"Home Video" For The 21st Century

Communicating And Expanding Visual Culture From Analog To Digital

VICTOR COMPANY OF JAPAN, LTD.

Introduction

JVC (Victor Company of Japan, Ltd.) invented VHS in 1976. The history of home video started then. By the end of 2002, close to 900 million VHS video units would have been shipped worldwide (JVC estimates), with the software recorded using these VCRs comprising a gargantuan amount.

Over 25 years have passed since its introduction, and now the environment in which VHS exists is changing profoundly. Representative of this is the digitization of TV broadcasts. In Japan, terrestrial broadcasts will begin in 2003. Digital terrestrial broadcasts have already started in the United States and the United Kingdom along with digital satellite broadcasts.

VHS, which has continually evolved and progressed along with changes in broadcasting, will be required to meet the needs of digital broadcasts while securing the visual link to the past. Moreover, with digital broadcasting, various types of digital data can be transmitted in addition to images and sound. A solution for recording all types of digitally broadcast information in their original digital form, with the ability to play back the enormous number of analog VHS recordings, is D-VHS®. D-VHS makes possible a smooth transition from analog to digital, and is the next-generation home video format that enables the household visual culture created in the 20th century to be passed on to the 21st century.

User-Friendliness And Flexibility

D-VHS was developed in order to meet the recording requirements of digital broadcasts while ensuring that the existing VHS video images that have been accumulated thus far will remain accessible and will not become obsolete.

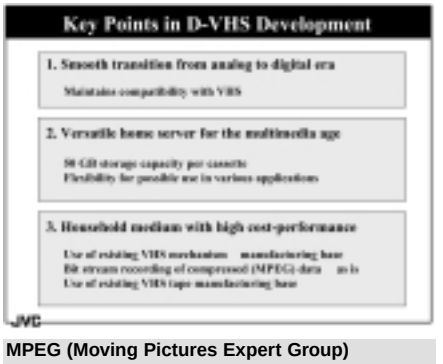
In the 21st century, not only will TV broadcasts go digital, but a wide variety of information will be transmitted as digital signals, and a household appliance that can record and store such information will become necessary.

Also, it should be noted that among the various types of storage media, tape media offers important advantages by way of its high-storage capacity and superior cost-performance.

D-VHS, which enables digital recorders to take advantage of the high-capacity characteristics of tape, was developed as a format based on the VHS standard. D-VHS allows the continuation and advancement of the legacy created by VHS, and will not impose a burden on manufacturers nor consumers. This is because of the enormous cultural value of accumulated VHS images was given high priority in the development of D-VHS.

To that, D-VHS adds the potential of meeting the needs of future digital broadcasts. Although originally developed to accommodate the MPEG signals of digital TV broadcasts, the D-VHS format itself can work with standards other than MPEG. So even if some other broadcast scheme is adopted in the future, D-VHS will be able to accommodate it while maintaining compatibility with VHS.

D-VHS is a new proposal for household digital recorders in the 21st century.

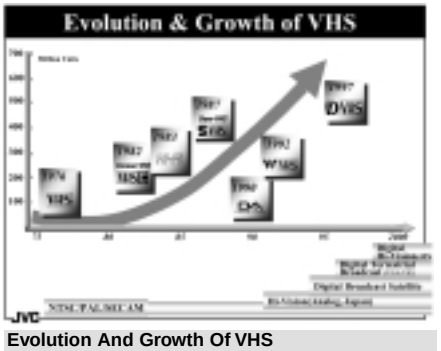


MPEG (Moving Pictures Expert Group)
An encoding method used in storage media such as optical discs and tapes, as well as communication media including broadcasts and telecommunications. Data volume is reduced through compression technology. Video CDs utilize MPEG-1 whereas DVD and digital broadcasts use MPEG-2 to attain higher picture quality.

Characteristics Of D-VHS

Bit Stream Recording

One of D-VHS's characteristics is that it utilizes bit stream recording, which is a method of recording inputted signals, such as those of digital broadcasts, on a tape directly as digital bit stream data. No special



Evolution And Growth Of VHS
JVC introduced the VHS format in 1976. Since then, the VHS-C compact cassette developed for use in compact and lightweight camcorders was introduced in 1982; Hi-Fi VHS, which provided high quality stereo sound, was introduced in 1983; and Super-VHS, which achieved a higher level of picture quality, was introduced in 1987. In the 1990s, Digital Audio was introduced to accommodate the satellite broadcasts that began then, and in 1992 W-VHS was introduced to record Hi-Vision broadcasts. Then, in 1997, D-VHS was developed to meet the requirements of digital broadcasts. Although VHS has grown and evolved in many ways along with the TV broadcasts, which comprise VHS's recording source, compatibility has always been maintained with the basic VHS format's recording and playback.

processing or digital conversion (encoding) takes place, and the inputted digital signal is simply recorded onto tape in the D-VHS format. This is what is called bit stream recording.

During playback, the same digital signal is routed through a set-top box (STB) or within the VCR which converts the signal into analog video and audio signals that can be reproduced on a TV, etc. Depending on the STB or unit, the signals may be output in digital form.

Since bit stream recording itself does not include analog-to-digital conversion (encoding) or digital-to-analog conversion (decoding), the circuitry can be simplified to allow a reduction in cost.

The maximum transfer/recording rate is 28.2 Mbps. Data recording capacity is 50 GB (using DF-480 cassette). This means that even if a 23 Mbps digital HD broadcast is sent along with 5 Mbps data in a sub carrier, four hours of HD recording is possible. Or if the signal is 2 Mbps (level equivalent to Video CD), then 49 hours of recording will be possible per cassette. Achieving these capabilities will be dependent on the design of the actual unit (product).

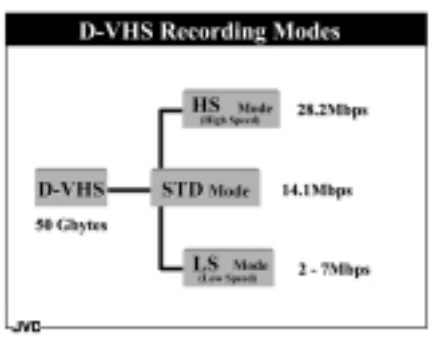
With the STD (Standard) mode at its base, the D-VHS format offers three recording modes that also include HS (High Speed data rate) and LS (Low Speed data rate) modes, which can be selected according to the quality or needs of a particular broadcast.

Aside from manually selecting the recording mode, in the future when picture quality information is included in the broadcast signal, auto selection will be possible. Also, EPG-based programming and other benefits associated with digital broadcasts will be incorporated. D-VHS adopts IEEE 1394 as the digital interface (also referred to as FireWire® or iLink® with DTCP being the terminology used for the interface incorporating copy protection technology). So connection to a TV or STB will be as easy as connecting an IEEE 1394 cable.

Basic Specifications of D-VHS

		STD Mode	HS Mode	LS Mode LS2	LS3	LS5	LS7
	Head Configuration	Rotating 2-Head	Rotating 4-Head	STD Mode +1 Head	Same as STD Mode		
Recording Time	DF-300 (31.7GB)	5 hours	2.5 hours	10 hours	15 hours	25 hours	35 hours
	DF-480 (50GB)	8 hours	4 hours	16 hours	24 hours	40 hours	56 hours
Track Composition	Tape Speed	16.67 mm/sec	33.33 mm/sec	8.33mm/s	5.55 mm/s	3.33 mm/s	2.38 mm/s
	Head Azimuth	+/- 30Å	←	←	←	←	←
	Drum Rotation Speed	1,800 rpm	←	←	←	←	←
	Tracking System	CTL track system	←	←	←	←	←
Recording Specifications	Main Data Input Rate	14.1 Mbps	28.2 Mbps	7.0Mbps	4.7 Mbps	2.8 Mbps	2.0 Mbps
	Sub-data Input Rate	0.146 Mbps	0.292 Mbps	73.0 Kbps	48.7 Kbps	29.2 Kbps	20.9 Kbps
	Recording Rate	19.14 Mbps	38.28 Mbps	19.14 Mbps			
	Track structure	1 sector	←	←	←	←	←
	Sync Block Length	112 Bytes	←	←	←	←	←
	Inner Correction	RS code	←	←	←	←	←
	Outer Correction	RS code	←	←	←	←	←
	Code Word Shuffling	6 track	←	←	←	←	←
	Modulation System	SI-NRZI	←	←	←	←	←

JVC



STB (Set-Top Box)
Equipment that receives digital TV broadcasts and converts them to analog signals so that MPEG digital signals can be viewed on a TV. Also called "digital TV adapter" or "digital tuner." As digital broadcasts increase, they are likely to be incorporated into TV sets and peripherals including VCRs.

Mbps (Megabits Per Second)
M (Mega) denotes a value of one million. "bps" stands for the number of "bits per second." 1 Mbps means 1,000,000 bits per second.

GB
G (Giga) denotes a value of one billion. B stands for Byte, which is equivalent to 8 bits.

EPG (Electronic Program Guide)
A TV program guide that is transmitted along with a TV broadcast. EPG programming will allow automatic recording of a program by selecting it on the EPG.

D-VHS Tape

The shape and dimensions of a D-VHS cassette are identical to those of a VHS cassette. No special processes such as metal evaporation are used for this videotape, instead opting to utilize the ferric-oxide magnetic particles which have a proven track record and cost advantages. Ferric-oxide magnetic particles have already proven their reliability through VHS and Super VHS, and basically the same Super VHS manufacturing facilities can be used for D-VHS. Since the mass-production facilities of tape manufacturers can be used without retooling, large-scale distribution can be done at reasonable cost.

D-VHS tape is a high-performance ferric-oxide tape developed on the basis of Super VHS tape technology. On the cassette, there is a D-VHS logo which signifies that quality level required for D-VHS guaranteed performance. A D-VHS cassette also has the ID holes on the bottom of the cassette. These ID holes are used for the purpose of cassette discrimination by D-VHS recorders.

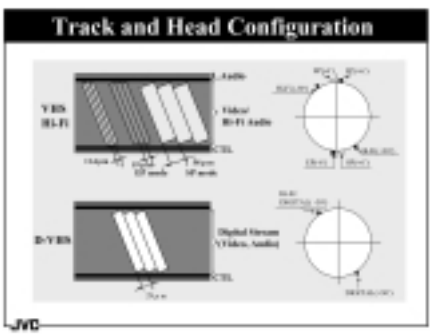
Ferric-Oxide Magnetic Particles
Magnetic particles such as gamma ferric-oxide which offer stable characteristics. In Super VHS and D-VHS tapes, ferric-oxide with maximized performance is used.

D-VHS Mechanism

The D-VHS mechanism, which constitutes the heart of a video deck, is essentially the same as that of VHS video. A 62 mm diameter drum rotates at 1800 rpm.

The difference is in the heads; for D-VHS, heads with a narrower head gap for digital recording are used. And since the recording track width is changed, the tape speed is also changed accordingly.

The recording track width is 29 microns, which is half the 58 microns used for VHS



SP mode. The tape speed differs depending on the recording mode. (See D-VHS Specifications)

Head azimuth is 30 degrees, which is the same as the Hi-Fi VHS audio head. For this reason, shared use with the analog Hi-Fi VHS audio recording head is made possible. The standard STD mode uses two heads, while four heads are required for HS mode, and three heads for LS mode.

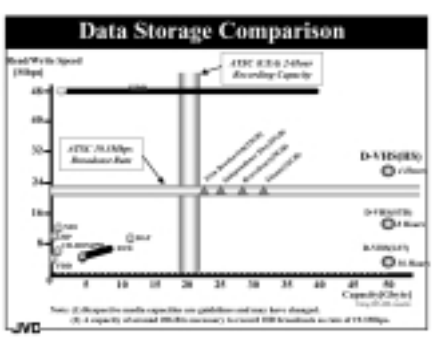
Data Storage

Conventionally, home video was a medium used to record images and sound. But in the age of digital broadcasts, the demands upon video will change. That is because in addition to digitized images and sound, a wide variety of data will also be transmitted. Data-only broadcasts are also being planned.

In the case of images and sound only, VHS will be able to record from digital broadcasts, but the main advantage of D-VHS is not only its ability to record digital images and sound with their original broadcast quality maintained, but also the ability to record data along with it.

Furthermore, in the future, there will arise a need to address information infrastructures such as those using fiber-optical cables in addition to broadcasts. D-VHS will be able to prove its power as a data storage device that can record in their original state the various types of digital data that will be entering future households. That is because, although with small amounts of data it will be possible to segment them while receiving them, by contrast with large amounts of data it is necessary to store the information first.

There are many types of data storage media including HDD, MO, and DVD-RAM, and they are becoming increasingly large-capacity. However, only D-VHS is able to offer the storage capacity and recording speed that lets it meet the demands of recording future digital HDTV broadcasts with room to spare. And the tape medium used by D-VHS offers an extremely low cost per bit, so media cost is inexpensive. Also, it **offers the benefits of being a removable medium**. D-VHS is ideal for use as a household data storage media.



DVD And D-VHS

Gaining attention as a data storage medium is DVD-RAM and DVD-RW. The main characteristic of disks such as DVD-RAM and HDD is their fast access speed.

On the other hand, tape offers an advantage in the amount of data it can store. Even next-generation optical disks can only store 20-30 GB of data on a single side, which is only about half that of D-VHS.

In the future, it is believed that the media chosen will depend on the particular application; those requiring fast access speed will use disk, while those requiring large capacity will use tape. Generally speaking, PCs will use disk while broadcasting will use tape. Also, hybrid use of tape and disk is also a possibility. It may be important to note that virtually all hi-def professional recordings are currently being made using the tape medium.

It may also be important to note that not all digital signals are equal. Just as there are very noticeable differences between high-definition and standard-definition broadcasts (which are both “digital” and use MPEG-2), there is a major difference between the picture quality of D-VHS in the HS mode (which is high-definition with a maximum data transfer rate of 28.2 Mbps) and that of DVD Video (which has an average data transfer rate of around 4.5 Mbps for a two-hour movie) although both use MPEG-2. D-VHS in the HS mode has such a large capacity that hi-def ATSC broadcasts at 19.3 Mbps can be recorded with no additional compression. The DVD has a 720 x 480 pixel (SD) picture versus a 1920 x 1080 pixel (HD) picture for high-definition D-VHS. The difference in information density contained in a single picture is immense.

Flexible Recording

The maximum data transfer rate for D-VHS is 28.2 Mbps. Although MPEG-2 utilizes a number of different profiles/levels in accordance with the desired resolution level or processing speed, the norm for digital broadcasts and DVD applications is MainProfile@MainLevel, which has a maximum transfer rate of 15 Mbps. The D-VHS STD (standard) mode, which has a 14 Mbps transfer rate, nearly matches this.

With the STD mode at its core, the D-VHS format offers a number of other modes to better accommodate a variety of situations. Flexible recording is made possible because multiple channels can be recorded simultaneously, or the recording time can be extended, as long as the total remains within the maximum 28.2 Mbps limit.

Although the transfer rate for digital HD broadcasts is about 19 Mbps, there may also be a possibility of 14 Mbps HD programs. It will be possible to record such programs using the D-VHS STD mode instead of the HD mode. And with SD (Standard Definition) broadcasts, programs transferred at 6 Mbps can be recorded for 16 hours per cassette using the LS2 mode.

Although the transfer rate differs by channel in digital broadcasts, on the average it is said to be around 3.5 Mbps for SD broadcasts. Since the STD mode has an input rate of 14.1 Mbps, theoretically it would be possible to record three different 4.7 Mbps channels simultaneously.

The ability to flexibly accommodate, based on broadcast quality or priority of programming, is a major merit of D-VHS. The 28 Mbps of the HS mode roughly corresponds to the data volume of one transponder of a broadcast satellite. For SD broadcasts, it would be equivalent to six channels.

D-VHS Recording Method And Track Pattern

D-VHS provides three recording modes: STD, LS, and HS. Among them, the STD mode is the standard base, and the HS and LS modes are optional standards. Since the ability to record and play back analog VHS is mandatory, compatibility with current VHS is maintained. Track width has been set at 29 microns, which is half the width of analog VHS SP mode (58 microns). The tape speed will change in accordance with the recording mode, but the track width remains fixed.

DV And D-VHS

Among the digital video technologies is DV, which is used in camcorders. In order to record MPEG digital TV broadcasts on DV, it will be necessary to first convert it to a baseband signal and then apply DV compression. Since DV and MPEG use different compression methods, they have no electronic compatibility.

DV, which offers the merits of high recording density and compact size is the optimum media for camcorders. However the running costs of the tape are high because of the use of (metal) evaporated tape. DV is a video camera format, whereas D-VHS is a bitstream recording format.

D-VHS Recording Modes

D-VHS has three recording modes: STD (Standard), HS (High Speed data rate) and LS (Low Speed data rate). The reason why they were not named HD (High Definition) or LD (Low Definition) is because there is much variation among the image quality (data volume) planned for digital broadcasts, making it possible for some HD broadcasts to be recorded in the STD mode. The flexibility of D-VHS recording possibilities is expressed in the names of its modes.

In analog video, one track records one field's worth of visual information. With MPEG, however, compressed data is received via a transport stream. So if, say, a single satellite transponder sends out six channels worth of broadcasts, all six channels worth of data are received at one time.

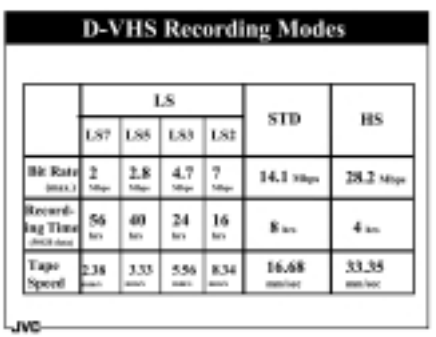
With D-VHS, it is therefore necessary for the data within the transport stream to first be separated and reorganized into the individual channel streams. At this time, a time stamp is recorded in order to ensure that the correct block is read during playback.

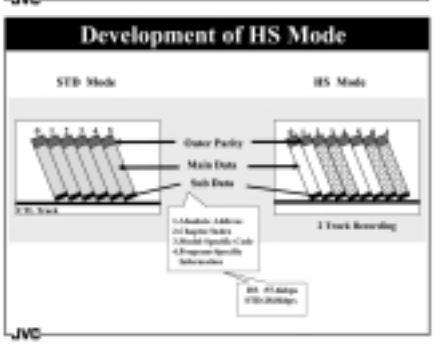
In this way, a sync block (SB) is created. Two sync blocks are equivalent to one data packet used in MPEG. Although 336 sync blocks are positioned in the Main Data track to be recorded on tape, more sophisticated processing actually takes place. For instance, although search functions are optional to the format, since the head will cross over the track laterally, it is necessary to position the image data in a location where the heads will come into contact during search.

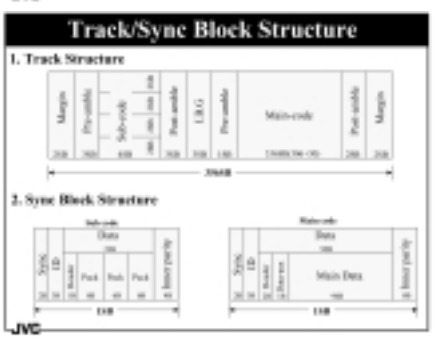
The track pattern is, generally speaking, made up of three sectors: Outer Parity, Main Data, and Sub Data. Parity is the sector that carries error-correction codes, and in addition to the Outer Parity there is also error-correction information in the Sync Block, which together provide robust error-correction for accurate recording and playback. The Main Data sector contains audio and video data as well as data received from data broadcasts.

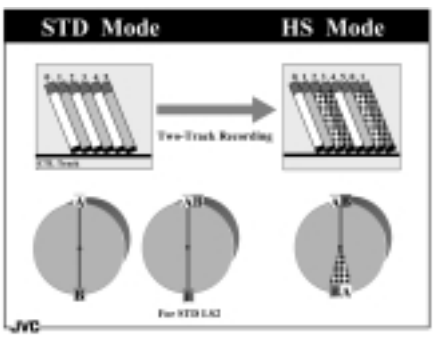
The Sub Data section carries the absolute address as well as the chapter/index information necessary for search functions. These are not sent from a broadcaster, but are generated internally and written onto the tape by the recorder during recording.

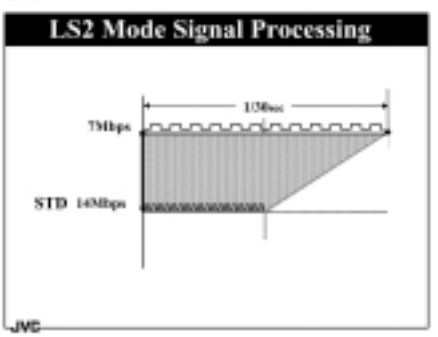
In order to allow these data to be read even during fast-forwarding or rewinding, Sub Code data is redundantly recorded on the tape. This boosts the accessibility and operability of the format.



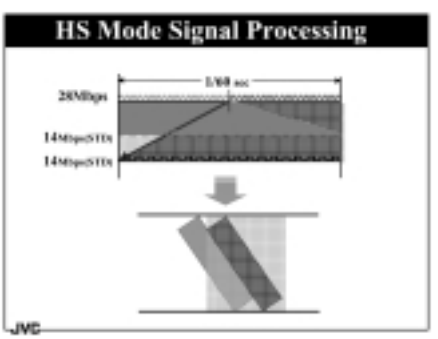








Tape speed and recording rate necessary for LS2 mode is half that of STD mode. It memorizes the 7 Mbps data and records to tape at 14 Mbps, the same as STD mode.



HS mode divides a 28.2 Mbps data into two, and records them in two STD tracks at 14.1 Mbps. Recording time becomes 4 hours, half that of STD mode.

D-VHS Head Configuration

It is D-VHS's simple and unique head configuration that enabled D-VHS's flexibility of recording, from HD broadcast recording to 56-hour extended-time recording.

A pair of heads placed diagonally on the rotating drum is used for the basic STD mode recording. The LS mode includes the LS2, LS3, LS5, and LS7 sub modes. As does the STD mode, LS3, LS5, and LS7 all use just one pair of heads.

Though tape speed is slowed down in order to extend the recording time, the number of times the drum rotates is the same as STD mode, and, per track, the recording rate of 14.1 Mbps is also the same. In the LS mode, recording is done intermittently in accordance with the slower tape speed. The head is designed so that it does not come into contact with the tape during the drum rotation except only when actually recording onto the tape.

Specifically, slow rate signals are accumulated in memory, and are recorded onto tape when they reach a level that allows recording of one track at 14.1 Mbps.

The D-VHS format adopts the azimuth recording technique that enables accurate recording and playback of signals without any interference between neighboring tracks. Therefore, only with the LS2 mode was there a necessity to add one more head in order to prevent the head azimuth from being the same when recording tracks alternately using one pair (A, B) of heads.

The same thinking is used with the HS mode as well. The D-VHS format is based around the 14.1 Mbps recording in the STD mode. In the HS mode, a two-track recording method is used. That is, the tape speed becomes doubled in order to record 28.2 Mbps, twice the data amount of the STD mode. Though the amount of data per one track remains at 14.1 Mbps, recording of the doubled amount of data (28.2 Mbps) becomes possible by using two tracks.

Therefore, a four-head configuration is used for the HS mode. The four-head configuration of the HS mode can also be applied to the three-head necessities of the LS2 mode.

Azimuth Recording
Noise that is called crosstalk appears when the head reads signals of a neighboring track during playback. Azimuth recording is a method to prevent crosstalk by angling the gaps of the two heads. The angles differ: ±6° for VHS video head, ±30° for D-VHS.

IEEE 1394

The D-VHS standard has adopted IEEE 1394 as its digital interface technology. A IEEE 1394 terminal is beginning to be used as the DV terminal (iLink) of digital video cameras and VCRs, and also gaining attention for use in home digital networks.

For its IEEE 1394 terminal, D-VHS uses the same four-pin terminal as used in DV terminals. Just one simple cable enables transmission of all kinds of information including images, sounds, and data to an STB or television.

Digital Broadcasts And D-VHS

Digitization of broadcasts not only brings us high-quality images and sound, multi-channel and multi-functions, but also gives us a method to efficiently use the airwaves, which are a limited resource.

This is not to imply that a digital video recorder is absolutely necessary to record digital TV programs. Since it is ultimately necessary to convert to analog in order to show images on a conventional TV screen, it is possible for analog VCRs, such as the VHS VCR, to record digital broadcasts after the signals are converted from digital to analog.

However, the amount of information sent over-the-air will increase dramatically with the start of digital broadcasts. Though analog VCRs can record this information as a single TV program, the digital video recorder will be necessary to record all the information included in the data broadcasts, while maintaining the high-quality images and sound that are main characteristics of digital broadcasts.

D-VHS is a way to record the data transmitted through broadcasts, making the most of its vast storage capacity. By taking advantage of the characteristics of tape media, only D-VHS is capable of recording HD broadcasts and also offering a maximum 56 hours of extended-time recording.

Although D-VHS can be used as a stand-alone digital VCR, when it is combined with DVD-RAM or HDD, it gains broader potential as a household digital recorder that can be used as a home server that offers both the huge-capacity characteristics of tape and the fast-access characteristics of disc. ■

P.S. This technical white paper was prepared by Victor Company of Japan, Ltd. and is published herein with the company's permission.

HDD And Archiving
Hard disk drives perhaps have unlimited potential to increase capacity and theoretically will enable recording of multiple HD broadcasts on a single hard disk space. This may become a trend in the future. However, hard disks being as they are, it will be difficult to remove them and use as archiving media due to manageability as well as running costs. In as much as you want to back up or archive data on your hard disk, the easiest, most cost effective and capable form of archiving recorded HD content on a hard disk recorder in the future would be D-VHS. It is a perfect archiving solution even when HDD recording comes of age and a combination would be ideal.

Specifications Supplement

	D-VHS Recording	S-VHS/VHS Recording
Recording format	D-VHS MPEG2 HS/STD/ LS3 modes	S-VHS/VHS with Hi-Fi Audio
Channel reception	VHF 2—13, UHF 14—69, CATV 113 channels	
Cassette	D-VHS, S-VHS, VHS cassettes (D-VHS cassette required for D-VHS recording)	
Max. recording/playback time	HS mode: 4 hours* (full HD quality) STD mode: 8 hours* (better than DVD quality) LS3 mode: 24 hours* (S-VHS quality) *using DF-480 cassette	SP mode: 3 hrs. 30 min.* EP mode: 10 hrs. 30 min.* *using ST-210 cassette
Tape speed	HS mode: 33.4 mm/sec. STD mode: 16.67 mm/sec. LS3 mode: 5.55 mm/sec.	SP mode: 33.4 mm/sec. EP mode: 11.1 mm/sec.
Analog inputs	AV x 3, S-Video x 3 (including front)	
Analog outputs	AV x 2, S-Video x 2, Component Video x 1 (Y, Pb, Pr)	
Optical digital out	x 1 (5.1ch Dolby Digital / 2ch Linear PCM Audio)	
i.Link terminal	x 2 (4-pin, MPEG2 in/out, DV in) (including front)	
Other connectors	JLIP x 1, Remote pause/AV Compu Link x 1	
Dimensions (W x H x D)	17-15/16" x 4-3/16" x 13-5/8" (455mm x 105mm x 345mm)	
Weight	13.3 lb. (6.0 kg)	