancing used to calculate the available space for the data field in a sector. The data field includes the header, data, and the check bytes.

Let T_{DF} be the time (in μsec) for the data field in a sector.

Therefore, we obtain the following inequality:

$$(T_{pr\,min} + T_{DF} + T_{EG} + T_{SL} + T_X) < T_S \qquad (9)$$

where

$T_{pr\,min}$ = Time (in μsec) for minimum preamble length.
T_{DF} = Time (in μsec) for data field.
T_{EG} = Time (in μsec) to traverse the erase gap
= minimum postamble length.
T_{SL} = Time (in μsec) to allow for mechanical tolerance in sector-hole location.
T_X = Time (in μsec) to allow for the speed variation.
T_S = Time (in μsec) for one sector.

The only unknown in the above inequality is T_{DF}. Hence, the upper limit for T_{DF} can be calculated for a given configuration, using the inequality shown in Equation (9) above.

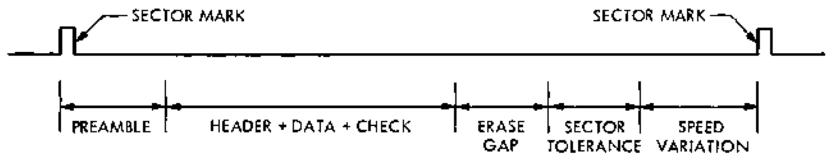


Figure 5. Data Format

2.7 EXAMPLE

Using the parameters set forth earlier and the equations developed, a flexible disk drive user can employ the following example to develop sector timing in accordance with his requirements.

Assumptions:

Let

N = Number of sectors for one revolution = 32

S = Disk Speed = 360 rpm

First, Sector Time (T_S) is calculated using Equation (2)

$$T_S = \frac{60 \cdot 10^6}{S \cdot N} \ \mu sec$$

$$= \frac{60 \cdot 10^6}{360 \cdot 32}$$

$$= 5208 \ \mu sec$$

Next, the minimum read preamble delay $R_{G\ min}$ is obtained using Equation (3) repeated below:

$$R_{G\ min} = (2\ ESJ + \tau)$$

Using a single-shot separator ($\tau = 10\ \mu sec$), we have

$$R_{G\ min} = (2 \cdot 66) + 10$$

$$= 142\ \mu sec$$

Further, the minimum preamble length ($T_{pr\ min}$) is calculated using Equation (4) repeated below:

$$T_{pr\ min} = 2\ ESJ + R_{G\ min}$$

$$= (2 \cdot 66) + 142$$

$$= 274\ \mu sec$$

Also, the minimum postamble length is calculated using Equation (6) repeated below:

$$T_{EG} = \frac{6 \cdot 10^4 L_{EG} (1 + X/100)}{2 \cdot \pi \cdot S \cdot R_{in}}$$

The erase gap L_{EG} (in mils) is 32 ±3 mils; the radius of the inside track (R_{in}) is 2.029 inches, the speed variation X = ±3%; therefore, in further substituting we find that

$$T_{EG} = \frac{6 \cdot 10^4 \cdot (32 + 3) \cdot (1 + 3/100)}{2 \cdot \pi \cdot 360 \cdot 2.029}$$

$$= 472 \mu\text{sec (approximately)}$$

Sector-hole tolerance T_{SL} is calculated next using the Equation (7) repeated below.

$$T_{SL} = \frac{SL (1 + X/100) \cdot 10^6}{180 \cdot S} \mu\text{sec}$$

In conjunction with this calculation, the worst-case mechanical tolerance for the sector-hole location is typically ±5 minutes of arc; therefore,

$$T_{SL} = \frac{5 (1 + 3/100) \cdot 10^6}{180 \cdot 360}$$

$$= 79 \mu\text{sec (approximately)}$$

At this point the tolerance due to speed variation (T_X) is calculated, using Equation (8) repeated below:

$$T_X = \frac{60 \cdot X \cdot 10^4}{S \cdot N} \mu\text{sec}$$

$$= \frac{60 \cdot 3 \cdot 10^4}{360 \cdot 32}$$

$$= 156 \mu\text{sec (approximately)}$$

Substituting the preceding calculations in the inequality stated in Equation (9) we now have:

$$(T_{pr\,min} + T_{DF} + T_{EG} + T_{SL} + T_X) < T_S$$

$$(274 + T_{DF} + 472 + 79 + 156) < 5208$$

$$(981 + T_{DF}) < 5208$$

$$T_{DF} < (5208 - 981)$$

$$T_{DF} < 4227\,\mu sec$$

The following is a digest to highlight the principal areas of the hard-sectored format. Note that the bit data rate used is 0.25 megabits/sec.

- READ-PREAMBLE DELAY (READ GATE):

$$R_{G\,min} = 142\,\mu sec$$
$$= (142 \cdot 0.25) \text{ bits}$$

Approx. 36 bits
Approx. 5 bytes

- WRITE-PREAMBLE DELAY ($T_{pr\,min}$):

The minimum write-preamble length is:

$$T_{pr\,min} = 274\,\mu sec$$
$$= (274 \cdot 0.25) \text{ bits}$$

Approx. 69 bits
Approx. 9 bytes

- DATA FIELD

The maximum number of data bytes $= \frac{4227 \cdot 0.25}{8} =$ 132 bytes (approx.)

- POSTAMBLE DELAY (T_{EG}):

The minimum postamble length $= \frac{472 \cdot 0.25}{8} =$ 15 bytes (approx.)

It is recommended that, in actual practice, the maximum available space for the Data Bytes should not be used. The following practical values are recommended.

Read-Preamble Delay	=	6 bytes
Write-Preamble Delay	=	10 bytes
Postamble Delay	=	16 bytes
Data Bytes Per Sector	=	128 bytes

PERTEC

III. SUMMARY

These formulae can be used to calculate the various sector areas.

Disk Revolution Timing:

$$T_{REV} = \frac{60 \cdot 10^6}{S} \mu sec$$

Sector Timing:

$$T_S = \frac{T_{REV}}{N} \mu sec$$

Minimum Read Gate Timing:

$$R_{G\,min} = (2\,ESJ + \tau)\,\mu sec$$

Write Preamble Delay:

$$T_{pr\,min} = 2\,ESJ + R_{G\,min}$$

Linear Track Speed:

$$V_{min} = \frac{2\pi \cdot S \cdot R_{in}}{60\,(1 + X/100)} \text{ inches per second}$$

Postamble Delay:

$$T_{EG} = \frac{L_{EG}}{V_{min}} \mu sec$$

Sector-Hole Tolerance:

$$T_{SL} = \frac{SL\,(1 + X/100) \cdot 10^6}{180 \cdot S} \mu sec$$

Speed Variation Allowance:

$$T_X = \frac{60 \cdot 10^6 \cdot X}{S \cdot N \cdot 100} \mu sec$$

Data Field Timing:

$$T_{DF} = T_S - (T_{pr\,min} + T_{EG} + T_{SL} + T_X)$$

PERTEC

9600 IRONDALE AVENUE · CHATSWORTH, CALIFORNIA 91311 · PHONE (213) 882-0030 · TWX (910) 494-2093

75605 Revised 1-77