ON COMPACT DISC TAPE MASTERS

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ABSTRACT

The Compact Disc (CD) represents a new revolution in sound technology. This technical paper will describe the CD tape mastering process and Subcode editing. Included will be specifications for developing the CD-master tape and Subcode information coding.

1. INTRODUCTION

The Compact Disc (CD), a digital audio disc system, developed by Philips and Sony, will soon be released by various companies.

The CD differs from the conventional analog record in many ways. Increased dynamic range and limitless repeatability of playing time give the CD unprecedented music quality and longevity. The Subcode signal encoded on the disc will provide number of music selections, indexes and timecode.

Subcode editing should be done at the tape mastering stage because the P and Q channels are related to the program source.

On the U-matic tape format for digital audio recording, the video track provides the digital audio signal. The two analog tracks contain the CD-Subcode and timecode information. The Subcode information is recorded in the beginning of the tape in a table of contents (TOC) format. This code is different from the P and Q channels of the CD format which must be generated by the CD-Subcode information data (CD-PQ-Cue Code) in conjunction with the SMPTE timecode when the disc is cut.

In CD-tape mastering, music editing and CD-Subcode information editing are often performed separately. Our philosophy of integrating the editing systems are as follows:

- Selectable system configuration between music and CD-Subcode information editing
- Ease of operation for the operator who may be unfamiliar with the detailed specifications of the CD-Subcode
- Precise input capability of the CD-Subcode point
- Short recording time for the CD-Subcode information
- The system for confirming input data in conjunction with the music
- The system for easily revising or appending the Subcode information
- The capability for extending the mode if a new mode is added for the CD specification in the future

The following text will describe the terms used in the production of the CD-master tape, the Subcode information for the editing system and the specifications for the CD-master tape and the CD-Subcode information format.

2. CD MASTERING

A CD master is made through several processes after the initial audio recording. Fig. 1 and Table 1 show the processes and terms used in the production of the CD-master tape and disc, respectively. In the CD-tape mastering stage, CD-PQ-Subcode and CD-R to W Subcode editing processes are added in comparison with the conventional analog production stages. The CD-R to W Subcode editing process is neglected at present since the CD-R to W Subcode has not yet been defined. In this instance the CD-tape master is recorded with the same data as the CD-master tape. The CD-master tape or CD-tape master can then be forwarded to the cutting center. Fig. 2 shows the CD-cutting system, including CD-PQ generator which generates CD-PQ-Subcode by using the CD-PQ-Cue Code and SMPTE timecode.

Regarding the rotary-head 2 channel system using U-matic tape, the digital audio signal is recorded on the video track. SMPTE timecode on the analog CH-2 track. The analog CH-1 track is available for the CD-PQ Subcode information.

3. CD-SUBCODE (CD-PQ-CUE CODE) EDITING

3.1 CD Subcode channel format

The CD signal format consists of frames for every 136 μsec of 7.35 kHz frame frequency as shown in Fig. 3. Subcode channel after the Frame Sync consists of 8 bits in a data base without EFM(eight to fourteen modulation) and constructs a block every 98 frames as shown in Fig. 4.

P and Q channels in P to W Subcode channels are already specified, but R to W channels are now defined as zero data. The information of the P and Q channels are as follows:

P channel

The P channel is a flag bit that indicates the position of music or pause piece.

Q channel

The Q channel data is for the number of channels, pre-emphasis (ON/OFF), and mode data. Q mode 1 data indicates the number of music selections, indexes, running time of the music and absolute time of the CD. Q mode 2 data represents the catalog number of disc, such as the Bar-code of UPC (universal product code), EAN (European article number), etc..

Q mode 3 data is used to give ISRC (International Standard Recording Code) for identifying a recording.

Q mode 2 and mode 3, however, can be deleted from the Subcode data.

3.2 CD-Subcode Editing System

The CD-master tape in which the CD-Subcode information is stored, is made with the sequence as shown in Fig. 1. In CD-Subcode editing, the table of contents of the program is input and stored on the tape, which corresponds with SMPTE timecode. The Cue Editor is used to process and store the data for generating the CD-P and Q channel signals when the disc is cut.

3.2.1 Cue Editor

The Cue Editor, developed by Sony as shown in Fig. 5, employs the rotary-head 2 channel digital audio recording system using the U-matic tape format. It employs the CD-PQ-Cue Code data (see Appendix 1) corresponding with the SMPTE timecode.

Main features of the Cue Editor are as follows:

(1) Capability of three input methods:
   a) Direct mode for indexing the beginning and end of the music program while simultaneously auditioning the program source
   b) Editor Transfer mode for inputting the data by the Digital Audio Editor (DAE-1100)
   c) Edit mode for inputting or revising the timecode data at the beginning, index and end of the music by the ten key.

(2) Automatic generation of music track number (TNO) and index (X): The music track number and index (X) of the CD specification are automatically generated in accordance with the timecode and the input switch.

(3) Automatic generation of P channel Cue data from input Q channel Cue data: Since the P channel Cue data (music or pause) is related with the Q channel Cue data, P channel Cue data can also be generated.

(4) Editing function for input data: The input data can be revised or deleted in the Edit mode.

(5) Review function: By indicating input points and playing, the context of data in the timecode can be checked.

(6) Storing or loading function of data: Data stored in memory can be loaded onto the analog track and vice versa.

3.2.2 System configuration

System configuration depends on the method of inputting the CD-PQ-Cue data by the Cue Editor.

Fig. 6 shows the system adopted for Direct or Edit input mode. The Direct mode enables the determination of positions for the beginning, end or index of music. This is done by pressing the switch when listening to the reproduced sound from the PCM-1610. SMPTE timecode should be already recorded in this system.

Fig. 7 shows the system adopted for input Direct, Editor Transfer or Edit mode. The Editor Transfer mode enables you to obtain the precise position of the beginning, end or index of the music. Searching is accomplished with the use of the Digital Audio Editor DAE-1100. CD-PQ-Cue Code data can also be gathered while editing the music.

4. SPECIFICATION OF THE U-MATIC TYPE CD-MASTER TAPE

(1) Sampling frequency : 44.10 KHz

(2) Source coding : linear, two's complement, 16 bit

(3) Emphasis (optional) : 15 + 50 µs

(4) Number of channels : 2

(5) Minimum tape playing time: musical duration + minimum 1 minute

(6) Maximum musical duration : 60 minutes

(7) Tape format : U-matic professional, NTSC-standard

(8) Cassette type : professional U-matic standard tape (e.g. Sony KCA-60BR)

(9) Tape modulation

(9.1) Digital audio section

(9.1.1) Tape lead-in/lead-out period:
minimum 30 seconds each (these parts must contain timecode as specified in point (10).)

(9.1.2) Maximum musical duration:
see CD-specification but restricted to 60 minutes.

(9.1.3) PCM-audio signal during lead-in/lead-out period:
the encoded data words are "zero"*1)

(9.1.4) Program modulation:
complete catalog stereo program assembled as final product

(10) Timecode information

(10.1) Track position : analog track 2

(10.2) Modulation : see SMPTE-timecode specification. (NTSC, ANSI V98.12M-1981)

(10.3) Timecode standard : real time (non-drop frame)

(10.4) Sequence : continuous up-counting timecode data covering lead-in, program/ pause, and lead-out periods

(10.5) Timecode synchronization: timecode must be synchronized to sampling frequency.

(10.6) Recording level : 100 ± 50 nWb/m*2)

(11) CD-Subcode information

(11.1) CD-PQ-Subcode information

(11.1.1) CD-Subcode-Cue information:
format according to CD-PQ-Cue Code

(11.1.1.1) Track position : analog track 1

(11.1.1.2) Signal format : according to CD-PQ-Cue Code Format/ Appendix 1

(11.1.1.3) Recording level: 100 ± 50 nWb/m*2)

(11.1.2) Note 1: SMPTE timecode in CD-Subcode information should refer to timecode on final U-matic type CD-master tape especially in case of prior sampling rate conversion.

(11.2) CD-R to W-Subcode information (R, S, T, U, V, W):
format to be defined

(12) Recommended equipment

The following equipment or equivalent are recommended as of September 1982.

(12.1) Recorder : SONY PCM-1610 and BVU-800DA (or VO-5850DA, BVU-200B)

(12.2) Cue Editor: SONY DAQ-1000

*Note: 1) zero = 000000000000XXXX(LSB) or two's complement
X means 0 or 1.
Offset or noise is allowed within defined zero level.

2) When the recording equipment meets SMPTE recommended practice RP 87 - 1980, the level of 100 nWb/m conforms to 0 dB VU.

5. CONCLUSION

The Compact Disc system has many advantages compared to the conventional analog record system. The CD software is important in popularizing the system. Several digital audio recording systems are now available, but the total system, from recording to CD-disc mastering is essential because the Subcode signal should also be recorded on the CD.

We have proposed the specifications for the U-matic type CD-master tape format.

The specifications are accepted by Philips for promoting the CD system.

Subcode editing by the Cue Editor takes about an hour for inputting and checking the data in correspondence with the music.

CD-PQ-Cue Code is recorded at the beginning of the tape for several seconds, the duration depending upon the quantity of input data.

CD-R to W channel Subcode is now under consideration on the purpose and the recording format. When the R to W channel Subcode is defined, the information should be recorded in the CD tape master. The U-matic type CD tape master has the capability of recording the R to W channel information on the other track which is newly built in the guard band between the analog CH-1 and CH-2 track having compatibility with the conventional U-matic tape format.

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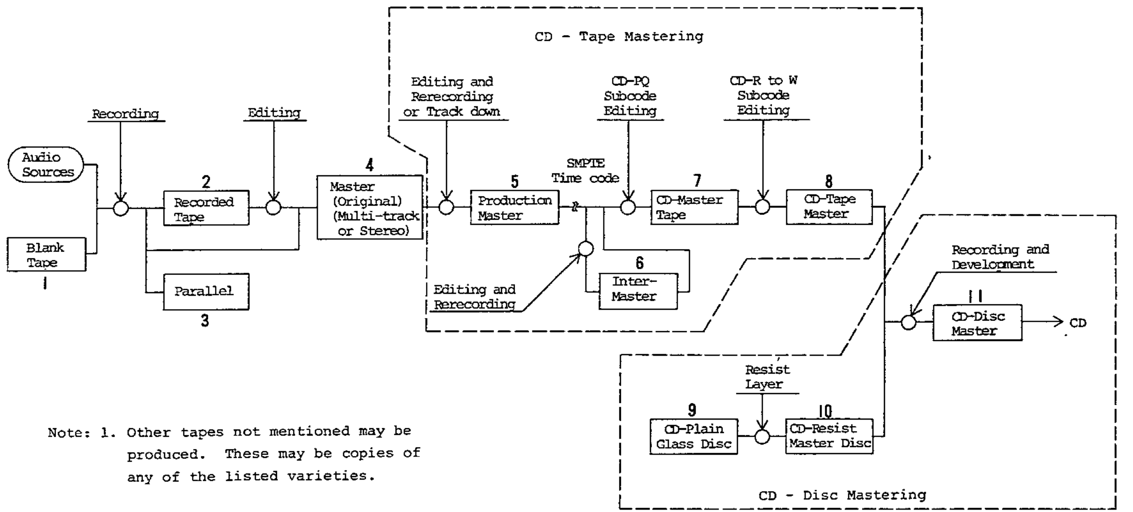


Note: 1. Other tapes not mentioned may be produced. These may be copies of any of the listed varieties.

2. The above numbering 1 to 11: refer to Table 1.

Fig. 1 CD-Mastering process

Table 1. Terminology of CD-Mastering process

Number	Term	Definition
1	Blank Tape	No recorded magnetic tape
2	Recorded Tape	A tape carrying non-edited recordings
3	Parallel	A tape which is recorded simultaneously with a Recorded Tape
4	Master(Original)	An edited copy from a recorded tape
5	Production Master	A copy from a Master(Original) by editing and re-recording
6	Intermaster	An edited and re-recorded copy from Production Master
7	CD-Master,Tape	A master tape including SMPTE timecode, edited CD-PQ-Cue code for CD use
8	CD-Tape Master	A master tape, completed with P to W Subcode information
9	CD-Plain Glass Disc	A glass disc without a photosensitive layer
10	CD-Resist Master Disc	A glass disc coated with a photosensitive layer
11	CD-Disc Master	A recorded, developed, silver-coated, and inspected CD-Resist Master Disc

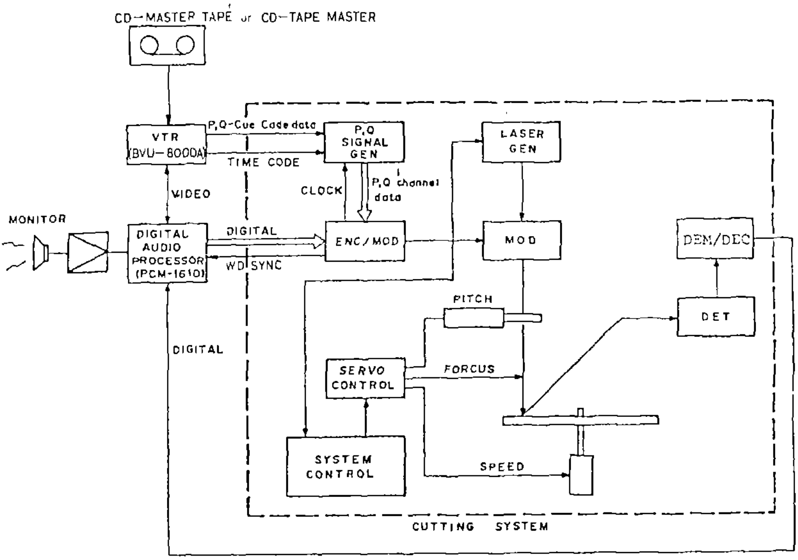
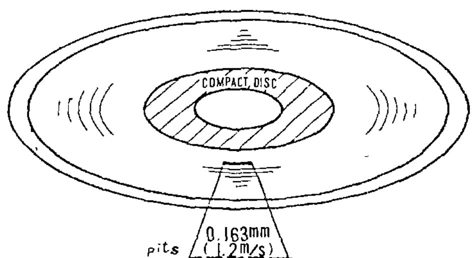


Fig. 2 CUTTING SYSTEM BLOCK DIAGRAM

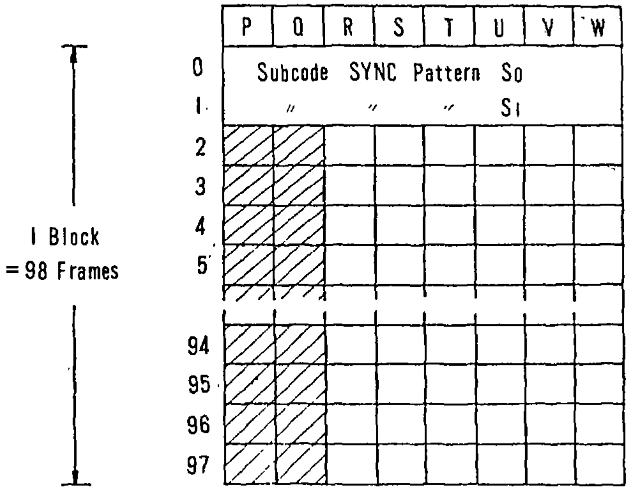


1 Frame ($\frac{1}{7.35}$ m sec)

	SYNC	P.Q.RW Sub-code	DA Data-1	Parity -1	DA Data-2	Parity -2
Data bit	—	8 bit	(12×8) 96	(4×8) 32	96	32
Channel bit	24	14	168	56	168	56

Note:After Modulation each 8bit symbol is converted into 14channel bits plus extra 3bits for merging and low frequency suppression.

Fig.3 CD Frame format



Frame frequency = 7.35KHZ
Block frequency = 75HZ

Fiq.4 Subcode channel format

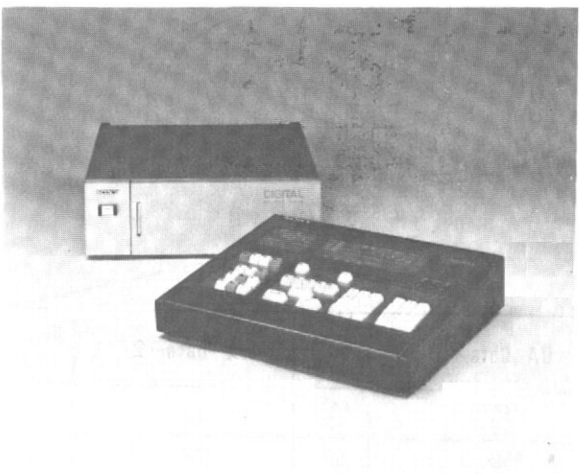


Fig.5 Cue Editor (prototype)

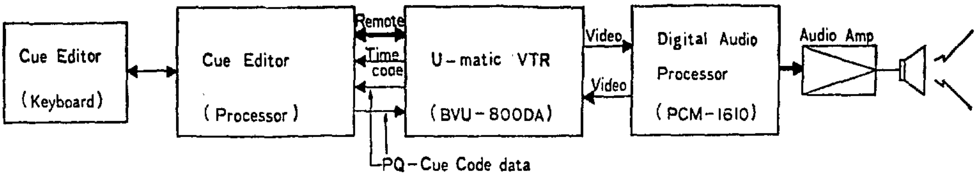


Fig.6 System configuration for Direct or Edit mode.

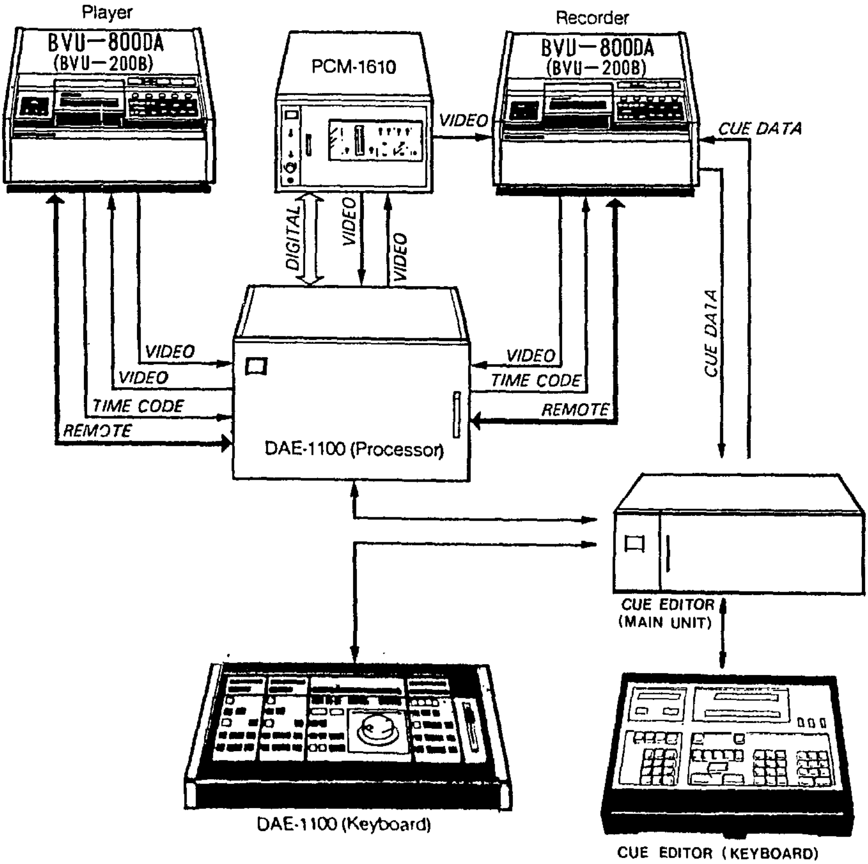


Fig.7 System configuration for Direct, Editor Transfer or Edit mode.

Appendix 1

CD-PQ-Cue Code Format : Format for recording information on a digital audio master tape which will generate the P and Q channel data on a Compact Disc.

1. General

The CD-PQ-Cue Code Format on a digital audio master tape is used to record information such as the numbers of the music selections, the indexes, timecode data, and so forth, which will generate P and Q channel data on a Compact Disc. Since the CD-PQ-Cue Code Format differs from the P and Q channel format of a Compact Disc, P and Q channel data must be generated by CD-PQ-Cue Code data in conjunction with the SMPTE timecode when the disc is cut.

In a digital audio system employing a VTR, CD-PQ-Cue Code data is recorded on one analog channel of a video tape independent both of the other digital audio channel and of the timecode channel.

The CD-PQ-Cue Code Format has the following capabilities.

-It can correct a burst error caused by a dropout.

-It can add Control or User area.

-It can add additional CD-PQ-Cue Code data in the future.

The CD-PQ-Cue Code Format data is of byte (8 bit) units so that it can be generated by micro-computer.

2. Modulation Technique

Modulation when recording CD-PQ-Cue Code data on an analog track of a video tape must be self-clocking, free of DC component and free of coding polarity. The data in the CD-PQ-Cue Code Format is FM encoded.

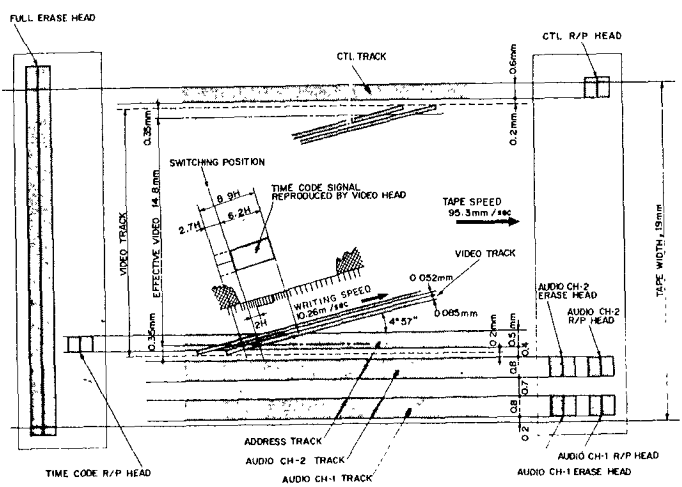
The recording density on the analog track of a video tape is 1279 BPI (bits per inch), and the data transfer rate is 4800 BPS (bits per second).

The basic parameters are shown in Table 1, and the U-matic tape format in Fig. 1.

Table 1 Basic parameters of CD-PQ-Cue Code Format

Recording tape	U-matic tape
Recording track	Analog track 1
Tape speed	95.3 mm/sec
Track width	0.8 mm
Data transfer rate	4800 BPS
Modulation	FM
Recording density	1279 BPI
Flux density	2559 FCI
Recording wavelength	19.9 μm
Recording capacity	1440K bytes

Fig. 1 U-matic professional NTSC standard tape format



3. Recording format

The recording data stream on the analog track contains a Preamble, Sectors and a Postamble. CD-PQ-Cue Code data is recorded in the Sectors.

The Midamble between the Preamble and the Postamble can be utilized to record a quantity of CD-PQ-Cue Code data which cannot be handled by the capacity of the CD-PQ-Cue Code data processing equipment in one time.

Fig. 2 shows the recording format. In this format the number of Gap bytes has a built-in tolerance to allow for deviation in tape speed when rerecording part of the original data. The initial recording shall be made with the nominal Gap width. The data described here is in hexadecimal notation and the recording data stream shall be output MSB (most significant bit) first.

The purpose of the Gap, SYNC and Mark in the format are as follows.

Gap : Data in a Sector is deleted or rerecorded between two succesive Gaps. Gap data is "FF" (HEX). The number of bytes including the tolerance is applied when rerecording to allow for deviation in the tape speed.

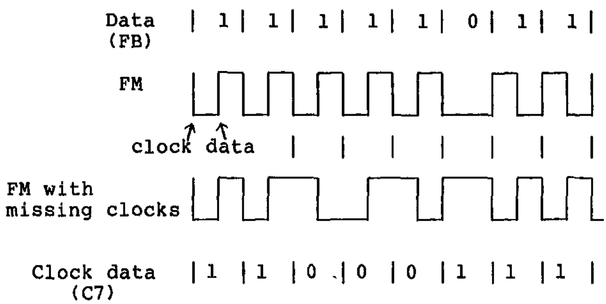
SYNC : SYNC gives the PLL (phase locked loop) the clock phase to lock the transfer data. SYNC data is 4 byte "00" (HEX).

Mark (IM-1, IM-2, IM-3, AM-1 and AM-2) : These Marks are for synchronizing in order to separate successive data, and to identify the data of the Preamble, Midamble, Postamble, ID Field, and Data Field. Mark data has missing clocks*1).

*1) Missing clock

In the FM encoding rule, each bit cell begins with a clock pulse and the center of the bit cell defines the data. If the data = 0, no pulse is written ; if the data = 1, a pulse is written in the center of the cell. A missing clock is not covered by the FM encoding rule and is encoded without a clock pulse in the "1" data stream of more than two bits. Fig. 3 shows an example of missing clock data.

Fig. 3 An example of missing clocks



3-1) Preamble

The Preamble is a block of data which denotes the beginning of the CD-PQ-Cue Code data. Table 2 shows the components of the Preamble.

Table 2 Components of the Preamble

Component	Number of bytes	Data	Clock	Remarks
Gap-0	5	FF	FF	
SYNC	4	00	FF	
IM-1	1	FC	D7	Missing clocks
Gap-1	22±2	FF	FF	Recording tolerance ± 2 bytes

3-2) Midamble

The Midamble is a block of data inserted in the data stream when more than 128 Sectors are required and indicates the continuance of the data stream. The function of the Midamble is to limit the required memory capacity in the CD-PQ-Cue Code processing equipment. A Midamble or string of Midambles shall always be preceded by a Preamble and concluded by a Postamble in the data stream. A Midamble follows every 128 Sectors, and is succeeded by at least one Sector.

The Sector address after the Midamble can start either at zero or can follow the number of the section preceding the Midamble.

The Midamble can be initially recorded using 29 bytes of Gap-4 which is the maximum width of Gap-4 to enable rerecording one of a group of successive Sectors.

Table 3 shows the components of the Midamble.

Table 3 Components of the Midamble

Component	Number of bytes	Data	Clock	Remarks
SYNC	4	00	FF	
IM-2	1	FD	D7	Missing clocks
Gap-4	27±2	FF	FF	Recording tolerance ± 2 bytes

3-3) Postamble

The Postamble is a block of data which denotes the end of the CD-PQ-Cue Code data.

Table 4 shows the components of the Postamble.

Table 4 Components of the Postamble

Component	Number of bytes	Data	Clock	Remarks
SYNC	4	00	FF	
IM-3	1	FA	D7	Missing clocks
Gap-5	27	FF	FF	

3-4) Sector format

Each Sector has an ID Field and a Data Field. Gap-2 and Gap-3 are located before and after the Data Field, and only the Data Field in a Sector can be deleted or rerecorded. Gap-2 is given a tolerance of ± 2 bytes to rerecord the Data Field, and Gap-3 a tolerance of ± 3 bytes to rerecord the whole Sector (ID Field + Data Field).

3-4-1) ID Field

The ID Field is a block of data consisting of 7 bytes which denotes the Sector address. The Sector address begins with "0000" (HEX) and ends with the sequence number of the Sector in the string of Sectors following a Preamble or a Midamble, increasing one every Sector.

Table 5 shows the components of the ID Field.

Table 5 Components of the ID Field

Component	Number of bytes	Data	Clock	Remarks
SYNC	4	00	FF	
AM-1	1	FE	C7	Missing clocks
Sector address	2	0000 | FFFF	FF	

3-4-2) Data Field

The Data Field is a block of data in which CD-PQ-Cue Code data for generating CD-P and Q Subcode channels contents is recorded.

Table 6 shows the components of the Data Field.

Table 6 Components of the Data Field

Component	Number of bytes	Data	Clock	Remarks
SYNC	4	00	FF	
AM-2	1	FB or F8	C7	Missing clocks
Data Length	1	00 | 80	FF	P=05 , Q mode 1 or mode 2 = 08 Q mode 3 = 0E
Data	128	—	FF	
CRC	2	—	FF	Polynomial $G(X)=X^{16}+X^{12}+X^5+1$
Parity	4	—	FF	Fire Code Polynomial $G(X)=(X^{21}+1)(X^{11}+X^2+1)$

AM-2 Mark

AM-2 is a mark which denotes valid data or deleted data in a Data Field. Valid data is encoded as "FB" (HEX) and deleted data as "F8" (HEX). AM-2 data has missing clocks. Clock data is modulated as "C7" (HEX).

Data Length

Data Length determines the number of data bytes per word in the Data Field of the Sector. P channel CD-PQ-Cue Code data consists of 5 bytes, Q channel CD-PQ-Cue Code data both mode 1 and mode 2 of 8 bytes and Q channel mode 3 CD-PQ-Cue Code data of 14 bytes as is noted in the following "Data" section.

If the number of data bytes recorded in the Data area is not fully assigned to the number of bytes denoted in Data Length, vacant bytes shall be zero.

Whenever the Data area is used to record Control or User data other than P or Q channel CD-PQ-Cue Code data, the Data Length shall be encoded as "00" (HEX).

Table 7 shows Data Length of each data.

Table 7 Data Length

Channel	Data Length	Remarks
P channel CD-PQ-Cue Code data	05	
Q channel mode 1 CD-PQ-Cue Code data	08	
Q channel mode 2 CD-PQ-Cue Code data	08	One data for a disc
Q channel mode 3 CD-PQ-Cue Code data	0E	One data for a TNO
Control or User data	00	

Data

The Data area consists of 128 bytes containing P or Q channel CD-PQ-Cue Code data, or Control or User data. Data area without assigned data shall be zero. Channel Flag of P or Q channel CD-PQ-Cue Code data, or Control or User data shall be located at the first byte of a word or Data Field for any data structure.

The most significant bit (MSB) of the first byte of the word shall be first out.

The Control channel can be used to record VTR control data for generating P and Q channel data on a Compact Disc using multiple master tapes.

The User channel can be used to record the number of the Compact Disc, and so on.

The Control or User channel is for further use.

Table 8 shows the Channel and Mode Flag data located at the first byte of the word.

Table 8 Channel and Mode Flag data

Channel and Mode	Flag data
Control data	01
User data	02
P channel CD-PQ-Cue Code data	1X *2)
Q channel mode 1 CD-PQ-Cue Code data	21
Q channel mode 2 CD-PQ-Cue Code data	22
Q channel mode 3 CD-PQ-Cue Code data	23

*2) See Table 9, P channel Contents flag

(a) Control data

The Control data Sector can be deleted if the Compact Disc is provided from a single master tape. If the Compact Disc is recorded using more than one, the Control data can be employed, but this format has not yet been defined.

(b) User data

The User data flag "02" (HEX) is located only at the first byte of the Data area. Data Length shall be encoded as "00". When the User data consists of multiple Sectors, the first byte of the Data area of each Sector is located by "02" (HEX). The numbering of the Sectors in which User data is located shall be continuous. The User data Sector shall be deleted if data is not assigned.

(c) P channel CD-PQ-Cue Code data

P channel CD-PQ-Cue Code data consists of 5 bytes per word. The upper 4 bits of Flag data located at the first byte of the word are used for Channel Flag and the lower 4 bits are used for the flag of a music, start flag or lead-out signal. The bytes between the 2nd and 5th are provided with timecode data of the music or start flag beginning point in BCD notation. The drop frame / non-drop frame flag of the SMPTE timecode shall be deleted.

P channel CD-PQ-Cue Code data shall be located in sequence of time on the tape.

Table 9 shows the data of the Contents Flag.

Fig. 4 shows the structure of the P channel CD-PQ-Cue Code data.

Table 9 Data of the Contents Flag

Flag data	Contents
d3 0000 d0	Music beginning point
0001	Start flag beginning point
0010	Lead-out beginning point

Fig. 4 Structure of the P channel CD-PQ-Cue Code data

bit / byte	(MSB) d7	d6	d5	d4	d3	d2	d1	(LSB) d0
1st	Channel Flag 0	0	0	1	Contents Flag			
2nd	ten's Hour				unit's Hour			
3rd	ten's Minute				unit's Minute			
4th	ten's Second				unit's Second			
5th	ten's Frame				unit's Frame			

(d) Q channel mode 1 CD-PQ-Cue Code data

Q channel mode 1 CD-PQ-Cue Code data consists of 8 bytes per word. The upper 4 bits of the first byte of the word are provided with a Channel Flag and the lower 4 bits are provided with a Mode Flag.

The upper 4 bits of the 2nd byte contain the Control data in the Q channel of a Compact Disc, the 3rd byte contains the TNO data, and the 4th byte contains the X data. The 5th - 8th bytes are for the timecode data of the beginning point of TNO or X data without a drop frame / non-drop frame flag.

Q channel mode 1 CD-PQ-Cue Code data shall be located in sequence of time on the tape.

The Control data of a Compact Disc is shown in Table 10, and the structure of the Q channel mode 1 CD-PQ-Cue Code data in Fig. 5.

Table 10 Control data of the Compact Disc

Control data	mode
$^{d7}0000^{d4}$	2 channels without pre-emphasis
1000	4 channels without pre-emphasis
0001	2 channels with pre-emphasis
1001	4 channels with pre-emphasis

Fig. 5 Structure of the Q channel mode 1 CD-PQ-Cue Code data

byte \ bit	(MSB) d7	d6	d5	d4	d3	d2	d1	(LSB) d0
1st	Channel Flag 0	0	1	0	Mode Flag 0	0	0	1
2nd	Control data (See Table 9)				Not assigned 0	0	0	0
3rd	ten's digit			TNO *)	unit's Hour			
4th	ten's digit			X *)	unit's digit			
5th	ten's Hour				unit's Hour			
6th	ten's Minute				unit's Minute			
7th	ten's Second				unit's Second			
8th	ten's Frame				unit's Frame			

*) Lead-out point is TNO=AA(HEX) and X=01(HEX).

(e) Q channel mode 2 CD-PQ-Cue Code data

The Q channel mode 2 CD-PQ-Cue Code data consists of 8 bytes per word. Control data in the Q channel of a Compact Disc is assigned to the upper 4 bits in the 2nd byte, and 13 digits (BCD) are assigned to the lower 4 bits of the 2nd to 8th byte. The most significant digit shall be first out.

Fig. 6 shows the structure of the Q channel mode 2 CD-PQ-Cue Code data.

Fig. 6 Structure of Q channel mode 2 CD-PQ-Cue Code data

byte \ bit	d7	d6	d5	d4	d3	d2	d1	d0
1st	Channel Flag 0	0	1	0	Mode Flag 0	0	1	0
2nd	Not assigned 0	0	0	0	N1			
3rd	N2				N3			
4th	N4				N5			
5th	N6				N7			
6th	N8				N9			
7th	N10				N11			
8th	N12				N13			

(f) Q channel mode 3 CD-PQ-Cue Code data

Q channel mode 3 CD-PQ-Cue Code data consists of 14 bytes per word. The upper 4 bits of the first byte of the word are provided with a Channel Flag and the lower 4 bits are provided with a Mode Flag.

The second byte contains the TNO data for the successive 12 characters of ISRC (International Standard Recording Code).

The 3rd - 14th bytes are for ISRC represented by 7 bit ASCII code without a parity code as shown in Table 11. The most significant bit (d7) of each character shall be zero.

I_1 - I_2 give the Country-code, I_3 - I_5 the Owner-code, I_6 - I_7 the year of the recording and I_8 - I_{12} the serial number of the recording.

Fig. 7 shows the structure of the Q channel mode 3 CD-PQ-Cue Code data.

Table 11 shows the ASCII code for ISRC.

Table 11 ASCII code for ISRC

Alpha-numeric	Code		Alpha-numeric	Code	
	Binary	Hex		Binary	Hex
0	0110000	30	I	1001001	49
1	0110001	31	J	1001010	4A
2	0110010	32	K	1001011	4B
3	0110011	33	L	1001100	4C
4	0110100	34	M	1001101	4D
5	0110101	35	N	1001110	4E
6	0110110	36	O	1001111	4F
7	0110111	37	P	1010000	50
8	0111000	38	Q	1010001	51
9	0111001	39	R	1010010	52
A	1000001	41	S	1010011	53
B	1000010	42	T	1010100	54
C	1000011	43	U	1010101	55
D	1000100	44	V	1010110	56
E	1000101	45	W	1010111	57
F	1000110	46	X	1011000	58
G	1000111	47	Y	1011001	59
H	1001000	48	Z	1011010	5A

Fig. 7 Structure of Q channel mode 3 CD-PQ-Cue Code data

bit / byte	(MSB) d7	d6	d5	d4	d3	d2	d1	(LSB) d0
1st	Channel Flag 0	0	1	0	Mode Flag 0	0	1	1
2nd	ten's digit			TNO	unit's digit			
3rd	0	I_1 (ASCII)						
4th	0	I_2 (ASCII)						
5th	0	I_3 (ASCII)						
6th	0	I_4 (ASCII)						
7th	0	I_5 (ASCII)						
8th	0	I_6 (ASCII)						
9th	0	I_7 (ASCII)						
10th	0	I_8 (ASCII)						
11th	0	I_9 (ASCII)						
12th	0	I_{10} (ASCII)						
13th	0	I_{11} (ASCII)						
14th	0	I_{12} (ASCII)						

CRC

CRC is 16 bit parity which is generated for information bits of AM-2, Data Length and Data. The following is the polynomial used.

$$G(X) = X^{16}+X^{12}+X^{5}+1$$

CRC bits shall be inverted on the master tape.

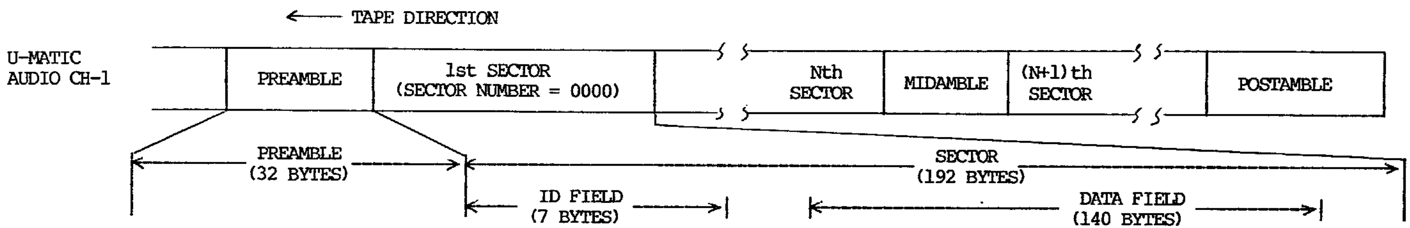
Parity

The 4 byte (32 bit) Parity is encoded to correct data errors. A Fire Code is applied to generate Parity for 1056 information bit stream of AM-2, Data Length, Data and CRC. The following is the polynomial used.

$$G(X) = (X^{21}+1)\ (X^{11}+X^{2}+1)$$

A burst error of up to 11 bits can be corrected by this Fire Code.

Parity bits shall be inverted on the master tape.



	GAP-0	SYNC	IM-1	GAP-1	SYNC	AM-1	SECTOR NUMBER	GAP-2	SYNC	AM-2	DATA LENGTH	DATA	CRC	P	GAP-3
			INDEX MARK			ID ADDRESS MARK				DATA OR DELETED DATA MARK				FIRE CODE	
NUMBER OF BYTES	5	4	1	22±2	4	1	2	22±2	4	1	1	128	2	4	23±3
DATA	FF	00	FC	FF	00	FE	0000 – FFFF	FF	00	FB OR F8	00 – 80	—	—	—	FF
CLOCK	FF	FF	D7	FF	FF	C7	FF	FF	FF	C7	FF	FF	FF	FF	FF

MIDAMBLE (32 BYTES)

	SYNC	IM-2	GAP-4
		INDEX MARK	
NUMBER OF BYTES	4	1	27±2
DATA	00	FD	FF
CLOCK	FF	D7	FF

POSTAMBLE (32 BYTES)

	SYNC	IM-3	GAP-5
		INDEX MARK	
NUMBER OF BYTES	4	1	27
DATA	00	FA	FF
CLOCK	FF	D7	FF

* PQ-Cue Code Format starts at Preamble and ends at Postamble.

Midamble does not exist in normal use for P and Q channel PQ-Cue Code data. (Refer to 3-2)

Fig. 2 Recording layout of PQ-Cue Code Format