THE ENCYCLOPEDIA OF SCMS DAT

Introduction to DAT

Q1. What is a DAT?

- DAT stands for digital audiotape recorder—a new recording and playback system using special cassette tapes and a deck capable of digital sound recording and reproduction.
- DATs are superior in sound quality, functions and operability to conventional analog recording systems. Along with CDs, they are expected to become a core technology of the new era of digital audio.
- It is predicted that, just as LP and EP records now are being replaced by CDs, digital audiotape will soon supersede ordinary audio cassette tapes as the mainstream recording medium.

Q2. What are the chief characteristics of a DAT?

- DAT's chief characteristics are as follows:

(1) Sound quality equivalent or superior to that of a CD.
(2) Smaller size than ordinary cassettes; two hours of continuous recording or playback in the standard mode. (A maximum of four hours of recording or playback is possible with the extended mode.)
(3) Outstanding operability including a speedy (several hundred times the normal playback speed) and accurate search function.
(4) No deterioration of sound quality through dubbing.
(5) Ease of use afforded by subcodes.
(6) Globally uniform standards that will enhance future development.

Q3. Specifically, what does DAT offer in terms of sound quality?

(1) DAT has a dynamic range of 96dB or more—broad enough to cover (roughly) the dynamic range of a live performance by an orchestra.
(2) In digital recording, the sampling frequency (f_S: the frequency at which the signal is sampled when an analog signal is converted to a digital signal) is high. The greater the bit numeral of quantization (digital determination of the amplitude of the sampled signal), the better the sound quality.

Because the DAT sampling frequency is 48kHz and the bit numeral of quantization is 16 bits, the sound reproduction frequency band is flat, 2 to 22kHz and the high-frequency reproduction characteristics are superior even to those of a CD.

(3) No tape hissing; good S/N ratio.
(4) No drum rotation irregularity.
(5) Good channel separation.
(6) Minimal distortion (0.005 percent or less).
(7) The signal can be corrected and compensated for so that the sound will not be interrupted or distorted even if tape dropouts occur.
(8) Dubbing does not result in the deterioration of sound quality.

- Even if the recording level fluctuates, there is no change in recording characteristics. Moreover, there is no tape modulation noise. In this respect, DATs differ fundamentally from analog systems.

Q4. In what other ways does a DAT cassette differ from a conventional audio cassette deck?

The characteristics and functions of a DAT cassette differ from those of a conventional audio cassette as shown below.

	Audio Cassette	DAT
Recording method:	Analog	Digital
Frequency characteristics:	40 to 18kHz	2Hz to 22kHz
S/N ratio:	68dB (Dolby B on)	96dB
Distortion:	0.3%	0.005% or less
Tape size:	102.4 × 63 × 12 (mm)	73 × 54× 10.5 (mm)
Recording time:	Max. 2 hrs (double track)	2 hrs. (single track)
Search speed:	About 20 times faster than playback speed	200 times faster than playback speed
Tape speed:	4.75cm/sec.	0.815mm/sec.

Q5. What are the features of the DAT mechanism?

- A DAT, like a VCR, employs a helical-scan rotary head.
- The angle of tape winding onto the rotary drum (rotary cylinder) is 90°—smaller than that of a VCR. The load on the tape hence becomes lighter, making it possible to run the tape at high speed while the signal is being read out as the tape maintains contact with the drum.
- As a result, rapid search at a speed several hundred times the normal playback speed of 3.133m/sec. is possible.

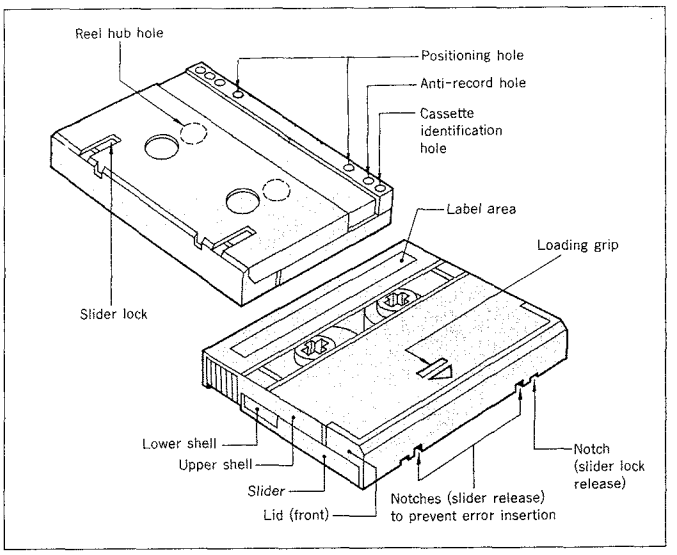


Fig. 1: Construction of DAT tape

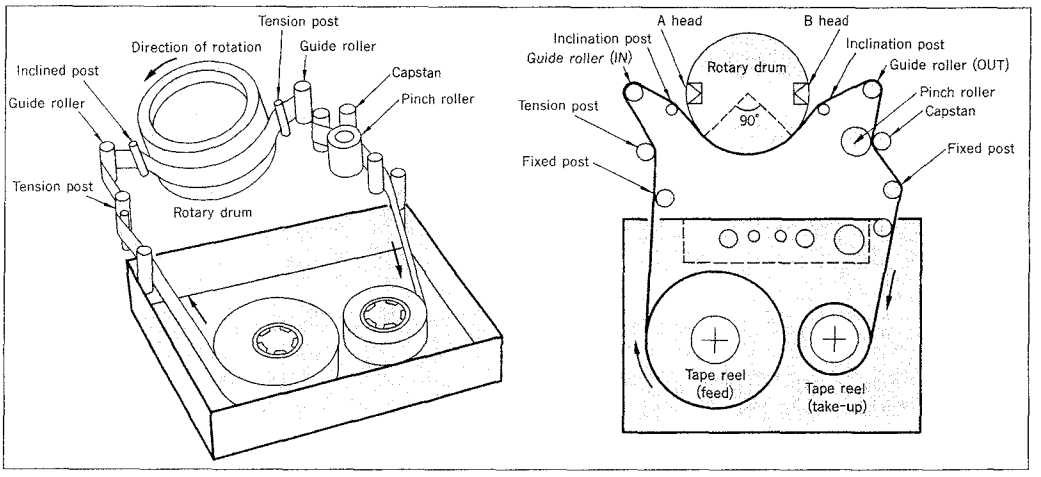


Fig. 2: DAT mechanism (tape loading)

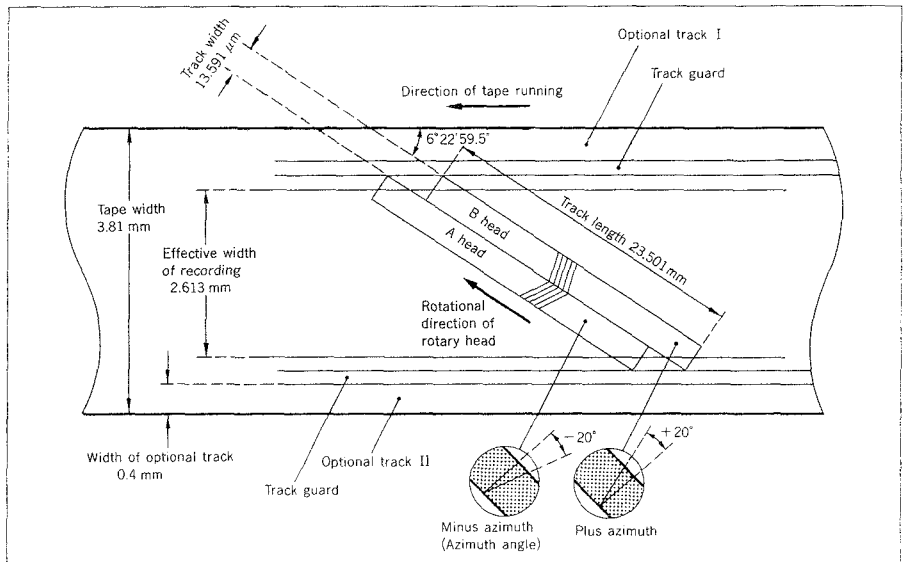
Q6. How is a DAT recording made?

- As in a VCR, the signal is recorded on the tape obliquely (see Fig. 3).
- Two heads (A and B) mounted on the rotary drum record the signal alternately and because each head has an azimuth of ±20°, there is never any recording error caused by crosstalk from an adjacent track.
- The signal is recorded in a digitized pulse. The width of the track on which the signal is recorded is 1.36μm (1/5 the diameter of a human hair). The heads accurately trace this thin track.

Q7. Other than music signals, what kinds of signals are recorded on a DAT system?

- DATs record three kinds of signals.

(1) Music signals (targeted program source) digitized by pulse code modulation (PCM).
(2) Subcodes, signals provided for user convenience that make it possible to record information such as the selection number, various control signals and expanded functions.
(3) Automatic track finding (ATF) signal, which automatically follows tracks. Using this signal, the head accurately traces the recorded track during playback.



Item \ Mode	Normal track mode		Wide track mode
	Normal speed	Half-speed	
Tape width	3.81 mm	3.81 mm	3.81 mm
Tape speed	8.150 mm/sec	4.075 mm/sec	12.225 mm/sec
Track pitch	13.591 μm	13.591 μm	20.41 μm
Track angle	6°22'59.5"	6°22'59.5"	6°23'29.4"
Track length	23.501 mm	23.501 mm	23.471 mm
Head azimuth	±20°		
Effective width of recording	2.613 mm		
Width of optional track	0.4 mm		

Fig. 3: Tape recording format

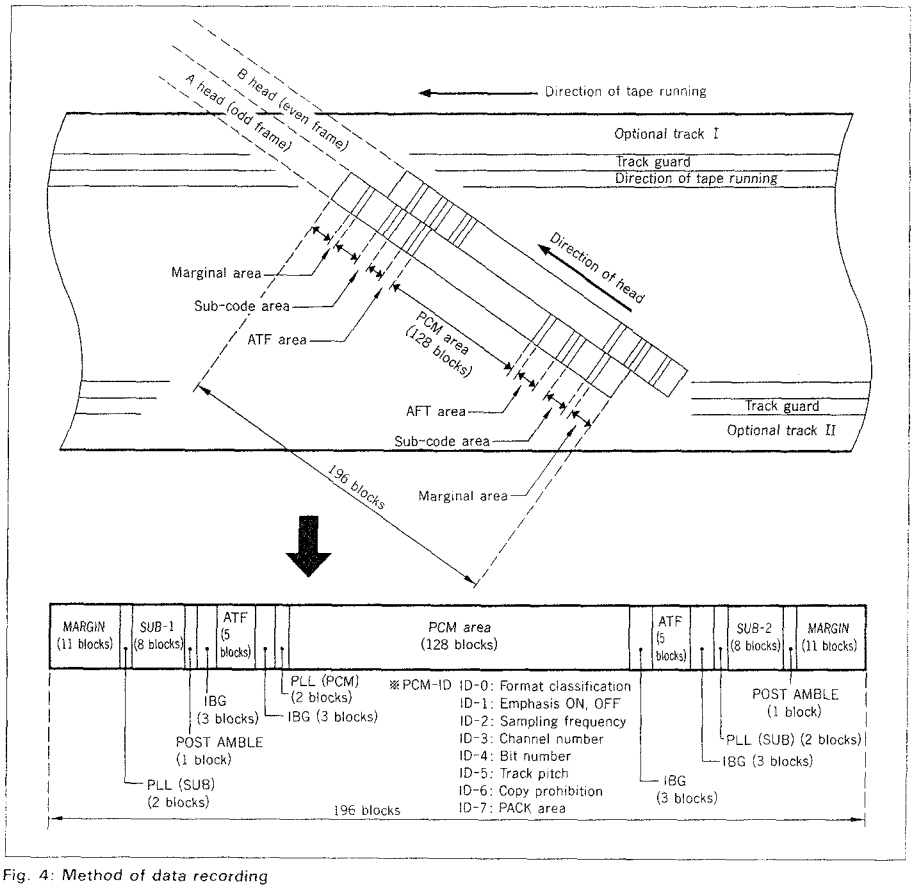


Fig. 4: Method of data recording

Q8. What are the standards for DATs?

- As shown in the table, DAT has six formats.
- Two kinds of modes—recording/reproduction modes (four modes) and reproduction-only modes (two modes)—are available.
- Of these six formats, a standard recording/reproduction mode with a sampling frequency of 48 kHz and a reproduction-only mode with a frequency of 44.1 kHz are necessary for all DAT decks.
- With an eye to future development, three modes were established as options for recording and reproduction for the following purposes:

(1) direct digital recording (digital-to-digital) of television sound from satellite broadcasting (A mode);
(2) long-period (maximum: four hours) recording or playback;
(3) four-channel recording and reproduction.

Item \ Mode	Mode I	Mode II	Mode III	Mode IV	Mode V	Mode VI
	Standard mode	Option 1	Option 2	Option 3	Pre-recorded tape	
		Compatible with Satellite broadcasting A mode	Long-time mode	4-channel mode	Normal track	Wide track
Available channels	2	2	2	4	2	2
Sampling frequency	48 kHz	32 kHz	32 kHz	32 kHz	44.1 kHz	
Bit numeral of quantization	16-bit (linear)	16-bit (linear)	12-bit (non-linear)	12-bit (non-linear)	16-bit (linear)	
Transmission speed	2.46 Mbit/s	2.46 Mbit/s	1.23 Mbit/s	2.46 Mbit/s	2.4 Mbit/s	
Sub-code capacity	273.1 kbit/s	273.1 kbit/s	136.5 kbit/s	273.1 kbit/s	273.1 kbit/s	
Modulation system	8−10 conversion				8−10 conversion	
Error correction system	Dual Reed Solomon				Dual Reed Solomon	
Tracking system	Area split ATF				Area split ATF	
Tape width	3.81 mm				3.81 mm	
Tape depth	13 ± μm				13 ± μm	
Tape in use	Metal powder					Oxide tape
Tape speed	8.15 mm/s	8.15 mm/s	4.075 mm/s	8.15 mm/s	8.15 mm/s	12.25 mm/s
Relative speed	3.133 m/s	3.133 m/s	1.567 m/s	3.133 m/s	3.133 m/s	3.129 m/s
Standard drum specs	φ30, 90° lap				φ30, 90° lap	
Drum revolution	2,000 rpm	2,000 rpm	1,000 rpm	2,000 rpm	2,000 rpm	
Track pitch	13.591 μm				13.591 μm	20.41 μm
Track angle	6°22′59.5″				6°22′59.5″	6°23′29.4″
Head azimuth angle	± 20°				± 20°	
Recording time	120 min. (tape depth of 13 μm) 180 min. (tape depth of 10 μm)		240 min. (tape depth of 13 μm) 360 min. (tape depth of 10 μm)	120 min. (tape depth of 13 μm) 180 min. (tape depth of 10 μm)	120 min. (tape depth of 13 μm) 180 min. (tape depth of 10 μm)	80 min. (tape depth of 13 μm) 120 min. (tape depth of 10 μm)
Cassette size	73 mm × 54 mm × 10.5 mm				73 mm × 54 mm × 10.5 mm	
Remarks	• For general purpose, recording/reproduction and playback of pre-recorded tape. • For specific purposes, it is possible to select optional specifications. • In standard format, the sampling frequency is 48 kHz, higher than that of CD. • It is possible to digitally record B-mode (sound) of satellite broadcasting BS-2.	• Option 1 is compatible with A-mode (TV sound) of satellite broadcasting BS-2.	• Option 2 is devised to meet the need for recording sound of W. German satellite broadcasting. Tape speed is reduced to half, thus enabling 4-hour recording.	• Option 3 is formatted to allow 4-channel recording.	• From the viewpoint of more efficient productivity of pre-recorded tape makers, the same sampling frequency (44.1 kHz) to CD format is employed in pre-recorded tape mode (playback only).	

Table 1: Major specifications of R-DAT (comparison of available modes)

Q9. Are DATs compatible with audio cassettes and videotape?

- No, there is no compatibility because the shape of the tape and the recording method are different. A DAT deck can only use special DAT tape.

About SCMS-accommodating DATs and Ordinary DATs

Q10. What is an SCMS-accommodating DAT?

- SCMS stands for serial copy management system. It is a "system to restrict copying from DAT" jointly proposed to national governments by the DAT Joint Working Group, composed of 12 leading Japanese electronics makers, the IFPI (International Record and Videotape Manufacturers' Federation), RIAA (Recording Industry Association of America), three European electronics makers and 12 member companies of the European DAT Joint Working Group council.
- The features of the SCMS are as follows.

(1) Digital copies (first generation) can be made even of copyrighted software such as CDs, store-sold prerecorded DATs and digital broadcasts. However, second-generation copying from DAT is not possible (See Fig. 5).
(2) Tape recorded by DAT from analog sources such as conventional LP records, cassettes and broadcasts can be digitally copied up to the second generation, but third-generation copies cannot be made (See Fig. 6).
(3) Personal copies made by analog recorder from DATs are not affected by the system.

- At a meeting of the DAT Joint Working Group held in Athens in June 1989, a memorandum deciding on the adoption of SCMS DATs was produced and the participants called upon the national governments to give the agreement legal force so that it could not be violated by newcomers to the DAT field.

Note

The DAT Joint Working Group is comprised of 15 companies—Philips International, Thomson Consumer Electronics and Gründig of Europe; and Sanyo Electronics, Sharp, Sony, TDK, Toshiba, NEC Home Electronics, Victor Company of Japan, Pioneer, Hitachi Manufacturing, Fujitsu General, Matsushita Electric Industries and Mitsubishi Electric of Japan (= DAT Joint Working Group Council)—plus two organizations, IFPI and RIAA.

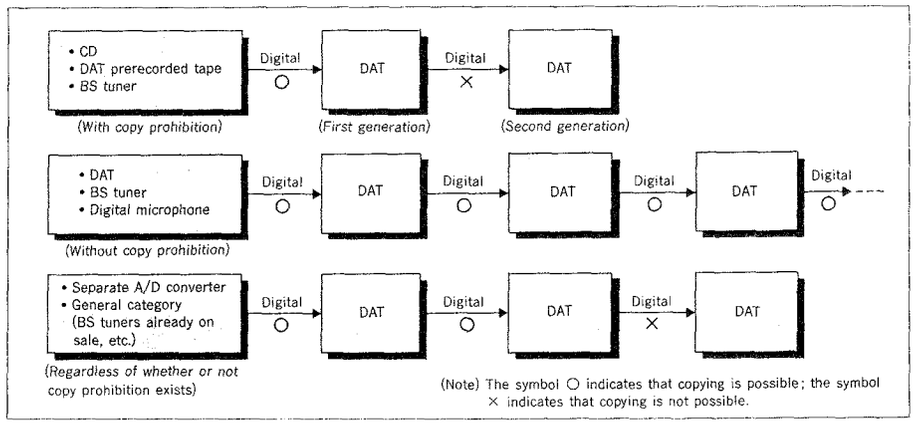


Fig. 5: Digital copying with the serial copy management system

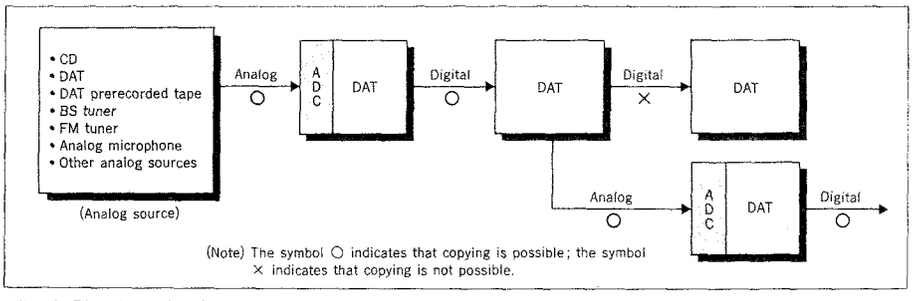


Fig. 6: Digital copying from analog sources

Q11. What is the difference between serial copying and parallel copying?

- Serial copying means copying in series from the original source (See Fig. 7). Each succeeding tape is copied from an earlier copy in the manner of parent (original) begetting child (first-generation copy), child begetting grandchild (second-generation copy), grandchild begetting great-grandchild (third-generation copy) and great-grandchild begetting great-great-grandchild (fourth-generation copy). Under the SCMS, digital copying is possible up to the level of the "child" (first-generation) tape.
- Parallel copying is a method in which copies are made in parallel from the parent DAT (See Fig. 8). Specifically, there is a real-time method by which a user can connect a number of DATs to the parent DAT in parallel and use them to simultaneously produce many tape copies (first generation). There is also a time-sharing method that uses only one DAT for recording copies. In this latter case, a fresh tape is put in after the copy is made from the original and copying from the original is repeated; by exchanging tapes one after another, many first-generation copies can be produced.

Note

Digital copying is a method in which a digital output signal from digital audio equipment such as a CD player, LD player, BS tuner, PCM processor or DAT (ordinarily an optical signal or electrical signal output by a coaxial cable) is fed into the DAT input terminal (REC terminal) and digital recordings are made by the digital input signal.

In contrast, there is a method to make digital recordings by inputting the output from the analog output terminal of a CD player, LD player, BS tuner, DAT or other digital apparatus into a DAT.

The first of these methods is called "digital-to-digital." Because it enables the user to record without losing the sound quality of the source, it is the most advantageous form of digital recording, but is has also given rise to the copyright issue. That is, because it is no longer possible to tell which source is the original, (which is the "child" and which is the "grandchild,") there is no difference in sound quality among the generations of tapes.

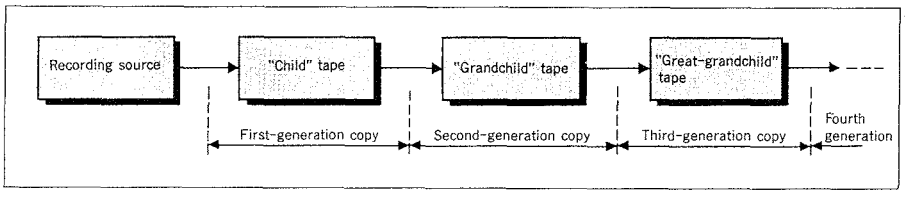


Fig. 7: Serial copying

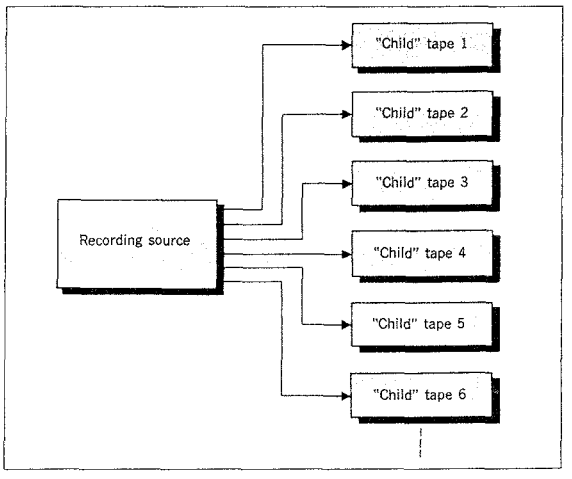


Fig. 8: Parallel copying

Q12. What is a copy prohibition code?

- In order to protect the author, DAT incorporates a copy prohibition code (ID-6) that discriminates between sources from which copying is allowed and those from which it is prohibited.
- The DAT system reads the ID-6 recorded on the DAT tape and, in the case of a tape for which copying is prohibited, the DAT recording function is suspended so that a copy cannot be made.

Q13. Where is the copy prohibition code recorded on the tape?

- As shown in Fig. 4 , the DAT signal format makes it possible to record the pulse code modulation identification code (PCM-ID), that controls the tape, in the PCM region, where the music signal (or other signal that the user wishes to record on the tape) is recorded.
- For this ID, the following eight identification codes have been established.

ID-0: Format classification

ID-1: Emphasis ON, OFF
ID-2: Sampling frequency, 32kHz, 44.1kHz, 48kHz
ID-3: Channel number, 2ch/4ch
ID-4: Bit number of quantization, 12 bits/16 bits
ID-5: Track pitch
ID-6: Copy prohibition
ID-7: PACK area

- Among these IDs, ID-6 is the copy prohibition code. As shown in Table 2, it is a 2-bit code with four variations: 00, 10, 11 and 01.

ID-6	Ordinary DAT	SCMS-accommodating DAT
00	Copying allowed	Copying allowed
10	Copying prohibited	Copying prohibited
11	Undecided	Copying one time only possible
01	Undecided	Undecided

Table 2: Copy prohibition codes

Note

For the difference between the ordinary DAT (DAT Working Group) method and the SCMS-accommodating DAT, see Fig. 9.

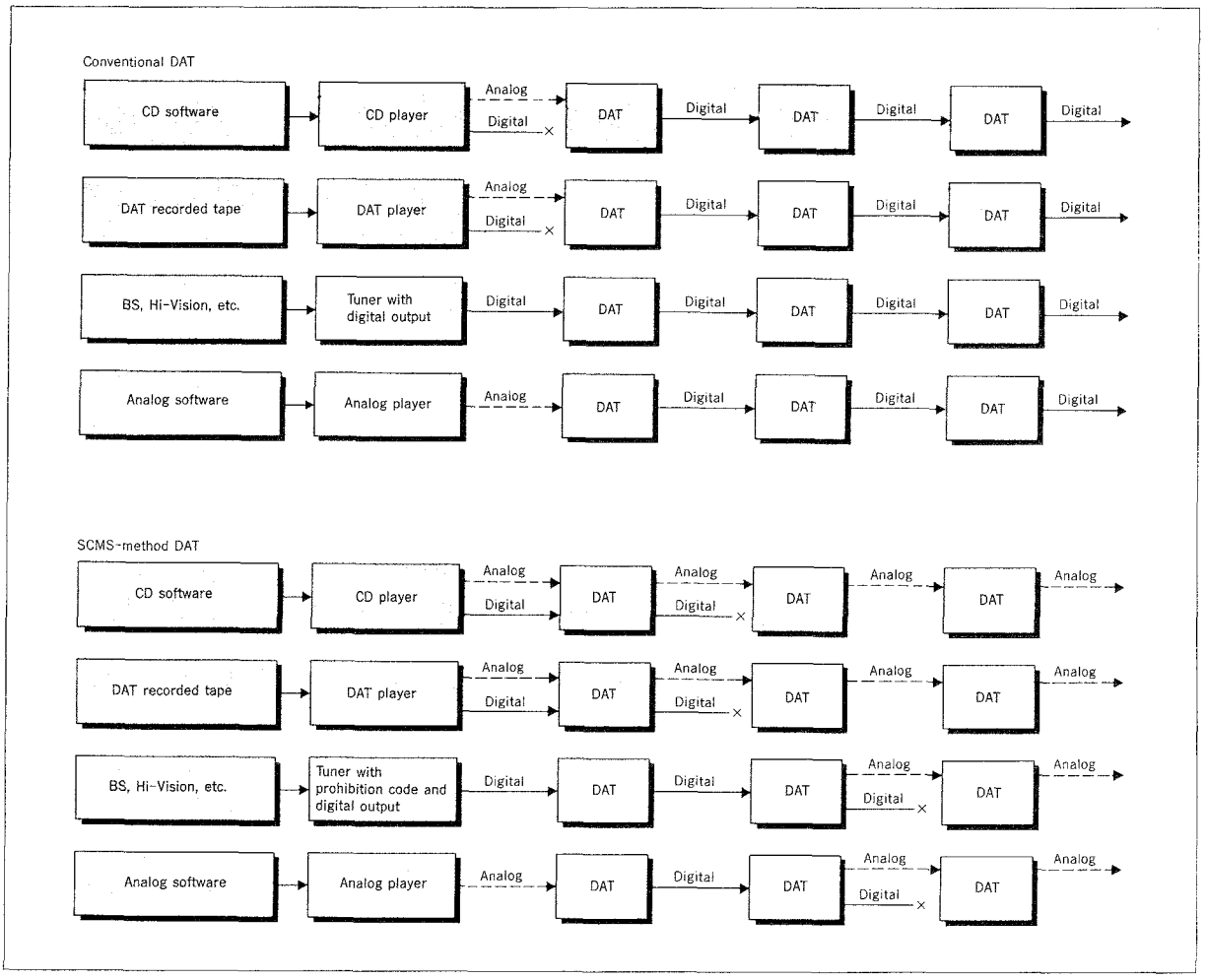


Fig. 9

Q14. How is digital copying (digital-to-digital) prohibited in conventional DATs (DAT confab method)?

- In conventional DATs, as shown in Fig. 10, the sampling frequency (f_S) of the DAT digital input signal is checked and in all cases in which the f_S is a 44.1kHz digital signal (CDs, etc.), the REC mute of the DAT deck is engaged, rendering the recording function temporarily inoperative and making it impossible to produce a digital copy.
- When the digital signal has an f_S of other than 44.1kHz the system checks whether or not copying is permitted. In the case of a source from which copying is prohibited (*ID – 6 =*), the recording function again is rendered temporarily inoperative and digital copying is inhibited.

- However, in cases in which copying is permitted (ID – 6 = 00), digital copying can be performed any number of times ("child" → "grandchild" → "great-grandchild"...).

Q15. How does SCMS-accommodating DAT discriminate between copy prohibition and copy permission?

- The SCMS-accommodating DAT has not only the conventional copy permission (ID – 6 = 00) and copy prohibition (ID – 6 = 10) codes, but also a mode in which copying one time only is possible (ID – 6 = 11). The system judges whether or not digital copying is possible as shown in Fig. 11.
- As explained the copy prohibition data is recorded in the subcode ID-6 in the PCM region of the DAT. When a digital copy is made, the digital signal, including the copy prohibition data, is output from the DAT deck.

Q16. What is the category code? (See Table 3)

- The category codes were established to enable the reception side to identify the digital signal delivery side when digital signal output from a CD, PCM processor, BS, or DAT is received. They are shown in Table 3.
- In addition to distinguishing the kind of digital equipment with this category code, it is also possible to display the code of the DAC amplifier on the indicator panel (indication of CD, BS, DAT and other sources).

Name of category	Category code
General	00000000
CD	10000000
PCM processor	01000000
BS tuner	00100000
DAT	11000000
DAT-P	11000001

(With DAT-P, digital copying is possible regardless of whether or not a copy prohibition code exists.)

Table 3: Category codes for digital output

Q17. What is the "General" category listed in Table 3 and Fig. 11?

- The code for the category named "General" is an 8-bit code consisting of all zeroes. It is used with products that have no corresponding category code or that were manufactured before the category codes were established; with sources in which the original signal is analog, such as a signal passed through an A/D converter; when it is unclear whether information on the rights exists; and with sources for which it is unclear if it is permissible to make copies.

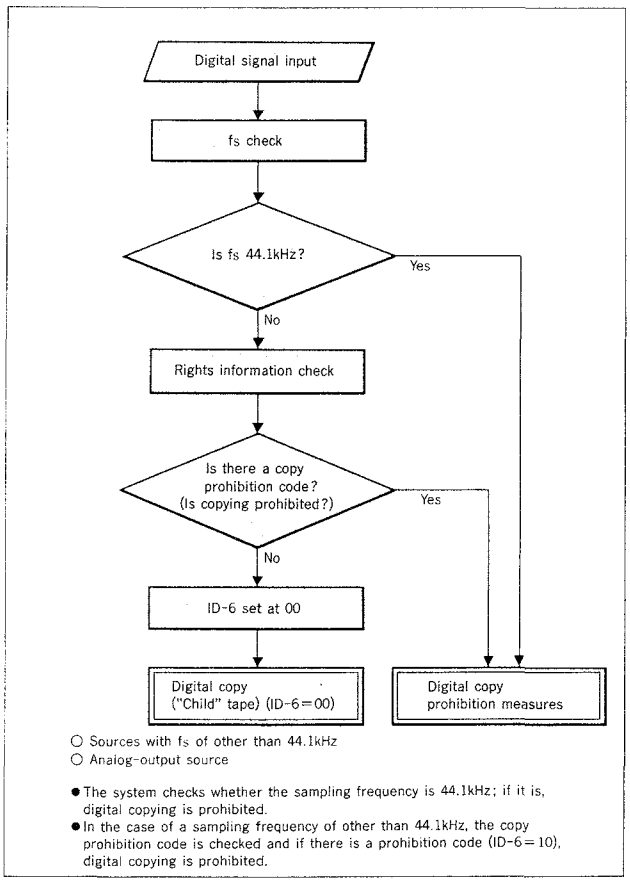


Fig. 10: Digital copying with a conventional DAT

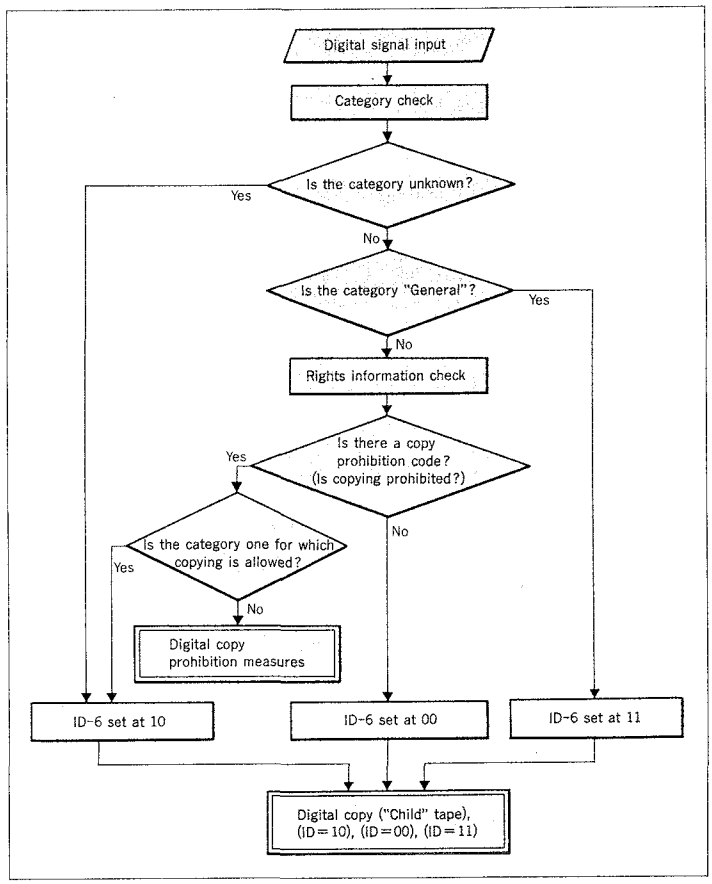


Fig. 11: Digital copying with an SCMS-accommodating DAT

- For example, some of the early BS tuners and conventional DAT products output the general category code.

Q18. What is the mechanism by which first-generation digital copies can be made?

- With SCMS-accommodating DATs, only first-generation digital copies can be made of music tapes that have copy prohibition codes. The key points of this mechanism are the copy prohibition code ID-6 recorded on the tape and the category code of the digital output (See Table 4).

(1) *In the case of a source-side ID-6 of "11" (indicating that one-time-only copying is possible)*

- The category code of the digital output becomes DAT-P and the copy prohibition code becomes "0" (copy prohibition). This means in conventional-method DATs, there is a copy prohibition code and digital copying is not possible.

- However, in SCMS-accommodating DAT, even if there is a copy prohibition code in the digital output, the category code is DAT-P and it is possible to made a digital copy, disregarding the prohibition code.
- There is one exception to this. In newly recorded tapes, the code "10" which indicates that copying is prohibited, is recorded in the ID-6. Therefore, no digital copies can be made from these tapes.
- In other words, when a tape with an ID-6 of "11" is digitally copied, the ID-6 is changed to "10" and recorded on the tape. Thus, no further digital copies can be made from this reproduced tape. This is the principle of first-generation copies.

(2) *In the case of a source-side ID-6 of "10" (indicating that copying is prohibited)*

- The category of the digital output becomes "DAT" and the copy prohibition code becomes "0" (copying prohibited). This means that a signal indicating that "copying is not allowed" is sent from the DAT and digital copying is not possible with either SCMS-accommodating DATs or conventional-method DATs.

(3) *In the case of a source-side ID-6 of "00" (indicating that copying is allowed)*

When a tape for which copying is allowed is played back, the category code of the digital output becomes "DAT" and the copy prohibition code becomes "1" (copying permissible). Therefore, because the DAT sends a signal indicating that "copying is allowed," digital copying is possible with either SCMS-accommodating DATs or conventional-method DATs. In a newly copied tape, the code ID-6 = 00 (copying allowed) is recorded, so it is possible so make digital copies from this tape repeatedly.

ID-6 (source side)	Digital output		Prohibition code after digital copying (ID-6)
	Category code	Copy prohibition code	
00	DAT 11000000	1 (copying allowed)	00
10	DAT 11000000	0 (copying prohibited)	Copying not possible
11	DAT-P 11000001	0 (copying prohibited)	10

Table 4: The relationship between the ID-6 code and category code of an SCMS-accommodating DAT

Q19. What happens when digital copies are made from a tape recorded from an analog source (from the analog input terminal)?

- With SCMS-accommodating DATs, the ID-6 becomes "11" (one-time-only copying allowed) at the time of analog recording. When tapes recorded in this manner are played back, the prohibition code of the digital output becomes "0" (copying prohibited), but the category code becomes DAT-P. Hence, the copy prohibition code can be ignored and digital copying is possible.
- However, because the copied signal is an ID-6 of "10" (copying prohibited), third-generation digital copies cannot be made.

Q20. Can tapes recorded by a conventional DAT be played on an SCMS-accommodating DAT?

- Yes, they can. And tapes recorded by an SCMS-accommodating DAT can also be played on a conventional DAT without problem.
- As far as playback is concerned, these two kinds of DATs are fully compatible.

Q21. Are they also compatible when it comes to copying music tapes?

- There are two kinds of conventional DATs, early products that output with the category code of "General" and products that output the category of "DAT." Thus, it is necessary to assess the two separately.

(1) *In the case of tapes played using a DAT that outputs the "General" category code*

- Because the music tape ID-6 of "11" (one-time-only copying possible) is interpreted as "10", the digital output becomes "copy prohibition" and digital copying is not possible.

However, the category code becomes "General" and digital copies can be made on an SCMS-accommodating DAT. Moreover, the ID-6 becomes "11" (one-time-only copying possible).

- Next, when this tape is played back, the category code changes to DAT-P, meaning that the copy prohibition code can be disregarded and a digital copy can be made again.
- This time, however, the ID-6 changes to "10" (copying prohibited), meaning that digital copies can no longer be made even with an SCMS-accommodating DAT.

(2) *In the case of tapes played using a conventional DAT outputting the DAT category*

- The ID-6 of "11" for music tapes is interpreted as "10" and the digital output becomes "copy prohibition" (the category is DAT, but copying is prohibited). Therefore, digital copying cannot be performed either with an SCMS-accommodating DAT or with a conventional DAT.

(3) *In the case of tapes of played using an SCMS-accommodating DAT*

- In this case, copying is prohibited and digital copies cannot be made with a conventional DAT. However, the category code becomes "DAT-P," so the copy prohibition code can be ignored and digital copies can be made on an SCMS-accommodating DAT.
- This time, however, the ID-6 changes to "10" (copying prohibited), meaning that it is no longer possible to make digital copies even with an SCMS-accommodating DAT.

- The ID-6 copy prohibition codes are as shown in Table 2, but in the case of conventional DAT, the DAT Working Group standards were slightly different. The significances of the codes "11" and "10" were undecided, "00" stood for "copying allowed" and "10" stood for copying prohibited. Because of this, in many of the conventional DATs, only the first of the two bits in the code is checked and the system interprets the code as "copying prohibited" when the first bit is "1" and "copying allowed" when the first bit is "0." For this reason, the kinds of mistaken interpretations mentioned in the text are made.

Q22. Is it possible to make digital copies of tapes copied from analog input with conventional DATs?

- In conventional DATs it is possible to make digital copies without limit.
- When a signal reproduced by a conventional DAT is recorded by an SCMS-accommodating DAT, digital copying is only possible up to the second generation in cases where the signal is output by early-model conventional DATs that output the "General category" code. With conventional DATs that output the "DAT" category code, unlimited digital copying is possible.

Q23. Is it possible to make a digital copy of a tape recorded from analog input using an SCMS-accommodating DAT?

- With an SCMS-accommodating DAT, only first-generation digital copies can be made. However, the ID-6 of the copied tape becomes "10" (copying prohibited), so no further digital copying is possible.

Future Outlook for DAT

Q24. What are the prospects for the future development of DAT?

- Among the standards for DAT, a satellite-broadcast-accommodating mode and modes to accommodate four-channel recording are available (See Table 1) and can be selected in accordance with the application of the product, allowing for future technological development.
- In terms of form as well, a variety of new developments can be expected. Changes in tape form, format and the recording mechanism are being considered to enable the production of not only stationary DAT decks, but also car stereo DATs (Japanese makers unveiled car stereo DATs in July), portable models (a number of models have already been brought out by several Japanese makers), headphone-stereo compact DATs and DATs exclusively for live recording.
- Furthermore, the applications of DAT technology will not be limited to audio-related products. It is predicted that DAT's outstanding recording capabilities will be used to advantage in still picture reproduction and in large external memories with a memory capacity for 1.2GB (1.2GB for 120-minute tapes; 540MB CDRO memory capacity; 1MB for 3.5-inch floppy disks).

Q25. What kinds of DATs are the stamp-sized DATs that have been brought out? (See Photo 1)

- In January 1990, Sony unveiled a stamp-sized digital tape recorder. This format has been tentatively named the NT format (See Table 5).
- The features of the stamp-sized cassettes are as follows (See Table 6).

(1) Small size (30 × 21.5 × 5mm) and low weight (2.8gr). Volume 1/4.2 that of a microcassette and 1/25 that of a compact cassette. Capable of 120 minutes of digital stereo sound recording and reproduction.

(2) The track is divided into an upper and a lower half and separate helical tracks are created for the forward and reverse directions. As is the case with conventional compact cassettes, the cassette can be turned over and both sides used.

(3) Employs nonloading method, meaning that the rotary head drum is inserted into the cassette from the front-surface opening without pulling the tape out from the cassette, as shown in Fig. 12.

A molded tape guide is housed in the cassette and plays the same role as the slanted guide and the perpendicular guide in the M-loading method (R-DAT uses M-loading; see Fig. 2).

(4) DIN Hi-Fi-class stereo sound can be digitally recorded and played back (See Table 7).

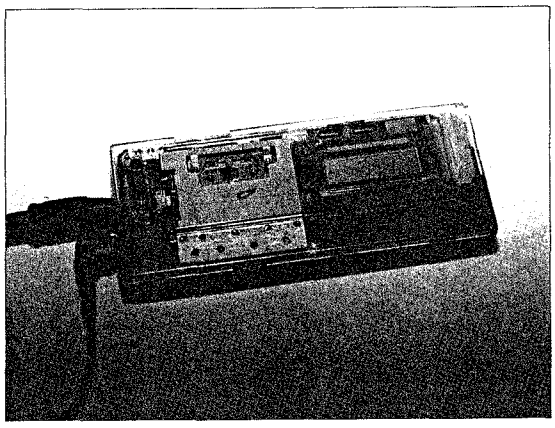


Photo 1: Prototype of world's smallest DAT and stamp-sized NT cassette

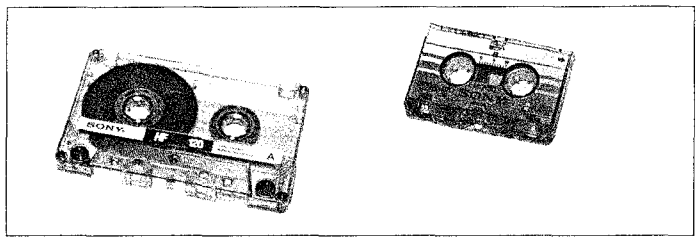


Photo 2: Microcassette (left) and stamp-sized DAT NT cassette

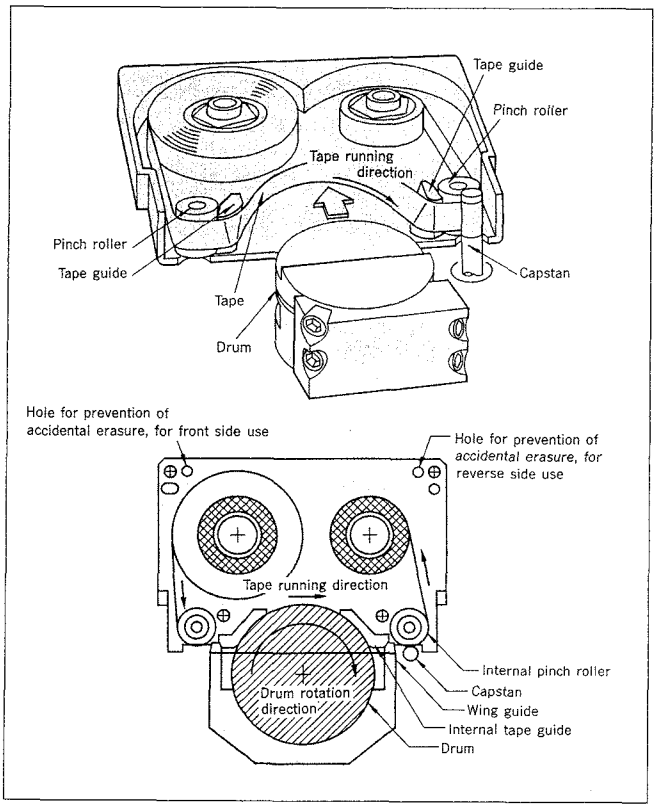


Fig. 12: NT-format DAT loading mechanism

Recording method	Two rotating heads, helical scan, azimuth recording
Tape width	2.5 mm
Tape running speed	5.5 mm/s
Drum diameter	14.8 mm
Drum lap angle	100° (mechanical lap angle)
Field frequency	50 Hz
Drum rotation frequency	50 Hz (for double-density scan)
Relative velocity of head	About 2.3 m/s (for double-density scan)
Track pitch	About 8.5 μm
Still angle	About 4.4°
Number of input channels	2ch, stereo
Sampling frequency	32 kHz
Quantization	12-bit polygonal line (corresponding to 17 bits)
Error correction and compensation code	Cross interleave code
Degree of redundancy	33% (synchronous idle, including address)
Modulation method	LDM-2 (Low Deviation Modulation)

Table 5: NT-format DAT specifications

Size	30 × 21.5 × 5 (mm) (when cover is closed)
Weight	2.8g (120-minute tape)
Tape width	2.5 mm
Tape thickness	About 5 μm
Tape length	About 20 m (120-minute tape)
Tape kind	Ni-Co metal deposition tape
Maximum recording time	120 minutes (forward and reverse)
Maximum recording capacity	About 690 MB

Table 6: NT cassette specifications

Frequency characteristics	5 ~ 15,000 Hz (+1 dB, −3 dB)
D range	80 dB or more
Overall distortion factor	0.05% or less
Wow and flutter	Measurement limit or under (crystal precision)
Size	115 × 50 × 21 (mm)
Weight	138g (including battery and cassette)
Power source	DC 1.5 V, one AA dry-cell battery
Total power consumption	About 270 mW (when powered by dry battery)
Battery life	About six hours (recording, playback; when alkaline AA dry-cell battery is used)
Head used	MIG (metal-in-gap) head
LSIs and ICs used	Six newly developed items, three general-purpose items

Table 7: Main specifications of NT recorder