Toshiba Corporation: Putting CD Graphics into Practical Use

The extra capacity of about 30 mega bytes on compact disks suggests other fields of applications which do not limit the compact disk only to the reproduction of music. The first such use is CD graphics. Toshiba Corporation has set about merchandizing CD graphics in order to add image and character inforamtion to music.

It has been more than three years since compact disk (CD) and CD players were put on the market. They have become increasingly popular as more titles have been released and players have come down in price.

The CD is small, light and high in sound quality. In addition, complicated random access is possible and it is easier to use than the existing analog disk (12-inch LP, EP). This easy use is realized by 8-bit subcode signals for the system control, recorded on a different channel than that of the music data. These 8-bit signals are positioned on channels P, Q, R, S, T, U, V and W. The P and Q channels were already standardized and have been used for random access of CD players, play time display and track number display.

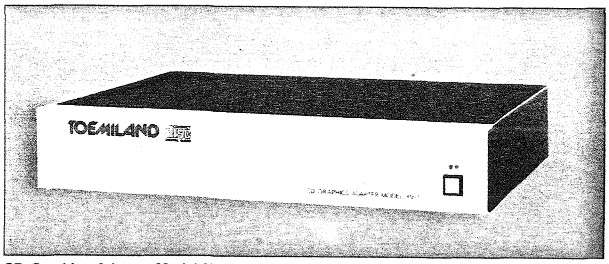
For the remaining R to W channels, standardization has been pushed by N.V. Philips and Sony Corporation. In February 1985, format and standards that apply to graphics were determined. Accordingly, Toshiba Corporation developed a CD graphics decorder, including the developemnt of LSI for special use, and unveiled the results in September 1985. In this report, we will explain the CD graphics decorder and look at the future of CD.

Format of R. S. T. U. V. and W Channels

Composition of CD frame and P and Q channels have been already explained in various documents. Therefore, they will be described here simply. The R-to-W channels are newly standardized and will be explained in detail. Fig. 1 shows the composition of CD data frame and subcode channels. For each frame, eight bits of R - W are transmitted at the speed of 58.1 kbits/sec. Among the data which can be recorded on CD, the rate of occupation of subcodes is only $8/(8 + 96 \times 2) = 0.04$ but, when the audio data is recorded for 70 minutes, the recording capacity of the subcodes is 30.87MB. The actual recording capacity, excluding the subcode synchronizing pattern (50, 51), is 30.24MB. The subcode part of one CD has the same recording capacity as that of a small-size hard disk. The recording capacity of the audio data part is as large as 740.88MB.

Among the demodulation subcode data in Fig. 1 (C), application standards have already been established for the P and Q channels and they have been used on the CD player side. The P channel distinguishes between the end and the middle of a selection. It is 1 between selections and 0 in the middle of a tune. The Q channel is a code for control and enables a higher level of random access by the track number, address data and index data.

For the remaining R - W channels, graphics image transmission, video picture (high-resolution still picture) transmission, and various other applications have been studied. In February 1985, Philips and Sony established the application standards for transmission format and graphics.



CD Graphics Adaptor Model XV-1

Fig. 1 (C) shows the transmission format of the R - W channels. The available maximum data rate is $6 \times 96 \times 75 = 43.3$ kbits/sec. In these standards, the six bits of R - W are called 'symbols'' and the 24 symbols together are called a 'pack''. Ninety-six symbols excluding the sync pattern of the 1 subcode frame is called 'packet'' and one packet is composed of four packs.

In the case of optical disks, the bit error rate before correction is as high as 10^{-5} to 10^{-4} and therefore it is indispensable to add the error detection/correction code when transmitting coded inforamtion. In the subcode R - W standards also, the error detection/correction code has been specified and six symbols in one pack are alloted to error detection/correction. The coding sequence is shown in Fig. 2

Reed Solomon code (R.S.C.) is employed for the error detection/correction code. First, (4, 2) Reed Solomon coding is conducted for the COMMAND and INSTRUCTION symbols, with the Q-parity encoder and Q parity symbol DS24n + 2 and DS24n + 3 added. Then, (24, 20) Reed Solomon coding is conducted for the total 20 symbols (18 symbols of the original data and Q parity symbols) with the P-parity encoder and four P parity symbols PS24n + 20, PS24N + 21, PS24n + 22, and PS24n + 23 added. The COMMAND symbol and INSTRUCTION symbol are required to decode the pack data transmitted and are protected doubly to data error. The data of one pack = 24 symbols added with the error detection/correction code is subjected to scrambling and interleaving processes to cope with burst error.

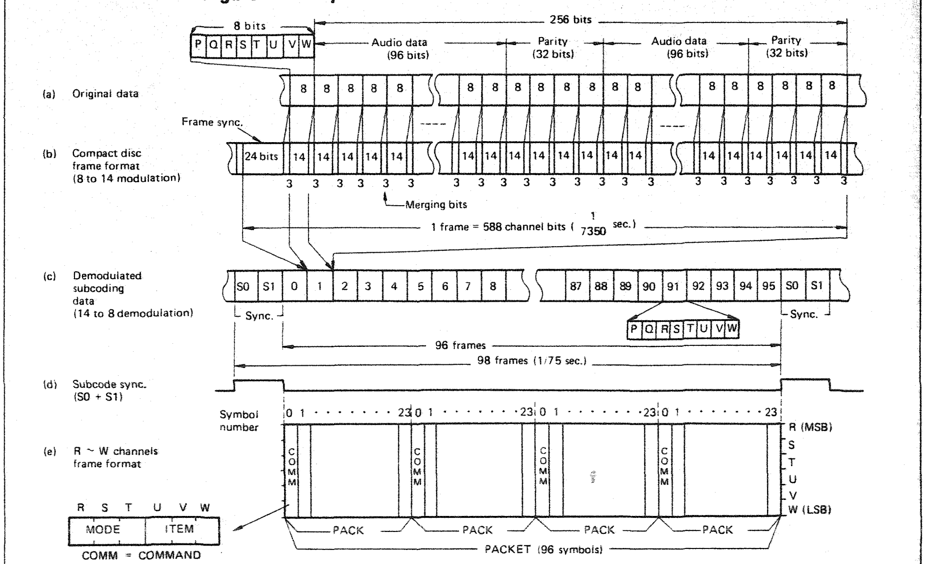
The burst error detection ability of the error detection/correction system after adding the interleaving and scrambling processes to the Reed Solomon code for random error correction is shown in Table 1.

By adding the error detection/correction code, the amount of data that can actually be transmitted by the R - W channels is 136 mega bits (max.) in the case of a 70-minute recording CD. It is converted to about 13 pieces of 8-inch, two-sided, double-density floppy disks with a recording capacity of 1.262MB. The format and data can be transmitted in large volume though the speed is a low 32.4 kilo bit per second.

Now, as shown in Fig. 1 (e) and Fig. 2, there is a COMMAND symbol at the top of the pack indicating the pack data property, which consists of a 3-bit MODE switch and a 3-bit item to subdivide the mode. The codes allotted now and the application modes are shown in Table 2. The MODE = 1 is a graphics mode, for which ITEMS of LINE-GRAPHICS (ITEM = 0) and TV-GRAPHICS (ITEM = 1) are specified. For the former, display on monochrome/color liquid crystal display or electroluminescent display are assumed and for the latter, display on a TV receiver is assumed.

Liquid crystal, EL or other flat-panel displays have become Higher in performance, smaller in

Figure 1: Composition of CD data frame and subcode channels



	Capacity	Strategy
P-parity with interleaving	8 symbol burst error	Single symbol correction
	16 symbol burst error	two symbol correction
Q-parity with scrambling and inter leaving	59 symbol burst error [symbol 0 ~ symbol 3 only]	single symbol

Table 1: Burst error correction ability

MŌDE	ITEM	Application mode
000	000	ZERŌ mode
000	000	LINE-GRAPHICS mode
	001	TV-GRAPHICS mode
111	000	USER mode

Table 2

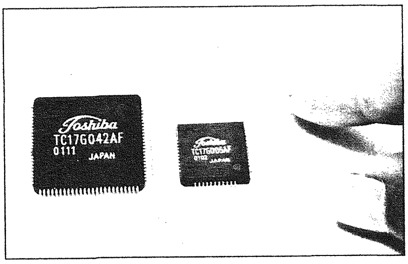
INSTRUCTIŌN		CŌDE
Preset MEMŌRY		000001
Preset BŘDER		000010
Writ FŇT FŌREGRŌUND/BACKGRŌUND		000110
EXCLUSIVE-ŌR FŌNT		100110
Scroll SCREEN with preset		010100
Scroll SCREEN with copy		011000
Load CLUT	Colour 0 ~ 7	011110
	Colour 8 ~ 15	011111

Table 3

thickness, and lower in price and, in the future, LINE-GRAPHICS display will become possible by attaching them to CD players. For the time being, however, TV graphics with TV receiver will be the main application.

With the graphics mode, drawing and shifting of pictures on display can be made by the INSTRUCTION and DATA FIELD data.

The ZERO mode is used when no data is transmitted through the R - W channels and keeps interchangeability with the CD that is not using the R - W channels. For the USER mode, users can define the INSTRUCTION and DATA FIELD but it is limited for professional use.



LSIs for CD Graphics System

TV-GRAPHICS Mode

The display picture format of the TV-GRAPHICS mode, which is supposed to be the main application for the time being, along with composition of graphics memory, CLUT and instruction are described in this paragraph.

On the CRT of a TV receiver set, a display page of 50 × 18 (Hor. × Ver.) FONTS consisting of 6 × 12 (Hor. × Ver.) as shown in Fig. 3 (a) is provided and the actual picture is displayed on the screen area of 48 × 16 (Hor. × Ver.) FONTS. The display page excluding the screen area is masked at the BORDER. The time required to form one picture on the screen area of 768 FONTS is 2.56 seconds since the FONT pattern defined by the DATA FIELD of the pack transmitted is copied to the memory corresponding to the FONT of the address [ROW, COLUMN]. Therefore, data of at least 1,600 pictures can be recorded on one CD for 70-minute recording.

Fig. 3 TV-graphics screen format and graphics memory structure

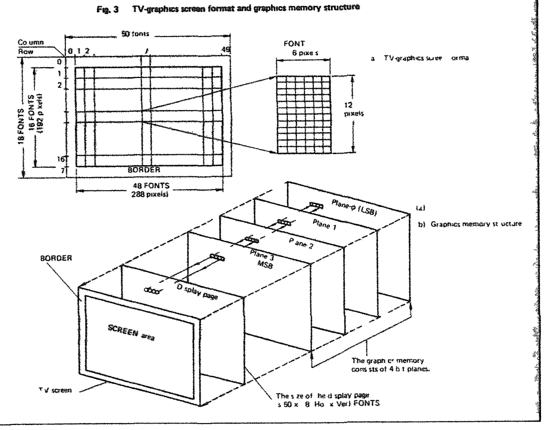
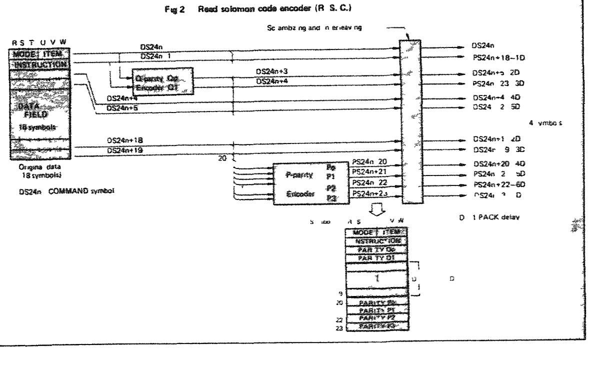


Fig 2 Reed solomon code encoder (R S. C.)



Composition of graphics memory

The TV-GRAPHICS mode employs full color graphics which can designate colors in the unit of one pixel for 16 colors at maximum selected from 4,096 colors. Four-bit color data is required for one pixel to display 16 colors. As shown in Fig. 3 (b), the graphics memory is composed of a four-bit plane from plane-6 to plane-3. The minimum required memory capacity is calculated as follows: (300 × 216) × 4 = 259,000 bits.

CLUT (Color Look Up Table)

CLUT converts the data of 4-bits/pixel readout of the graphics memory for display to data to give intensity to R, G and B colors respectively. Intensity of 16 stages is given to the R, G and B colors and expression of 16^3 = 4,096 colors becomes possible by combining them. CLUT is composed of a high-speed RAM. By rewriting the RAM, instantaneous color change of display picture or flushing of each display picture are possible without changing the color data in the graphics memory.

INSTRUCTION

For the TV-GRAPHICS mode, eight types of instructions as shown in Table 3 are available. By combining them, a high level of full color graphics pictures can be composed with a small volume of data. Each instruction is described below.

* Preset MEMORY/preset BORDER
  Instruction to paint out the screen area or BORDER in one specified color.

* Write FONT FOREGROUND/BACKGROUND
  Instruction to write the font pattern defined by the DATA FIELD of the pack to the address (ROW, COLUMN) of the display page in two designated colors.

EXCLUSIVE — OR FRONT

Instruction to enable the color change in the unit of pixel by changing the color code of the pixel composing the front designated by the address (ROW, COLUMN) of the display page by the EX-OR calculation.

* Scroll SCREEN with preset/Scroll SCREEN with copy
  Instruction to move the displayed picture vertically, horizontally or diagonally as if a rolled book is taken up on an axis. Especially the Scroll SCREEN with copy can cause the pictures to rotate continuously as a revolving lantern.

* Load CLUT
  Instruction to renew the content of CLUT. To renew all of the 16 colors, data of two packs is required.

Though detailed explanation of the LINE-GRAPHICS mode is omitted here, the display picture format is explained simply.

— FONT composition: 6 × 12 (Hor. × Ver.) pixel
— display page: 50 × 4 (Hor. × Ver.) fonts
— SCREEN area: 48 × 2 (Hor. × Ver.) fonts
— No. of display colors: 8 colors max.
— Instruction: write FONT and Scroll SCREEN

CD Graphics System and Decoder

Current CD players have no function to decode data of R - W channels and an external decoder should be connected for decoding. (It will become possible to incorporate a decoding function in the near future).

CD graphics system (TV-GRAPHICS mode) is composed as shown in Fig. 4. It includes a CD changer/player which can play 60 disks, graphics decoder, display, amplifier and speakers. It is a system for KARAOKE to reproduce a CD recorded with graphics data of a tune text card on the R - W channels and indicate the card synchronously to the progress of the tune on the display. The decoder is provided with three sorts of image outputs to be connected with various sorts of TV receivers.

In Japan, CD graphics will be started from the field of the KARAOKE reproduction systems aiming at converting the tape KARAOKE reproduction system to a tune text card display CD changeer player, thus trying to popularize the CD graphics.

Toshiba set to develop a CD graphics decoder, including the development of an LSI for exclusive use. It also developed application standards for R - W channels. The exclusive-use LSI is for a graphics display controller (GDC) which requires the largest number of ICs. It was designed to be compatible with the display screen format of TV-GRAPHICS mode and graphics memory composition. Most of functions required for GDC were integrated in CMOS LSI of two chips (100 PIN/44 PIN flat package).

Fig. 5 shows the system compositon of the CD graphics decoder XV-1 (for TV-GRAPHICS mode). It has a system controller composed of MPU (microprocessor unit), RAM 2KB and ROM 4KB, plus a graphics memory composed of R.S.C. (Reed Solumon Code) decoder, GDC, 16K × 4 bit dynamic RAM (6 pieces), CLUT, digital to analog converter, composite video encoder, RF converter, and channel selector.

The subcode R - W data output from the CD player is processed to correct errors with the R.S.C. decoder, and 18 symbols excluding the parity symbol are transmitted to the system controller (MPU) through the data bus at the cycle of about 3.3msec. The MPU decodes the instruction and prepares parameters required for GDV. When access is demanded from MPU (access demand of write FONT) and parameters are transmitted, GDG calculates the pixel data with ALU and writes the data equivalent to 6 pixels = 24 bits collectively to a desired graphics memory. The cycle steal access method is employed for drawing access to the graphics memory and therefore GDC can draw even during display.

The display pixel data is read out of the graphics memory periodically under the control of GDC and input to CLUT through the parallel to serial converter. The pixel data is converted to analog RGB signals with the CLUT and digital-to-analog converter. To apply to any sort of TV receiver sets, the decoder is provided with composite video signal output and RF signal output.

Users can select the graphics image to be displayed with a channel selector. According to the standards, 16 channels from channel-0 to 15 have been defined. Users can designate any combination and display the channel selection condition on the TV picture.

In the decoder XV-1, execution of six types of instructions, excluding "Loa CLUT," among those indicated in Table 3 and control of graphics memory are allotted to the GDC side. The graphics memory is separated from the main memory of the system controller and, therefore, it is unnecessary for MPU to pay attention to the collision of the system bus, and it can handle other processes even while GDC is drawing pictures. Thus the burden on the MPU side has been sharply reduced. Toshiba plans to release a CD recorded with subcodes R - W at the end of 1985, adjusting the timing to the release of a CD graphics decoder.

Fig. 4: CD graphics system

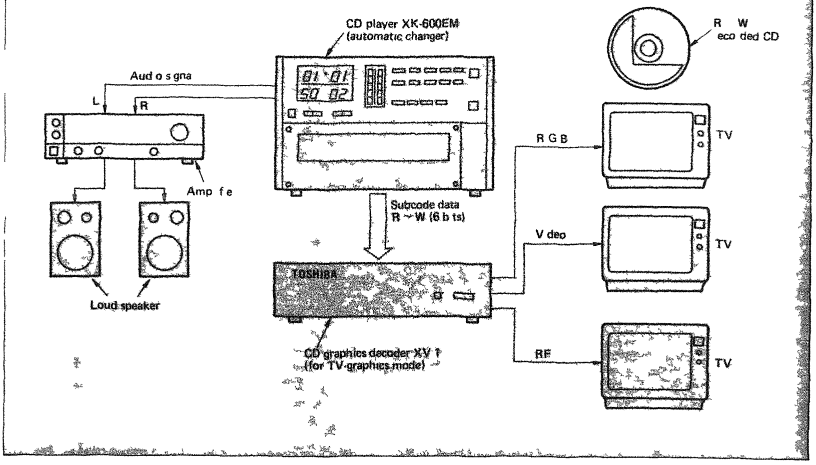
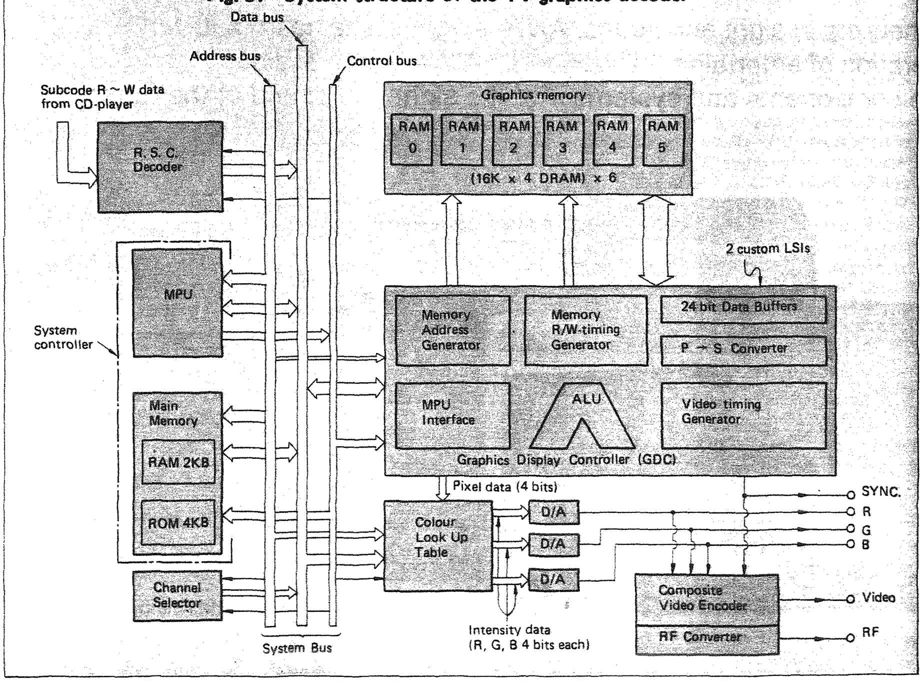


Fig. 5: System structure of the TV-graphics decoder



Conclusion

CD is rapidly establishing its position as a music recording medium taking the place of analog disk. As can be seen from this discussion, it has other new possibilities as well as for the music recording medium. Making use of the recording capacity of the CD audio data channel as large as 700MB, evolution of the CD as a code information recording medium is expected. For instance, the application of CD-ROM may progress to computers, translation machines or as road map memories for auto navigation systems. In addition, when erasing or rewriting techniques of CD become possible, substitution for floppy disks or hard disks is expected.

Thus, CD will develop, expanding its technical achievements not only to the field of electronic machines and equipment for public use but also to other fields.

Toshiba Corporation