A6 Video Recording

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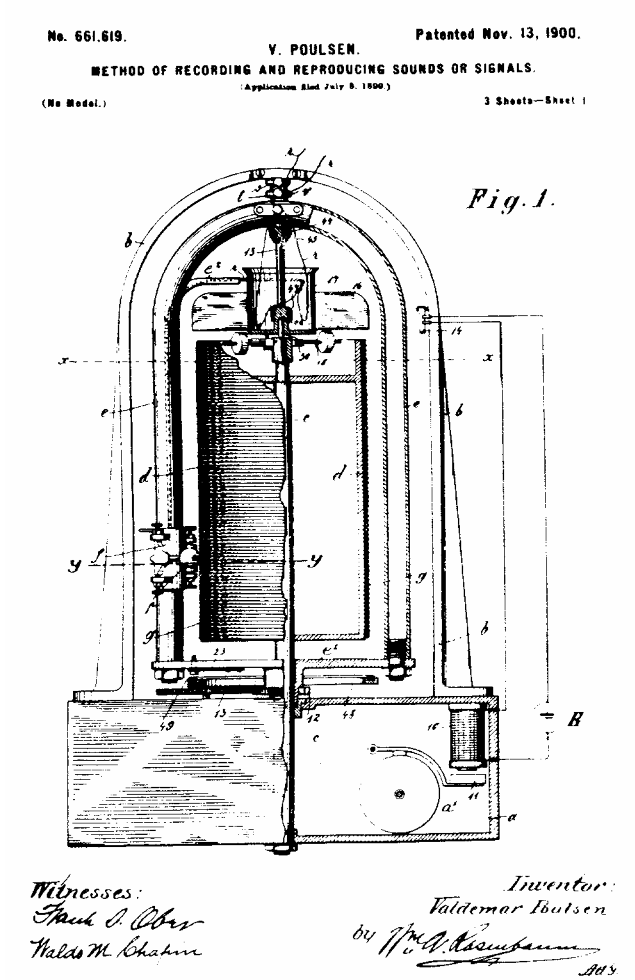
A6 Video Recording

Magnetic recording was developed by Valdemer Poulsen in 1898. Since then, recording media and techniques have improved to such an extent that magnetic tape is often the preferred recording medium. Thus leaving film for certain niche applications.



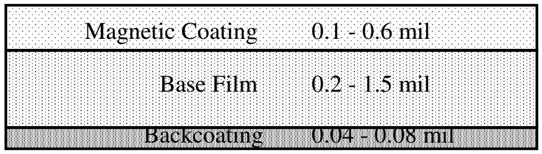
A6.1 Video Tape

Magnetic tape has a 10 octave frequency range [$2^{10} \approx 1000 : 1$], but video signals have an 18 octave frequency range [$2^{18} \approx 260{,}000 : 1$]. This means that without some clever manipulation, video signals cannot readily be put on magnetic tape.

Magnetic tape is composed of three components:

- Magnetic film
- Base film

- Back coating



The magnetic coating is generally comprised of magnetic particles suspended in an organic, polymer binder.

MAGNETIC COATING PROPERTIES[1]

Material	Permeability[†]	Coercivity[†]
Ferric Oxide	5,000	300 - 350
Chromium Dioxide	6,000	300 - 700
Metal Particles	10,000	1,000

Ferric oxide is the most common magnetic recording material. Metal particles suspended in lacquer are used for high performance applications.

The base film is usually made of some form of polyester and gives the tape its strength and stability. Balanced base film has uniform tensile characteristics in both directions. Tapes thinner than .5 mils require a higher tensile strength in the machine direction. These are known as tensilized tapes.

POLYESTER BASE[2]

Property	Balanced	Tensilized
Tensile Strength [N/m^2]	175 x10^6	275 x10^6
Force to Elongate 5% [N/m^2]	95 x10^6	150 x10^6
Elastic Modulus [N/m^2]	3.8 x10^9	7.5 x10^9
Elongation [%]	130	40
Thermal Coefficient [per ^{o}C]	1.7 x10^{-5}	1.7 x10^{-5}
Shrinkage at 100^o C [% over 30 min]	.4	2.5

Professional tapes use a back coating of carbon black to reduce static buildup. This helps to keep the tape clean since it will not as readily attract dust. It also has a lower friction than the base film, and thus helps to eliminate air between windings making for tighter and more uniform stacking.

Heads must be in close contact with the tape if they are to function properly. This eventually causes both the head and tape to self-destruct. The signal loss due to tape and head separation is given by:

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1 Video Engineering, Andrew F. Inglis, Table 6.2

† Permeability - a measure of the ability to conduct a magnetic field.

† Coercivity - a measure of the ability to remain magnetized.

2 Television Engineering Handbook, K. Blair Benson, Table 15-5

_____ Notes _____

$$\text{Spacing Loss } [\text{dB}] = \frac{54.6\,d}{\lambda}$$

d = tape to head spacing

λ = wavelength

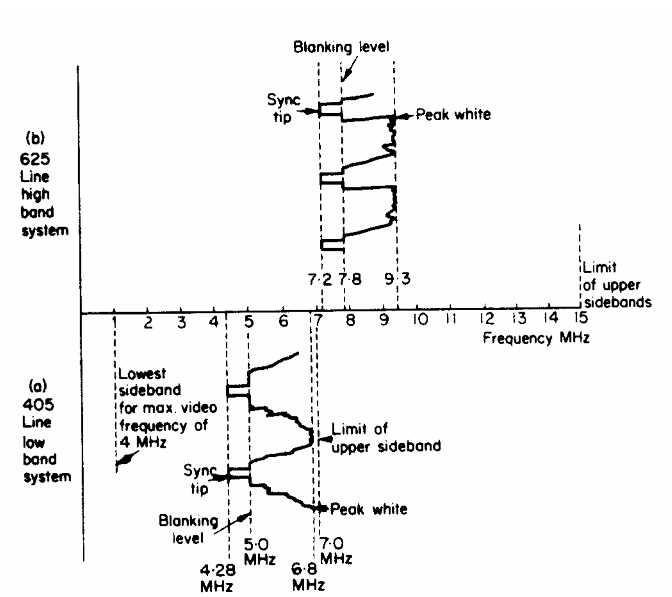
ANALOG RECORDING

Tape heads are comprised of ring shaped, high permeability cores, with a small gap currents induced in coils wrapped through the ring, induce magnetic fields, which bridge through the tape in order to complete their circuit.

The erase head of a tape transport mechanism applies a high frequency magnetic field to the tape. As the tape moves away from the erase head the field intensity diminishes and the tape is demagnetized.

The amount of magnetization is not necessarily a linear function of head current. For this reason, audio recorders add a high frequency bias current to the signal current. Video recorders do not require a separate ac bias since the signal is imposed on an FM carrier. Most commercial video recorders use the baseband video signal to frequency modulate a high frequency carrier. Although FM is not as bandwidth efficient as AM, it provides a much better signal to noise ratio. The chromance signals are generally stripped off and used to amplitude modulate a lower frequency chromance carrier.

HIGH - LOW FREQUENCY TAPE RECORDING[3]



Unlike standard FM, the carrier is deviated in only one direction since the baseband signal is DC. The FM carrier is effectively clamped to the sync tip of the composite video signal. It is also interesting to note that the FM carrier frequency is only slightly higher than twice the highest frequency in the baseband signal.

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3 Electronic Engineer's Handbook, ???. Fig 58.10

In order to improve the S/N ratio in FM recording, preemphasis of the high frequency components is employed.

The first quadruplex recorders used the low band technique and had a bandwidth of 6.5 MHz. This did not allow the upper side frequencies of the FM signal to be recorded. Later version used the high band system which increased the bandwidth to 10 MHz. Current commercial recorders have bandwidths exceeding 15 MHz. This contrasts sharply with domestic VCRs, which have a bandwidth of 7 MHz.

Some broadcast quality video recorders are capable of recording the composite video signal directly.

TAPE DUPLICATIONS

There are three methods used to duplicate videotapes:

- Machine to machine recording
- AC transfer method
- Thermal transfer method

At present, the machine-to-machine transfer method is the most common. This is the same method used for the duplication of audiocassettes, with one notable difference. Audiocassettes can be quickly duplicated with the use of equalizers to compensate for distortion caused by running at high speed. Since the video signal is already contains very high frequencies such compensation cannot be employed. Therefor, video duplication occurs in real time. For mass duplication, a hundred or more VCRs may be placed in parallel.

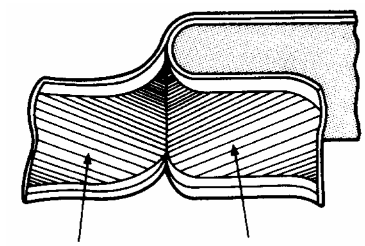
Close quality control must be implemented in the duplication process since any errors introduced by the master player will be added to the record errors of the slave unit. Some of these errors include time base instability, frequency and phase distortion, noise, and chromance luminance delay variations.

To improve the quality of the recording, some professional machines have direct outputs of the chromance and luminance signals at the under frequency. Thus eliminating the need to reconstitute the composite video signal at the master player, only to disassemble it at the recorder.

AC TRANSFER SYSTEM

The master tape must be a mirror image of the final re-recorded tape, and the two must be in intimate contact. The master tape is a high-energy type with a coercivity of about 72,000 A/m. It is placed in contact with a normal ferric oxide tape in the presence of an AC magnetic field. When the field is removed, the lower coercivity tape has its magnetic domains rearranged into the same pattern as the master tape.

TAPE DUPLICATION BY MIRROR IMAGING[4]



The master and slave tapes can brought into contact by winding them onto the same take-up spool [bifilar winding], or they can be wound on separate spools and momentarily brought into contact [dynamic winding]. With the dynamic method, as many as six duplicates can be simultaneously made. It takes six minutes to duplicate a one hour program with this method.

THERMAL METHOD

The Curie point or temperature at which most magnetic properties are lost, for chromium dioxide is lower than that of ferric oxide. A master tape made of ferric oxide is brought into contact with a chromium dioxide tape, at an elevated temperature, and immediately cooled. The slave tape is temporarily demagnetized, and then remagnetized in the same pattern as the master tape.

This process has an advantage over the AC transfer system, in that it does not require the master tape to be a mirror image. There is also no need to modify the control and audio tracks.

ANTI-COPYING SYSTEMS

Numerous techniques have been tried over the years to prevent the unauthorized duplication of video tapes. At the moment, there is no practical method which seems to work universally.

Methods that have been tried focused largely on the difference in the vertical synchronization. In playback, the VCR uses a control track to synchronize the drum, but the TV set uses the sync pulses in the composite video signal. The idea was to distort the sync pulses enough so that the TV could remain in lock, but a VCR recording the signal could not. However, this technique was ultimately doomed to failure since newer VCRs were designed to allow direct recording of weak direct or distorted broadcast signals.

Other suggestions have been the development of non-standard control tracks, but this would require the playing of pre-recorded tapes on modified VCRs.

4 Video Techniques, Gordon White, 1988, FIG 195

Notes

A6.2 Professional Video Recorders

Video tape recorders were initially reel-to-reel units designed to record the composite video signal. As mechanical and servo control techniques improved, it became possible to place the tape into cassettes, and the VCR was born. Later, with the advent of micro-technology, it became possible to include the video recorder into the camera unit. These combined camera-VCRs are known as camcorders.

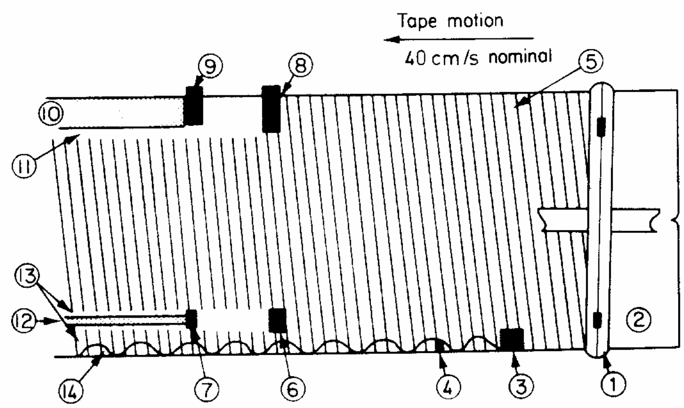
If video recorders used the same method as audiotapes, they would record the video signal as a continuous line of tape. This would require a broadcast quality to move the tape in excess of 50 mph, needless to say, this would consume enormous amounts of tape. Therefore, to reduce tape consumption, video heads move transversely with respect to the tape and record several lines per rotation.

QUADRUPLEX RECORDER

The quadruplex system was developed by Ampex Corporation in 1956 and was in use for some 20 years. It used 2 inch tape which was partially wrapped around a drum which spun at right angles to the tape.

The 2.064 inch diameter headwheel rotated at 240 rps and the tape moved at 15 inches per second. There are 4 video heads protruding 3.6 mils out of the drum, resulting in an effective head-to-tape speed of about 1560 inches per second. The system records 4 x 240 = 960 tracks per second or about 16.5 lines per track. Besides the video heads, the tape transport had three other heads for control, cue and audio.

QUADRUPLEX TRACKS[5]



Quadruplex videotape recorder-arrangement of tracks, 1 head-drum, 2 tape, 3 control track head, 4 edit pulse, 5 video tracks 0.25 mm wide with 15.9 mm guard band, 6 cue track erase head, 7 cue track record/reproduce head, 8 audio trace erase head, 9 audio track record/replay head, 10 audio track, 1.78 mm wide, 11 guard band, 0.5 mm wide, 12 cue track 0.5 mm wide, 13 cue track bands 0.25 mm wide, 14 control track 1.27 mm wide

In the record mode, the 4 video heads are continuously fed the same signal, but in playback mode, the heads are switched on during the blanking interval as they come in contact with the tape.

The quadruplex system remained the industry standard for more than 20 years, but is gradually being replaced by helical scan techniques.

HELICAL RECORDERS

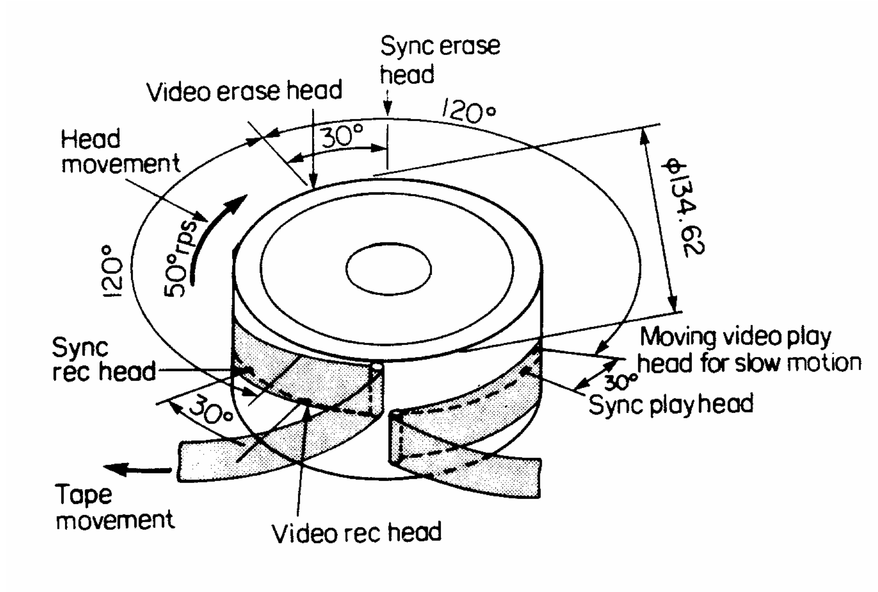
In this type or recorder, the tape is wrapped around a drum in a spiral or helical fashion. The drum contains 1 or 2 imbedded heads and rotates at the frame or field rate. Consequently, the tape track angle is quite low. In helical systems, the head always scans from the bottom of the tape to the top. There are two basic types of wrap: the alpha and omega. These take their name from the Greek letters, which have the same shape as the wrap.

The tape is completely threaded around the drum with the alpha wrap, while it only goes part way around with the omega wrap. The alpha wrap is most often used in reel-to-reel tape transports and the omega wrap is used in self-feeding cassette transports.

5 Electronic Engineer's Handbook, ???. Fig 58.5

_____ Notes _____

Ω WRAP HEAD [TYPE C FORMAT][6]



DYNAMIC TRACK FOLLOWING {DTF]

There is a slight difference between the scanning and track angles. This difference depends on which way the drum rotates with respect to the tape movement. As a result, the playback head will not be exactly aligned over the entire record track during stop action, and the picture quality will degenerate slightly. DTF is often used to overcome this.

Each video head is fitted with a pair of ceramic plates, which allow the head to be dynamically displaced. The head is slightly repositioned when a control signal is applies to the plates. This allows the head to accurately follow the track during slow or stop motion.

TYPE A FORMAT

This format is not suitable for commercial broadcast since there is only one head, and a recording gap occurs when the head crosses from one edge of the tape to the other. Electronic circuitry regenerates the missing vertical synchronization signals.

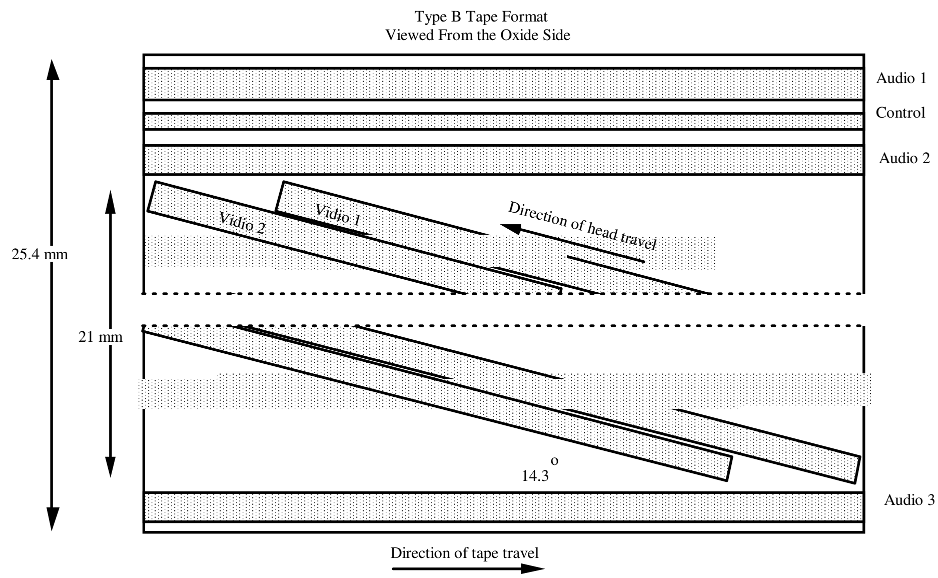
6 Electronic Engineer's Handbook, ???. Fig 58.6

_____ Notes _____

TYPE B FORMAT

Type B is also known as a segmented system because it requires several revolutions to record a single image. Some of its basic characteristics include:

- The drum rotates at 150 rps
- Head velocity is 24 m/s
- Each of two head scans 52.5 TV lines per revolution
- The two heads are 180^o apart, but the tape is wrapped 190^o around the drum to provide a slight overlap
- 5 complete revolutions [10 tracks] are needed to record one frame
- There is no easy way to provide stop action
- Video quality is equal to or better than the quad system



Track	Dimension
Audio 1, 2, & 3	0.8 mm
Control	0.4 mm
Video 1 & 2	80 mm x 160 µm
Video track gap	40 µm

SMPTE RECORDING STANDARDS

Although the above-mentioned recording techniques were used for many years with great success, they have all been replaced by new standards. The current SMPTE† broadcast video recording standards are:

- Type C 1983. Uses a 1 inch tape in a reel-to-reel format.
- M-II uses a 1/2 inch tape in a cassette
- BetaCam This is an upgrade from the now defunct Betamax VCR format, and is used largely in ENG camcorders.

CURRENT SMPTE PROFESSIONAL RECORDING STANDARDS[7]

	Type C	**M-II**	**BetaCam**
Transport	reel-to-reel	cassette	cassette
Geometry	full field	full field dual track	full field dual track
Tape Width [inches]	1	1/2	1/2
Tape Speed [ips]	22	2.6	4.6
Playing Time [min]	126	90	90
Composite S/N [dB]	49	47	47
Luminance S/N [dB]		49	49
Composite BW [MHz]	4.1	4.2	4.1
Luminance BW [MHz]		4.5	4.1
Chromance BW [MHz]		1.5	1.5
Differential Gain [%]	<4	<3	<3
Differential Phase [^{o}]	<4	<3	<3

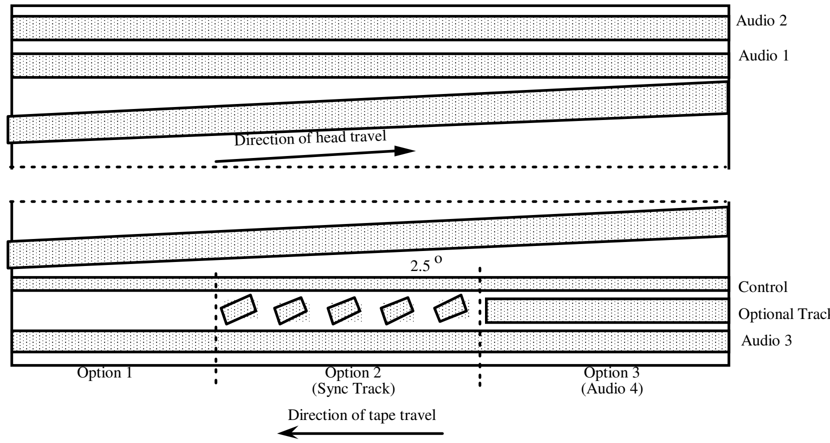
TYPE C FORMAT

Type C is the most widely used format in commercial broadcasting today. It was originally implemented with the reel-to-reel alpha wrap, but is more commonly implemented in the cassette omega wrap configuration. The video recording head tape velocity is 21.38 m/s.

† Society of Motion Picture and Television Engineers

7 Video Engineering, Andrew F. Inglis, Table 6.3

Type C Tape Format
Viewed From the Oxide Side



Track	Dimension
Audio 1, 2, 3, & 4	0.8 mm
Control	0.6 mm
Video	300 mm x 16 mm

This method allows slow motion or still frames to be generated. A sync track is provided to identify even and odd fields, thus providing a stable picture in stop action mode. These machines may also allow for variable forward and reverse speeds.

If a replay head is placed behind the record head, the record quality can immediately be checked. It can also be used to provide AST or automatic scan tracking, which centers the main head on the track and maximizes the signal level.

RECORDING FREQUENCIES [MHZ][8]

	NTSC	**PAL**
Peak White	10.0	9.3
Blanking	7.9	7.8
Sync Tip	7.06	7.06
Carrier Deviation	2.1	1.5

The FM modulation index for this recording system is about .7 in contrast with 2.5 for radio broadcast systems.

[8] Video Engineering, Andrew F. Inglis, Pg 171

_____ Notes _____

Some basic characteristics of the type C recording head:

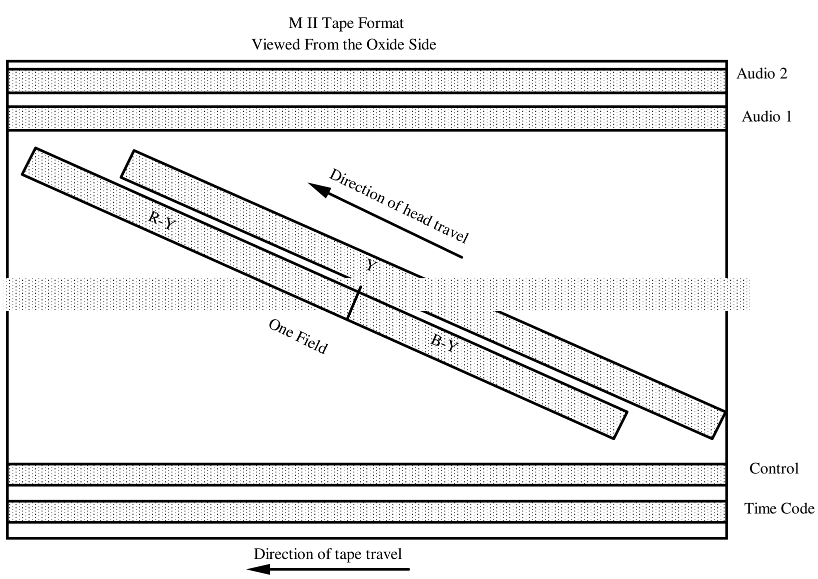
- There are 6 heads on the scanner drum:
  - 2 tracks record video
  - 2 tracks provide stereo audio
  - one track records an 80 bit time and frame identifying code which is used for synchronization and editing
  - one track is reserved for special features on full information machines
- Separate record and erase heads are used to assist in editing
- The video track has a 10 line signal gap during the vertical interval
- These 10 lines are recorded on a separate sync track
- One field is recorded per revolution
- Easy to implement stop action

M-II RECORDERS

The video information is placed on the tape in parallel paired tracks. One track contains the Y signal, and the other contains the time multiplexed color difference signals R-Y and B-Y. Unlike the C format, the tape and head rotate in the same direction. The tape moves at 2.6 inches per second.

Separating the luminance and chrominance signals into two separate tracks helps to eliminate any cross coupling between them. Recording the color difference signals allows the video signal to be readily converted to any of the standard broadcast chroma formats, since they are all based on the color difference signals.

M II TAPE FORMAT[9]



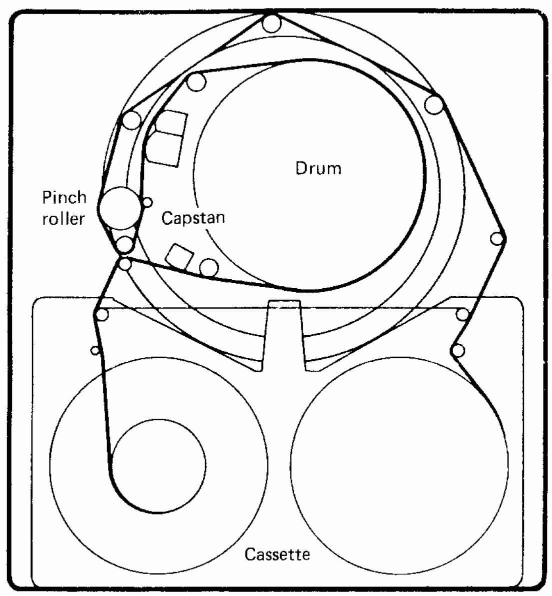
9 Based on Fig 6-15, Video Engineering, Andrew F. Inglis

BETACAM RECORDERS

The standard BetaCam video recorder uses 3 CCD image sensors to generate the video signals, although some use saticon or plumbicon tubes.

The BetaCam tape format is nearly identical with that of the M-II system with the notable exception of tape speed. The BetaCam system runs at 4.6 inches per second, nearly twice that of the M-II and thus requires a larger cassette. It provides negligible improvement in quality.

BETACAM TRANSPORT MECHANISM[10]

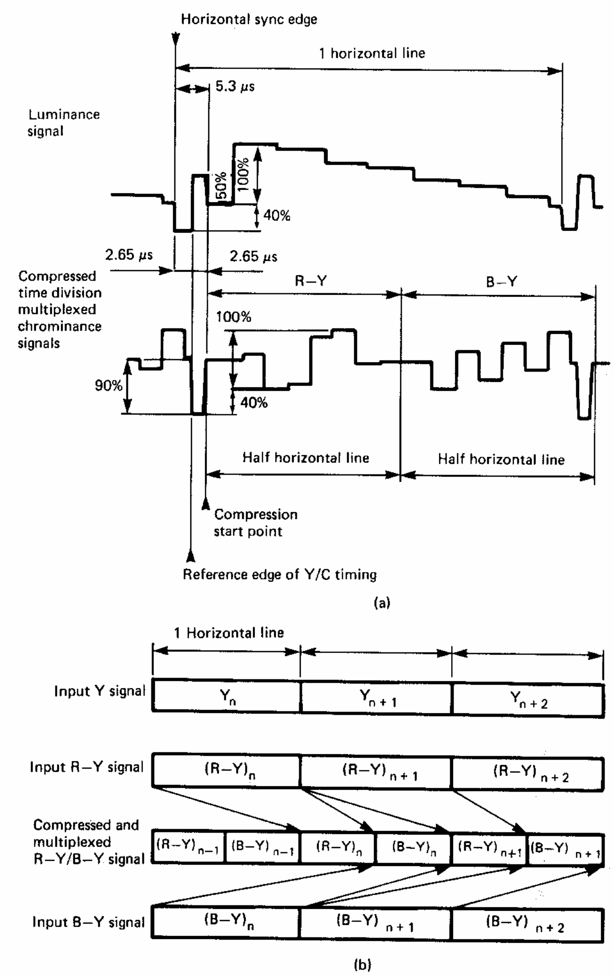


Betacam mechanism

The chromance and luminance signals are recorded on separate, parallel tracks. The color track consists of time compressed, multiplexed color difference signals. R-Y is followed by B-Y

10 Video Techniques, Gordon White, 1988, FIG 143

BETACAM CHROMA PROCESSING[11]



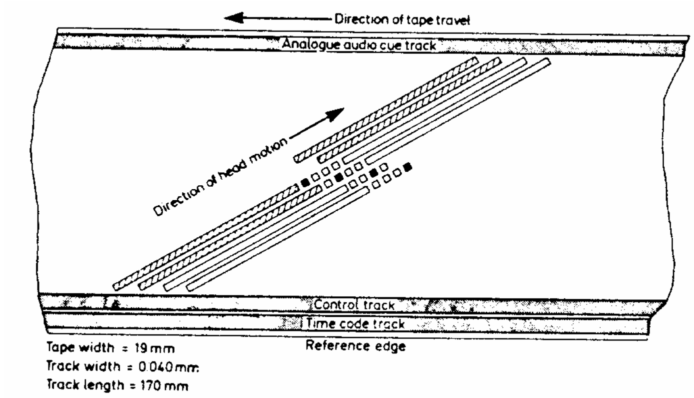
Betacam chrominance processing. R–Y and B–Y signals are compressed into time of a single line. (a) waveform of compressed signals; (b) time compression and multiplexing system; (c) block diagram of the video signal system (page 166)

DIGITAL VIDEO RECORDER

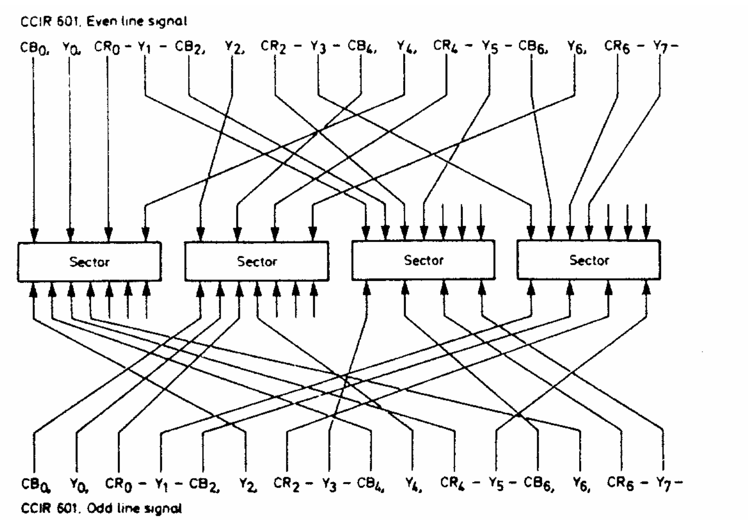
Sony has developed an all-digital video recorder. The audio and video signals are recorded as data bursts. The audio and video bytes are rearranged in such a way, that any errors caused by tape defects or damage, are distributed throughout the final image. This aids in error correction.

[11] Video Techniques, Gordon White, 1988, FIG 141

DIGITAL TAPE FORMAT[12]



DATA DISTRIBUTION[13]



A 50 line segment is split into four sectors and the video data is distributed between the sectors according to a pre-arranged program. The terms Y_o (luminance), CB_o (colour components) are time coincident. Where a '–' occurs it indicates there is a separation in time between the components

12 Video Techniques, Gordon White, 1988, FIG 324

13 Video Techniques, Gordon White, 1988, FIG 327

Notes

A6.3 Domestic VCRs

CASSETTE SIZE COMPARISON[14]

Cassette	Tape Width [mm]	Cassette Size WxHxD [mm]	Volume Ratio
8 mm	8	95x62.5x15	1
Beta	12.65	156x96x25	4.2
VHS	12.65	188x104x25	5.5
Audio	3.8	102x63x12	.87

COMPARISON OF PROFESSIONAL AND DOMESTIC VCRS

	Domestic	Professional
Price	$500	> $30,000
Size	4”x14”x12”	10”x17”x21”
Weight	< 10 kg	30 kg
Recording Time	2 to 6 hrs	1 to 1.5 hrs
Luminance Bandwidth	2.5 - 4 MHz	4.3 MHz
Composite S/N	45 - 47 dB	49 dB
Differential Phase	10°	3°
Timebase Instability	> 1 µsec	2 nsec

Price, size and weight are probably the three most important considerations in home VCRs. In professional machines, time-base stability is probably the most important consideration.

Of the three principle types of VCRs, U-Matic, Beta, and VHS, the most popular is VHS. Although many thought that Beta was a better format, it had only one half the playing time of VHS.

VHS

All VHS machines lay down audio and video tracks in the same manner, but there are no visual standards that players must meet. Consequently, there is a great range in the quality of recorders on the market.

Most recorders offer two or three playing times. While the tape transport speed changes, the tape to head speed of 229 inches per second, remains constant. Since there is no guard band between tracks, the track width varies and there is a change in picture quality.

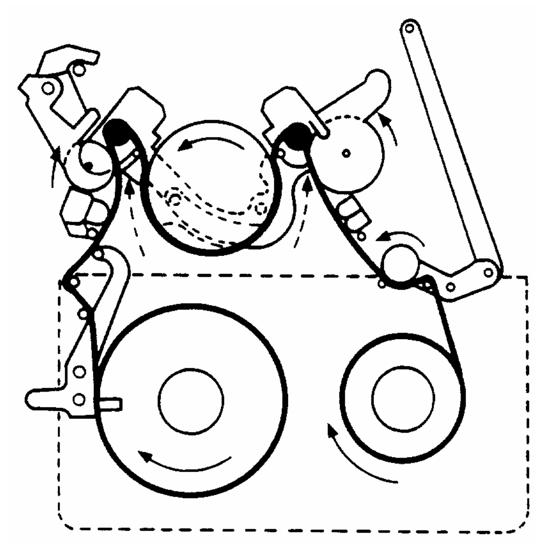
Recording Mode	Playing Time [hrs]	Track Width [mils]
Normal	2	2.3
Long Play	4	1.15
Super Long Play	6	.76

14 Video Techniques, Gordon White, 1988, page 171

VHS players come in one of two drum sizes. Both types are fully compatible.

	Standard VHS	Small Drum VHS
Drum Diameter [in]	2.42	1.6
Heads	2	4
Wrap Angle	180^0	270^0

STANDARD VHS DRIVE MECHANISM[15]



One of the techniques which is used to improve the S/N is azimuth recording. Instead of the video record head gap being at 90° with respect to the track, it is tilted by ±10° or ±15°. Adjacent heads are tilted in the opposite direction. This permits the use of slightly larger heads while reducing adjacent track pickup, since there is no guard band between tracks.

VHS FM VIDEO RECORDING PARAMETERS

Sync Tip	3.4 MHz
White	4.8 MHz
Chroma Subcarrier	629 KHz

Single channel audio is recorded on a 1.5 MHz FM carrier and stereo is recorded at 1.4 and 1.6 MHz. Some VCRs record audio on longitudinal tracks near the edge of the tape, but current domestic VCRs record the audio track directly on top of the video track. The audio channel has an azimuth angle of ±30°. Signal isolation is maintained by differences in:

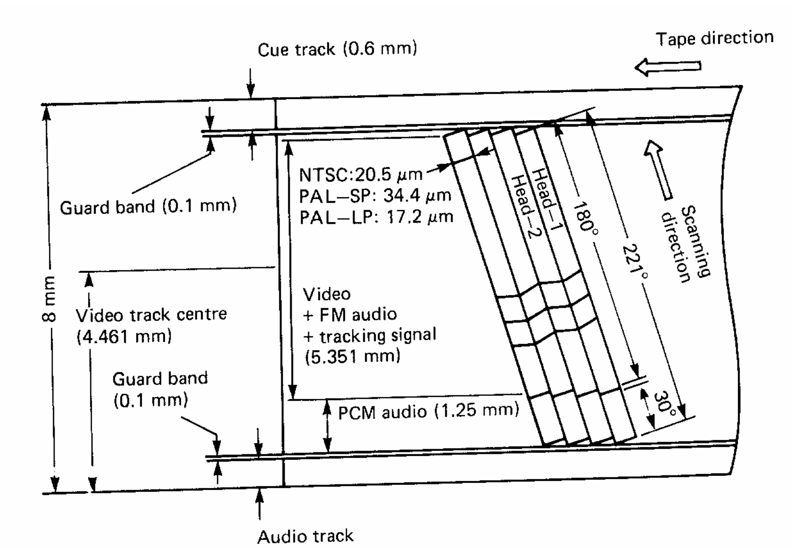
- Carrier frequencies
- Head azimuths
- Recording strength

[15] Video Techniques, Gordon White, 1988, FIG 109

8MM VIDEO RECORDERS

There are two modes of play in the 8 mm format: standard play [SP], and long play [LP]. In SP mode, the tape speed is 2 cm/sec, and a tape will play for one hour. In the LP mode, the speed is cut in half, with a resultant loss in signal quality.

8MM TAPE FORMAT[16]



8 mm tape format

This system does not use a control track to synchronize the servo motors. Instead, an automatic track finding [ATF] technique is used, in conjunction with low frequency pilot tones. Two tones [f1 and f3] are alternately recorded on channel 1, and two tones [f2 and f4] are alternately recorded on channel 2. They are recorded about 14 dB below the chromance signal to prevent signal interference.

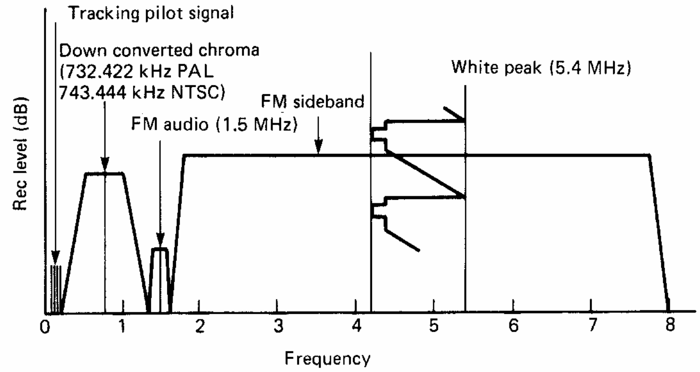
8 MM ATF TONES [KHZ]

	NTSC	PAL
f1	102.5	101.024
f2	119.0	117.188
f3	165.2	162.760
f4	148.7	146.484

The player recovers the ATF tones from tracks adjacent to the playback track and creates a difference frequency. The difference between f1 - f2 and f3 - f4 16 .5 KHz and the difference between f1 -f4 and f2 - f3 is 46.2 KHz. The tape speed is adjusted to keep these difference frequencies constant.

16 Video Techniques, Gordon White, 1988, FIG 146

8MM SPECTRUM[17]



Recorded signal spectrum of 8 mm format

A6.4 Video Disks

Video disks come in two basic forms: contact and non-contact. Contact disks have a stylus that touches the disk and uses the varying capacitance to regenerate an FM signal. Non-contact disks use laser technology and are somewhat similar to audio CDs† or CD-ROMs. Vinyl audio records have approximately 6 grooves per millimeter whereas video disks have between 400 to 700 grooves or tracks per millimeter. Several types of videodisk systems have been developed, including:

- Teledec by Telefunken/Decca
- RCA CED† Video Disk
- JVC VHD† Video Disk
- Thomson Video Disk
- Philips LaserVision

Of these, the JVC VHD contact system is the most widespread.

Most videodisks play from the outside in, like conventional vinyl records. Some however, are designed to play from the inside out, like audio CDs. This has the advantage of allowing the start of play mechanism to be the same regardless of the size of disk.

□Disks can be recorded with either a CAV† or CLV† format. CAV systems support stop motion imaging, since a frame can be stored in one revolution or less. CLV systems on the other hand, have longer playing times since the

17 Video Techniques, Gordon White, 1988, FIG 145

† Compact Disk

† Capacitive Electronic Disc

† Very High Density

† Constant Angular Velocity

† Constant Linear Velocity

linear recording density is constant. However, they require more complex servo systems since the angular velocity is not constant. CLV disks rotate at 600 rpm when playing an outside track, and 1800 rpm when playing an inside track.

As in tape systems, videodisks place the audio and video information on an FM carrier. This is used to vary the duty cycle of a series of pits placed on the disk. The sensing devices detect either the varying capacitance or optical reflection/conduction.

STANDARD CAV SPEEDS

RPM	Frames Per Revolution
450	4
900	2
1800	1

CAPACITIVE DISKS

TELEDEC

This system, introduced in 1970, used a recording method similar to that of vinyl records, except that a hill and dale spiral grove was used. A pressure sensitive stylus run along the grove generated a signal proportional to the vertical movement. The signal was encoded using an FM carrier as in video tape recording.

TELEDEC FM RECORDING PARAMETERS

Signal	MHz
Sync Tip	2.8
Black	3.22
White	4.2
Channel 1 Audio	.8
Channel 2 Audio	1.07

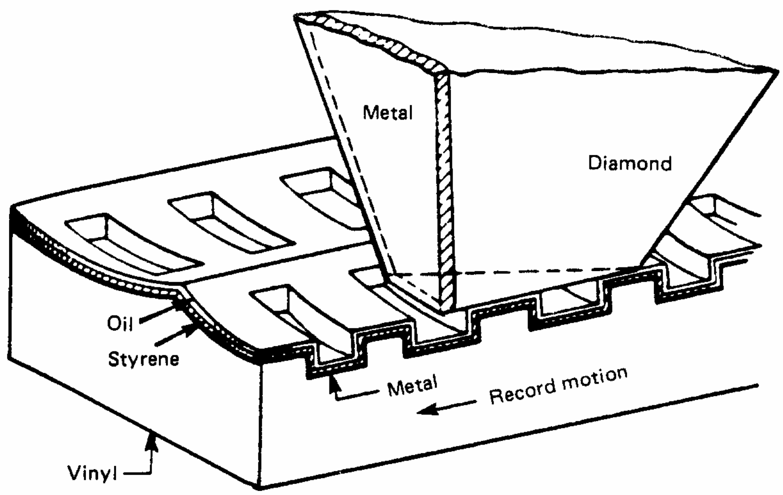
OTHER RECORDING CHARACTERISTICS

Characteristic	Comment
Frames per Revolution	1
Disc Diameter	120 mm
Disc Thickness	0.12 mm
Modulation Depth	0.3 µm
Track Pitch	3.6 µm
Groove Density	280 grooves/mm
Playing Time	10 minutes

The video signal was recorded using a line-sequenced red, green, blue mixed high system. Each recorded line of video contained one of the three color difference signals and the luminance signal.

RCA CED

This system used a combination of spiral groove and pits. The groove itself was used for tracking but at the bottom of the grove were pits corresponding to the video signal. A diamond with a metal electrode is used to sense the changing capacitance caused by the pits.



Capacitive stylus and Inconel-coated disc. *(RCA Corp.)*

RCA CED FM RECORDING PARAMETERS

Signal	MHz
Sync Tip	4.3
Black	5.0
White	6.3
Channel 1 Audio	0.716
Channel 2 Audio	0.905

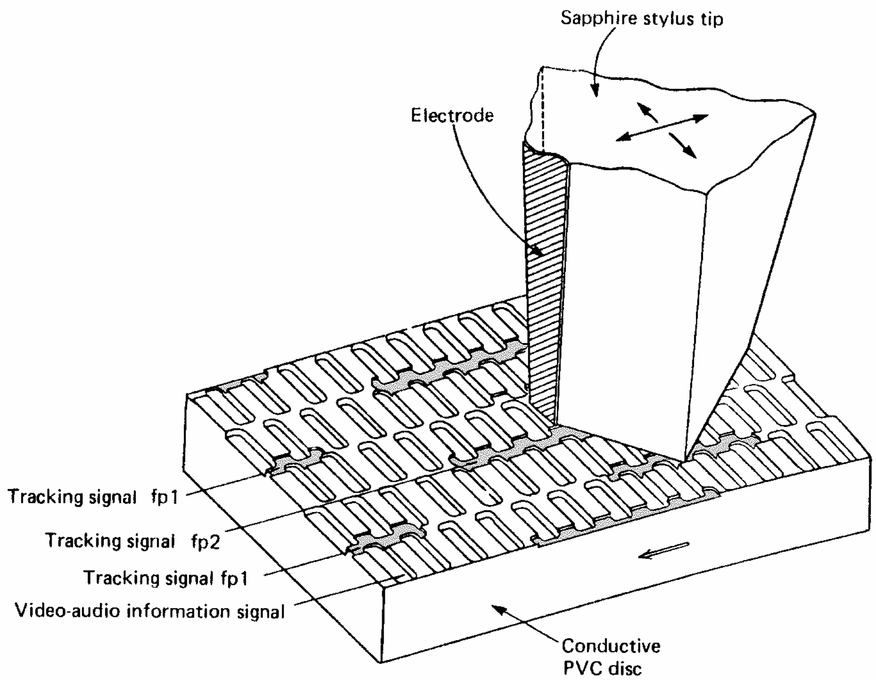
OTHER RECORDING CHARACTERISTICS [NTSC VERSION]

Characteristic	Comment
Frames per Revolution	4
RPM	450
Disc Diameter	279 mm
Disc Thickness	1.9 mm
Groove Depth	0.48 µm
Modulation Depth	0.085 µm
Track Pitch	2.68 µm
Playing Time	1 hour/side

CEDs are quite susceptible to damage caused by handling or dust.

JVC VHD VIDEO DISK

The VHD system, introduced in 1978, is similar to the SelectaVision system, in that it uses the same type of sensor to measure the capacitance between the disk surface and pit bottom. The pits all have the same width and depth, but vary in duty cycle. On either side of the video-audio track, is a series of shallow pits used for tracking. By sensing the lower frequency component recorded on these tracks, the stylus can adjust its position.



VHD conductive disc and stylus. *(Victor Company of Japan, Ltd.)*

VHD CED FM RECORDING PARAMETERS

Signal	MHz
Sync Tip	6.1
Black	6.6
White	7.9
Left Audio	3.426
Right Audio	3.733
Tracking Carrier 1	0.275
Tracking Carrier 2	0.551
Tracking Carrier 3	0.716

OTHER RECORDING CHARACTERISTICS [NTSC VERSION]

Characteristic	Comment
Frames per Revolution	2
RPM	900
Disc Diameter	279 mm
Disc Thickness	~ 2 mm
Signal Pit Depth	0.085 µm
Tracking Pit Depth	0.12 µm
Track Pitch	1.35 µm
Playing Time	1 hour/side

The disk is susceptible to damage and dust, and is therefore kept in a caddie. The disk rotates at 750 rpm in the PAL version and 900 rpm in the NTSC version.

OPTICAL DISKS

PHILIPS LASERVISION

Tiny pits were burned into the disk and covered over with a clear acrylic finish. The pits have a constant width and depth, but vary in length and spacing. A low power HeNe laser beam is focused on the disk, and the reflected signal detected. Initially, CAV was used and provided 36 minutes of programming on each side of the disk. Later a CLV version was developed. The disk rotated at 1500 rpm when playing inner tracks and 500 rpm when playing outer tracks.

PHILLIPS FM RECORDING PARAMETERS

Signal	MHz
Sync Tip	7.5
Black	8
White	9.2
Channel 1 Audio	2.3
Channel 2 Audio	2.8

OTHER RECORDING CHARACTERISTICS

Characteristic	Comment
Frames per Revolution	1 [CAV version]
Disc Diameter	305 mm
Disc Thickness	2.5 mm
Track Pitch	1.6 µm
Groove Density	280 grooves/mm
Playing Time [per side]	30 minutes [CAV] 60 minutes [CLV]

THOMSON VIDEO DISK

This system is similar to the Philips disk, with the notable exception that the disk was transmissive instead of reflective. The color difference signals R-Y and B-Y were recorded sequentially on a 3.6 MHz subcarrier, very much like the SECAM system.

The horizontal sync was suppressed and replaced by a 42 bit digital signal. Of these, 40 were used for the two audio channels, one for chromance sync and the other to identify the top and bottom of the disk. Amazingly enough, both sides of the disk could be used.

THOMSON FM RECORDING PARAMETERS

Signal	MHz
Sync Tip	~7.5
Black	8
White	~9.5
Right Audio	2.8
Left Audio	2.3

OTHER RECORDING CHARACTERISTICS

Characteristic	Comment
Frames per Revolution	1
Disc Diameter	301.6 mm
Disc Thickness	2 mm
Track Pitch	1.67 µm
Groove Density	640 grooves/mm
Playing Time	30 minutes [CAV] 60 minutes [CLV]

The following information was obtained from:

http://rodan.asu.edu/~guy/Formats.html

One of the primary technical considerations associated with producing quality video is the particular tape format one chooses for production. The term "tape format" refers to the specific type of tape and VCR used in the recording process. Just as there are various personal computer floppy disk drives, including 5 1/4" and 3 1/2", so too are there a variety of different sizes a grades of videotape and video recording equipment.

Most people are familiar with the popular VHS format, which is by far the most common of all videotape recording systems. This is primarily due to the low cost of VHS recording equipment and its wide acceptance in the consumer video industry. In fact, in all likelihood, regardless of which format you choose for the production of video Master tapes, the final distributed copies will usually be recorded on VHS because of the large availability of playback machines. Although the VHS system is very popular and the equipment is relatively inexpensive, it is designed for consumer use, and therefore is not a good choice for professional video production. The image quality of VHS does not meet professional "broadcast" standards, nor is the equipment generally built to stand up to the rigors of a professional production environment.

Professional video recording equipment can broadly be grouped into two separate categories: Broadcast and Professional or Industrial. Within each of these categories further divisions can be drawn between Digital recording technologies and Analog recording technologies. Below is a list of the current popular formats used in video production.

Broadcast Quality - Digital

D1: This format was introduced in 1986 and is currently the cr□me de la cr□me of video formats. It is a component format designed to be installed in a completely digital environment. The extremely high cost of D1 recorders (on the order of $100,000) limits there use to only the very elite production facilities that incorporate many special effects with multiple layering of the video signal. Such special effects layering does not degrade the image quality in the pure D1 digital environment. The D1 format supports four digital audio tracks and separate longitudinal tracks for SMPTE timecode, control track, and cue audio. The digital video is read from 12 video heads and recorded on the highest quality metal-particle tape. D1 video cassettes come in small, medium, and large housings.

D2: This is a composite format, but the quality is so high that signal degradation due to the mixing of video information is kept to a minimum. This format was introduced in 1988, and is very popular in high end post-production facilities. D2 is not a pure digital format, as the inputs and outputs are standard analog composite ports. Although this may degrade the digital signal somewhat, it does offer the advantage of integrating D2 with other existing equipment.

D3: This format was introduced by Panasonic in 1991, and has been touted as a low cost digital alternative with an outstanding price/performance ratio. D3 is also a composite format like D2, but information is recorded on a 1/2" tape, similar in size to standard VHS. This offers the unique advantage of smaller portable equipment, as well as lower costs.

D5: This is another low cost/high performance digital format introduced by Panasonic. Again, this format uses a 1/2" cassette mechanism, but this is a component format rather than composite. This is the newest digital format and its common use and acceptance have yet to be determined. However, it appears to be directed at the same production markets as is D1.

Broadcast Quality - Analog

Prior to Digital videotape formats, Analog technology was the only method of recording video signals. While analog is not as sophisticated as digital in many respects, it is a very mature technology and the best analog VCRs do produce first-generation picture quality equal to that of digital systems. High quality analog systems are still widely used throughout the professional video production industry and are likely to remain popular for some time to come.

One-inch Type C: Since its introduction in 1978 1-inch has been the premium choice format in broadcast television studios and high end post-production houses. Of all of the formats mentioned in this list, 1-inch is the only one that is not housed in a cassette mechanism of some kind. Instead 1-inch uses a "reel-to-reel" transport much like many high end audiotape formats. The Type

C format replaced the 2 inch "Quad" systems as the premium standard of the time because it was the first to offer many of the features in a videotape format that we currently take for granted, such as: viewable still-frames, slow and fast motion, and picture in shuttle.

Betacam & Betacam SP: The original Betacam format was introduced by Sony in 1982. It was the first component video format and was developed as a professional version of the then fairly popular 1/2" Betamax consumer video format. The professional quality was achieved through the component approach of recording the inherently separate portions of the video signal (chrominance and luminance) as separate signals on the tape to avoid them interfering with each other. Betacam SP was introduced in 1987 as an improved version of the original Betacam; improvements were primarily by using a metal particle tape capable of recording a higher bandwidth of video information. Betacam and Betacam SP have become the de facto field acquisition standard for most television stations and high end production houses.

M & M-II: These two formats are quite similar in their performance and history to both Betacam and Betacam SP. The original M format was introduced by Panasonic in 1982 and was promoted as a major upgrade from the original VHS consumer system, which had been introduced by JVC earlier. M is a 1/2" component system like Betacam, but processes the signal differently, and like Panasonic's digital tape formats it was generally less expensive than the Sony counterparts. M-II was introduced in 1986 as a major upgrade to the original M format which never received a great deal of acceptance in the professional video industry. And while M-II has not been as widely adopted as was Betacam (accept for nearly all of the nation's NBC television station affiliates who bought into the format under pressure from the network during the 1988 Olympics) in the professional industry, it is still a very fine format that produces excellent pictures for a reasonable cost.

Professional or Industrial

The majority of the video produced today (not even taking into account consumer home video) is not intended for broadcast television. It has been reported that 80% of activity in the video production falls into the category of Industrial Video. The terms Industrial and Professional grade video production refer to producing programs for corporate presentation work, training programs, point-of-sale informational tapes, and educational programming. Video equipment designed for the production material that is not intended for television broadcast does not have to adhere to the demanding standards in image quality or equipment durability that is generally required in broadcast television. A variety of relatively low-cost video formats have been developed for use in the

Professional grade industry.

3/4" U-matic & 3/4" SP: This format was introduced in 1972 by Sony and was originally promoted as a consumer system, because it was the first to use a cassette which was viewed as a major simplification of the video recording process. While the equipment costs kept U-matic from being widely accepted in the home, the cassette mechanism did enable it to be easily used for news acquisition, which until that time news had primarily been gathered on 16mm film.

Three-quarter-inch SP was introduced in 1985 and again achieved improvements over the original format by utilizing a high bias metal particle tape. U-matic was eventually replaced in news stations with Betacam, but it has been very popular for over twenty years in the professional market only recently being superseded by a relatively new format - SVHS.

SVHS: Ironically S(uper)VHS was also introduced in 1987 by JVC as a high end consumer video format. However, it too suffered from the high cost of equipment compared to other consumer electronics as did the original U-matic. But again, this format was perceived by the professional industry as an attractive alternative to existing formats. The 1/2" tape cassettes made for lighter and less costly equipment and the picture quality was as good and in some respects better than many U-matic systems. SVHS has recently become the industry standard for professional grade video production. The high picture quality of SVHS is achieved through as pseudo-component system dubbed 'S-video' which does separate the chrominance and luminance signals, although not as purely as do the true component systems such as Betacam. Standard VHS tapes may be played and recorded on an SVHS system, but the reverse is not true.

8mm & Hi8: This is the smallest video format available, with cassette mechanisms not much larger than a standard audio cassette tape. While standard 8mm is strictly a consumer format, which yields an image quality less than that of VHS, the improve S-video Hi8 introduced in 1988 has become quite popular in professional grade equipment. Not only does the tape produce an extraordinary image for its size (for any size for that matter) but the recording equipment is also very small, light, and relatively inexpensive. Many of the images gathered from the recent Gulf War were acquired on Hi8. The small equipment was inconspicuous and cheap enough to be easily disposed of if necessary, yet the 1st generation images approach being broadcast quality. Hi8 is an exceptional format.

Video Formats of the Future

Undoubtedly digital video acquisition will continue to develop as an emerging technology. However, advancements in videotape may have come about as far as they are going to. Manufactures are just now beginning to research and develop disk-based recording systems. While Digital Video production has been on the

rise for the past few years in the field of post-production graphics and editing, a viable field acquisition system has yet to be introduced. However, two major video production equipment manufactures (Ikegami a camera manufacture, and Avid a Non-Linear editing system company), neither of which are tied to the sales of an existing videotape format, have announced plans to join forces on the development of a camera/disk recording system. A working prototype has been promised for 1995. As other manufactures enter the field of non-linear digital video production, more camera/disk recording systems are sure to follow. However, it is important to note that all current video -to-computer disk recording systems rely on the compression of the incoming video signal to get it to fit manageably on a disk. This compression inherently degrades the image quality. Therefore, it is safe to assume that so long as such compression is necessary, it will still be some time before disk based systems replace the highest quality broadcast videotape formats.

A6.5 Summary of Recording Formats

The following table was obtained from:

http://www.hdtv.com/papers.htm

Analog Recording Formats

Format	Features	Intro - duced	Interfaces	Recorder Cost	Applications
Quad	First Videotape	1956	NTSC RS -170	$100K?	All NTSC Recording until 1970s
Type C	First Professional Helical Scan Recording	1972	NTSC RS -170	$100K?	Professional Recording 1975 - 1990
U - matic	First VCR	1969	RS -170, Y -688	$2K	1st Use of Video for News Gathering
Betacam	1st Professional Analog Component	1985	CAV	$30K (obs.)	News Editing
M II	Analog Component	1987	CAV	?	News Editing, Low -end Production
Betacam SP	Enhanced BW Analog Component	1989	CAV	$30K (obs.)	News Editing,

Consumer Analog Formats

Betamax	First Home VCR	1976	NTSC RS -170	$1K	Home Video
VHS	First Non - Sony VCR	1980?	NTSC RS -170	$0.2K	Home Video
SVHS	First Full - Bandwith Heterodyne VCR	1988	NTSC RS -170, SVideo	$0.5K (Consumer) $2.5K (Industrial)	Home, Industrial Video
Hi8	First Full - Band Compact VCR	1989	NTSC RS -170, SVideo	$1K (Consumer) $7K (Industrial)	Home, Industrial Video

Notes

Digital Video Formats

Format	Features	Intro - duced	Interfaces	Recorder Cost	Applications
D1	First Digital Component	1987	D1 Serial, Parallel	$120K	High -Quality Post Production
D2	Digital Composite	1988	D2 Serial, Parallel	$65K	Broadcast Station
D3	D2 in ½" Cassette	1990	D2 Serial	$50K	Broadcast Station
D5	D1 in ½" Cassette, 10bits	1993	D1 Serial	$72K	Post Production
Digital Betacam	1st Professional Digital Compressed Format	1994	CAV 4:2:2	$50K	Field, Low -Cost Production
D5 -HD	4:1 DCT Compression of 1125/60 to D5	1996	HD Serial	$150K	HDTV Research, NHK Broadcasts
Betacam SX	1st Professional MPEG	1996	CAV	$30K	Field, News Production
DV	1st Analog Digital Video	1996	NTSC, IEEE -1394	$3K	Serious Consumers
DVCPRO	2X bitrate DV	1996	NTSC, IEEE -1394	$17K	News Production
HD -2000	1125, 720 line and Proscan formats to D5	1997	?	$95K	HDTV
D6	Costs More	1997	SMPTE 240, 260	$400K	HDTV

Assignment Questions

1. The baseband video signal is used to [amplitude, frequency] modulate a carrier before it is placed on video tape.
2. [Quadruplex, Helical] tape recorders have heads which scan the tape at nearly right angles.
3. Stop action cannot be provided on video recorders which use type [A, B, C] format.
4. Automatic scan tracking can be provided if a replay head is placed [before, after] the record head.
5. Describe the basic characteristics of the following recording formats:

   a) Quadruplex

   b) Helical type A

   c) Helical type B

   d) Helical type C

6. Explain how it is possible to record a video signal which has an 18 octave frequency range onto magnetic tape which has only a 10 octave range.
7. What modulation scheme is used for the luminance signal recording on domestic VCRs?
8. Discuss and illustrate videotape recording from the following standpoint:

   a) Transport Mechanisms
   - quadruplex
   - helical

   b) Formats
   - quadruplex
   - C format
   - B format

   c) Modulation
   - luminance
   - chromance

   d) Non-video Tracks

   e) Features
   - frame freeze
   - slow motion

_____ Notes _____

For Further Research

Lowman, Charles E., Magnetic Recording, McGraw Hill, 1972

http://www.eklektix.com/dat-heads/

http://www.cd-info.com/

http://www.ww-radio.ch/pmc_tech.html

http://www-eu.philips.com/research/fields/trans/

http://www.magnavox.com/product/pv331vcr.html

http://www.philipsmagnavox.com/product/pv331vcr.html

DVD http://www.optibase.com/