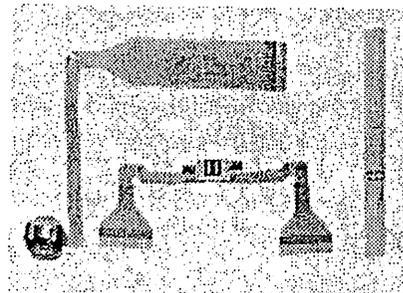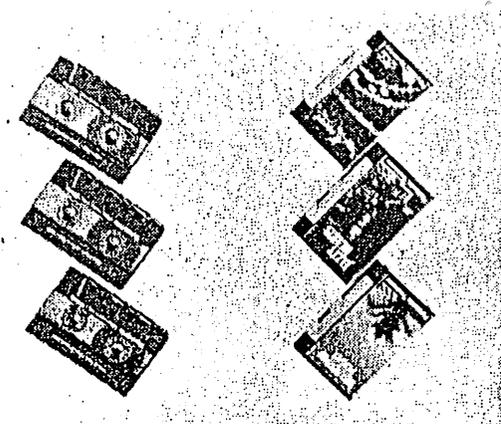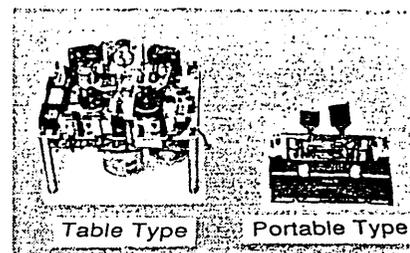# Digital Compact Cassette (DCC)

Matsushita and Philips Develop New Standard

Implementation of a Multi-channel Thin-film Head Using-High Performance Digital Coding and Precision Semiconductor Technology

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DCCs (left) and Analog Cassettes

Single (left) and Twin Thin-Film Heads

Table Type   Portable Type

DCC Deck Mechanisms

Matsushita Electric and N. V. Philips have developed a new Digital Compact Cassette (DCC) standard as a system to replace existing analog cassettes. The companies reached an agreement to jointly offer DCC technology to other companies. Licenses for the related patents will be collectively granted by Philips.

The specifications of DCC are different from those of DAT, a commercially-available digital audio tape system that feature a rotary head similar to those used in video cassette recorders. DCC features a stationary head, an idea suggested but still under development when DAT was being standardized. With the realization of a multi-channel thin-film head, DCC is expected to overtake DAT as the standard for digital recording on compact cassettes.

The development of DCC involved the implementation of a multi-channel thin-film head, development of a high-performance digital coding algorithm, and use of precision semiconductor technology. Features of DCC are listed below.

(1) In addition to digital recording and playback, DCC allows the same tape deck to perform analog playback using existing analog cassettes, thus providing backward compatibility.

(2) A new digital coding algorithm provides tone quality close to that of CD or DAT using only one fourth of the information.

(3) Existing analog cassette mechanisms with the exception of the magnetic head can be used, keeping new equipment costs down.

(4) Since existing analog cassette equipment can be modified to make duplicating equipment for DCC tapes, new equipment cost can be kept to a minimum.

A DCC tape has the same length and width (100.4 × 63.8mm) as existing analog cassette, however, the analog cassette is 8.7mm thick while the DCC tape is 9.6mm thick (see Fig. 1). The DCC is stronger, and because it has no convexities to support the tape running mechanism or holes for the reel hubs on
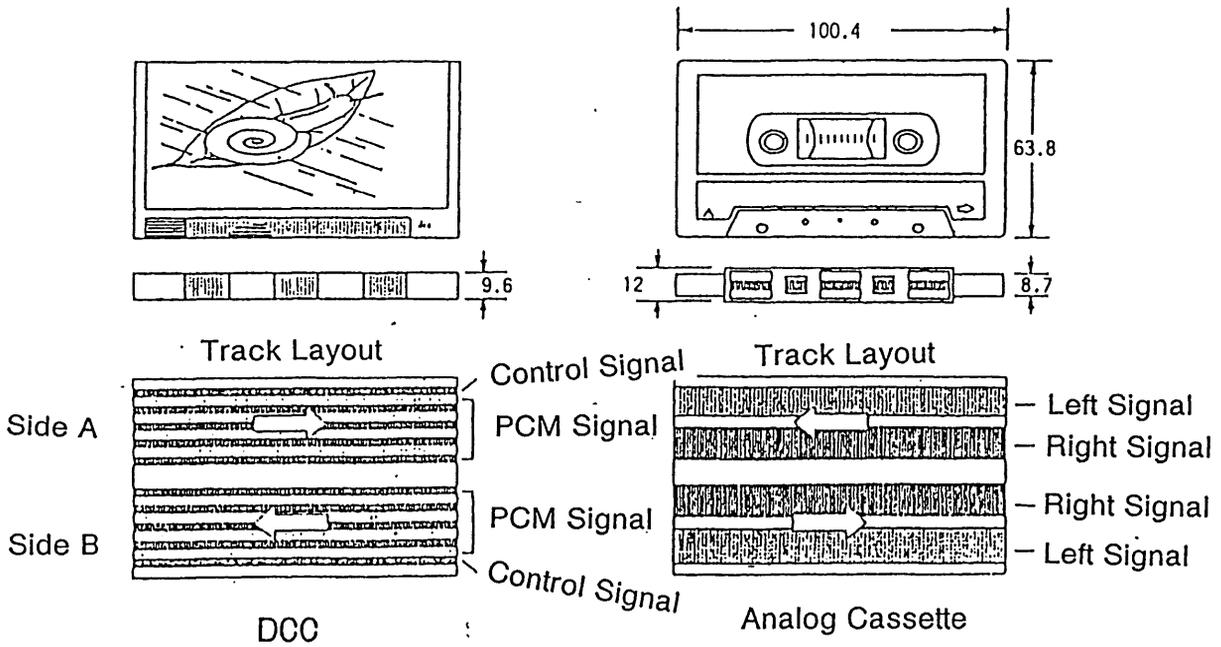
Comparison of DCC and Analog Cassette Size and Track Layout

the front face, a larger label can be used. A shutter similar to that used on 3.5-inch floppy disks is used to protect the exposed tape when the DCC is not in use. The shutter also covers the reel hub holes on the back side. When the cassette is loaded into a tape deck, the shutter opens automatically.

There are eight digital tracks and one control signal track for each tape direction.

An integrated thin-film magnetic head provides digital recording and playback as well as analog playback (see Fig. 2 and 3).

Figure 2:

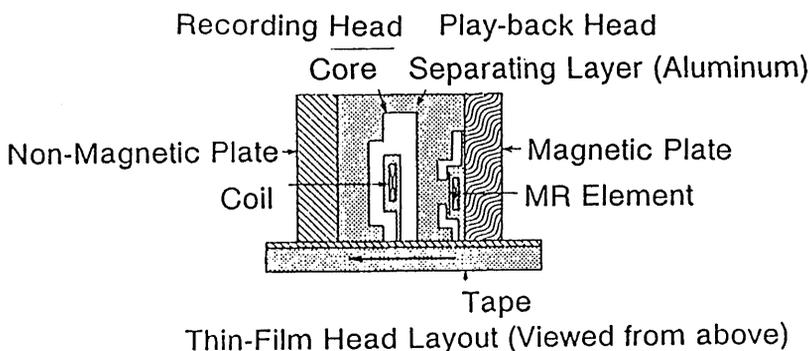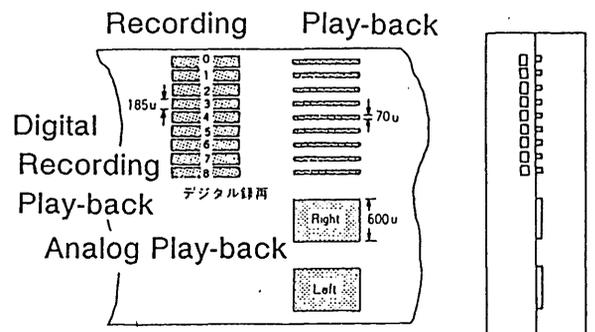Thin-Film Head Layout (Viewed from above)

Figure 3:

Track Layout (left) and Thin-Film Head Surface

Precision Adaptive Sub-band Coding (PASC) is used to compress audio information to one fourth its original size. By taking advantage of the characteristics of the human ear (See Fig. 4), signals below the audibility limit and signals masked by larger signals are cut to compress the original 1,536-K bits/s. signal to one fourth its original size (384K bits/s.). Address information is also recorded on the tape to allow the user to select music in a CD-like manner. Response to music selections will be slower than with CDs, however, because of tape travel time.

In addition to audio information, DCC will support text mode. Text mode will allow characters and pictures to be displayed on a CRT as either on line of 12 characters, two lines of 40 characters, or 21 lines of 40 characters. Text mode can be used to display tape titles, song titles, composers, players as well as other information.
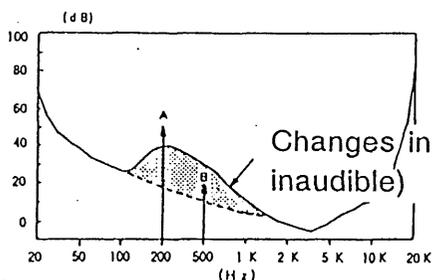
In addition to pre-recorded DCC tapes, blank DCC tapes will be available in two formats. The standard format will contain a start and reverse marker. The special format will contain the start and reverse markers as well as TOC information (various markers, text information, recording/reproduction channel number settings, etc.). Initially, gamma-iron-based 90-minute tapes will be available (120-minute tapes will be available in the future). The tape playback speed will be 4.76cm/s., the same as that for existing audio cassettes. Other deck specifications include a sampling frequency of 32, 44.1 or 48kHz; 16 bits per input sample, and 24 input channels.

Matsushita Electric recently demonstrated a DCC system using a trial DCC deck which delivered virtually CD-quality response. Music tapes will be the key to the popularity of the new medium. Matsushita and Philips say they have already obtained support from major recording companies. It is probable that DCC will be the standard for the next generation of audio tape systems.

Sound Level (dB)

Figure 4:
Precision Adaptive Sub-Band Coding (PASC) Method

Audibility Limit

Signal B is audible but signal C is not
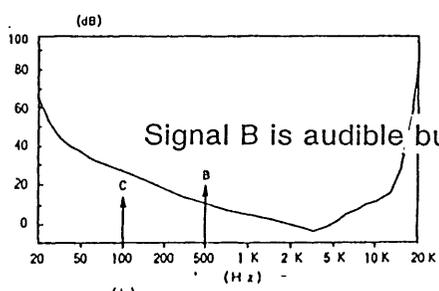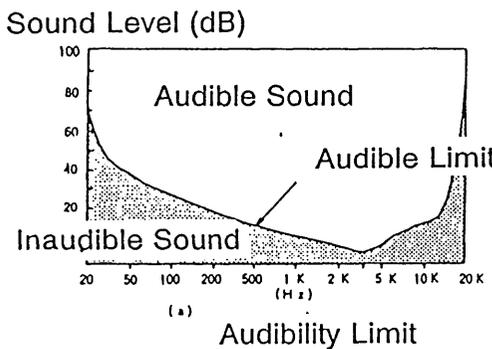
Signals below the Audibility Limit are Cut

Changes in the audibility limit caused by signal A (signal B becomes inaudible)

Masking Effect of Large Signals

DCC Block Diagram

Rec Head

Rec Amp

Sync/Mod

ECC Add

Encoder

Subband Analysis Filter

x32 Subband

Interface

ADC

Line In

Tape

Main 8ch
Aux 1ch

Head Amp

ECC/Modem

PASC

Audio Interface

PB Head

PB Amp

Sync/Demod

ECC Correction

Decoder

Subband Synthesis Filter

DAC

Line Out

ⓐ   ⓑ   ©   ⓓ   ⓔ

Capstan/Reel Motor

Ⓜ   Servo   System Controller

Key   Display

Digital Audio Interface

D I/O   Rx   Tx
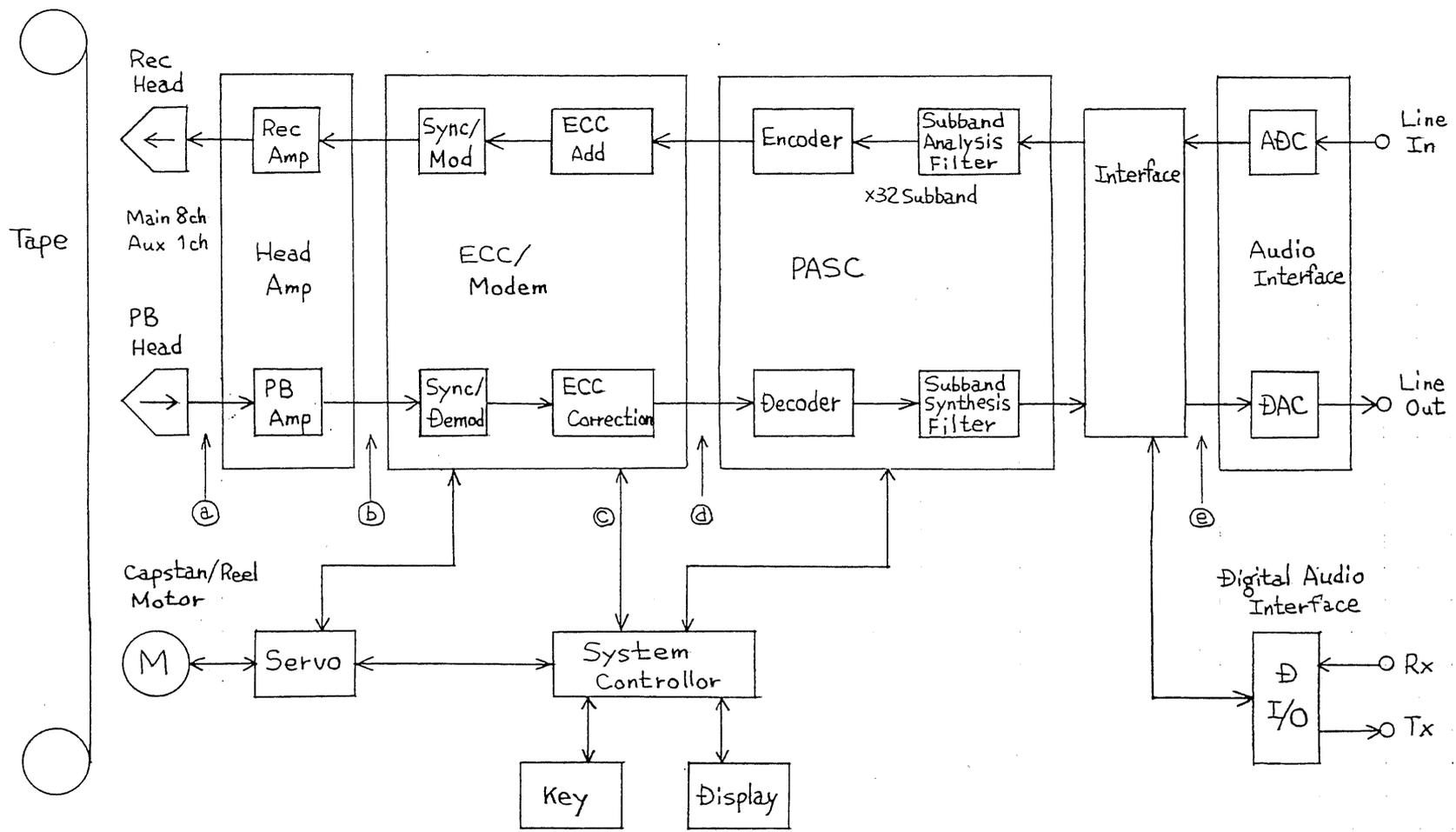
Transmission Rate

ⓐ Main 96 kbit/sec x8
    Aux   12 kbit/sec x 1

ⓑ Main 576 kbit/sec
    Aux   9 kbit/sec

© System Info 6 kbit/sec
    Aux   6.75 kbit/sec

ⓓ Main   384 kbit/sec

ⓔ $f_s = 48$ kHz   1.728 Mbit/sec
    $f_s = 44.1$ kHz 1.5876 Mbit/sec
    $f_s = 32$ kHz   1.152 Mbit/sec

The specification of the DCC system

Number of channels	2 (stereo or 2 channel mono)
Frequency characteristics	$f_S = 48$ kHz 5 ~ 22 kHz $f_S = 44.1$ kHz 5 ~ 20 kHz $f_S = 32$ kHz 5 ~ 14.5 kHz
Dynamic range	more than 105 dB
THD	more than 92 dB
Sampling frequecy	48 – 44.1 – 32 kHz
Audio coding	Precision Adaptive Subband Coding (PASC)
Bitrate of coded signal	384 kbit / sec
Error correction	product code of RS (24,20,5) and RS (32, 26, 7)
Modulation	8 – 10
Recording time	D90 45 min × 2
Types of tape	CrO_2
Tape width	3.78 mm
Tape Speed	4.76 cm / sec
Number of tracks	8 digital main data tracks 1 digital aux. data track
Track width	185 μm
Track pitch	195 μm
Minimum wavelength (λmin)	0.992 μm

Mechanism & Tape

Head

Head Rotates

Digital Recording Tracks

Digital PlayBack Tracks

Sector A

Sector B

Tape
Direction

Analogue PlayBack Tracks
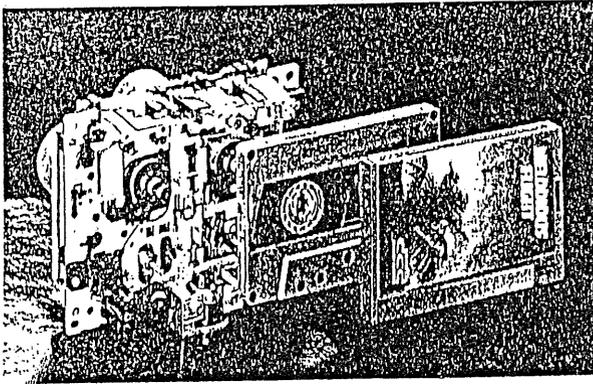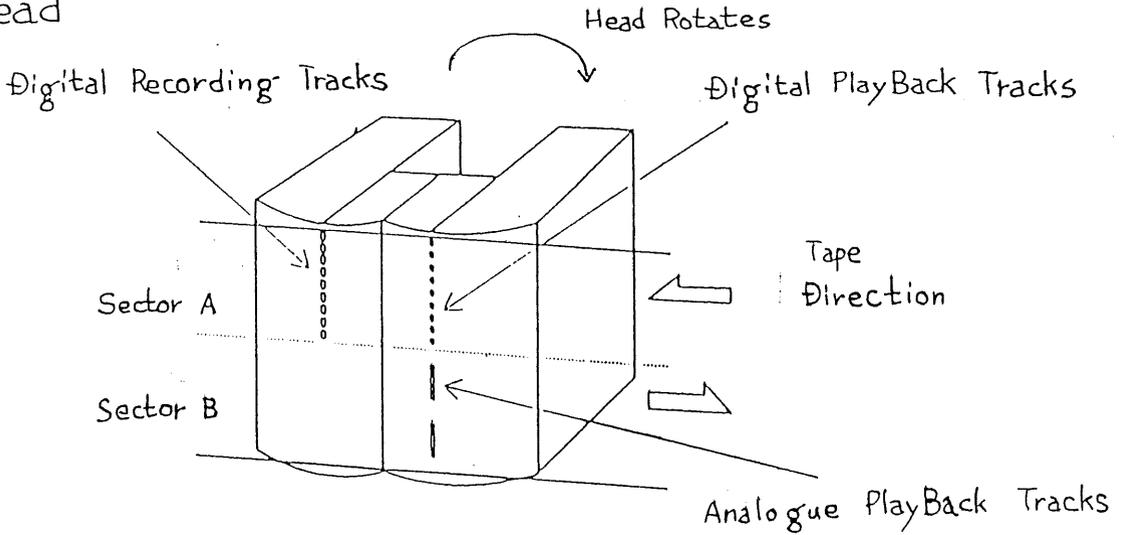
Track Configuration & Dimensions

Digital Recording   Digital PlayBack

$185 \mu m$

$70 \mu m$

$3.78 mm$

Right $600 \mu m$

Left

Analogue PlayBack

Main data format

track

	1 main data tape frame

0
1
2
3
4
5
6
7

0 1 2   32 tape blocks   29 30 31 |I| F G
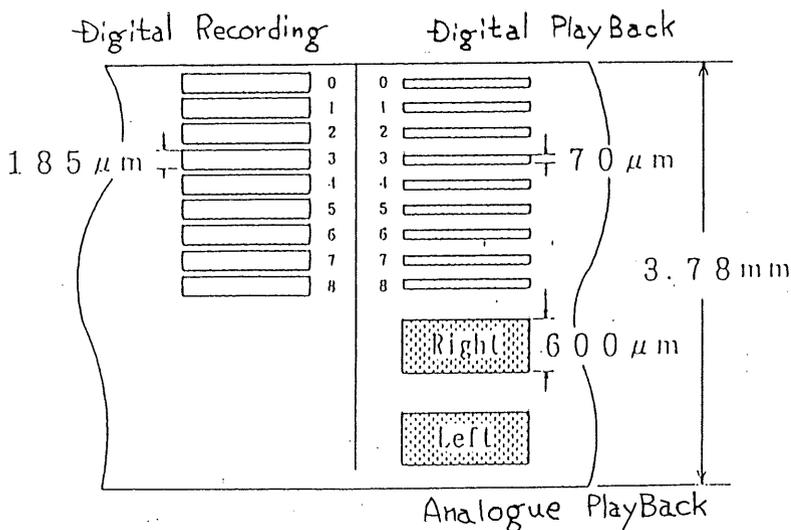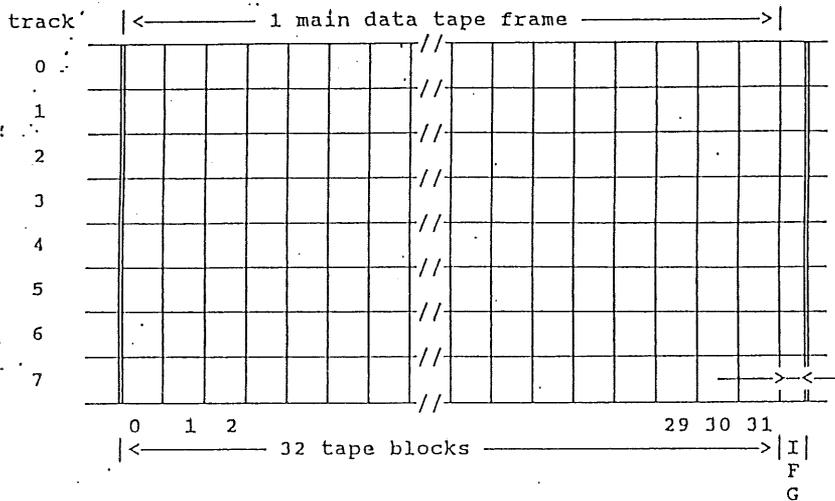
1 tape frame = 32 tape blocks × 8 tracks = 256 tapeblocks

1 tape block = 3 (Header) + 48 (Modulated Symbols) =51 byte
              = 408 unmodulate bits

FRAME COUNTER '0..7'

BLOCK ADDRESS COUNTER '0..31'

MSB		LSB	MSB				LSB
7	6	5	4	3	2	1	0

HEADER (UNMODULATED) $MH_1 - MH_2$

10 —BIT SYNC WORD

HEADER (MODULATED)

TAPE BLOCK BODY CONTAINING THE MODULATED SYMBOLS OF 48 BYTES

MH_0	MH_1	MH_2	MD_0	MD_1	MD_2	MD_3	MD_4	MD_{40}	MD_{41}	MD_{42}	MD_{43}	MD_{44}	MD_{45}	MD_{46}	MD_{47}

1 TAPE FRAME

DATA TAPE BLOCK NUMBER

TAPE FRAME (N-1)				TAPE FRAME (N)											TAPE FRAME (N+1)	
30	31			0	1	2	3	4	28	29	30	31		0	1

IFG

1 TAPE FRAME

AUX TRACK

DATA TRACKS

Tape

Aux data format

track — 4 tape blocks — 1 auxiliary data tape frame

AUX
MAIN
IFG

1 auxiliary data tape frame = 4 tape blocks

1 tapeblock = 3 (Header) + 48 (Modulated symbols) = 51 byte

10 → BIT SYNC WORD

AH_0, AH_2 ARE PLL SYMBOLS CORRESPONDING TO MODULATED S_3 OR S_2 DEPENDING ON LABELLING

TAPE BLOCK BODY CONTAINING THE MODULATED SYMBOLS OF 48 BYTES

| AH_0 | AH_1 | AH_2 | AD_0 | AD_1 | AD_2 | AD_3 | AD_4 | AD_{40} | AD_{41} | AD_{42} | AD_{43} | AD_{44} | AD_{45} | AD_{46} | AD_{47} | AH_0 | AH_1 |

HEADER (MODULATED)

1 TAPE BLOCK

TAPE FRAME (N)   TAPE FRAME (N+1)

Aux track | 3 | | H | 0 | H | 1 | H | 2 | H | 3 | | H | 0 | H | 1 |

even   odd   even   odd   IFG

1 TAPE FRAME

AUX TRACK
DATA TRACKS
Tape