



DV Format

Digital Video

1. Preparing for the Digital Age

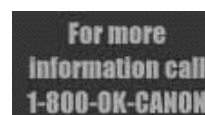
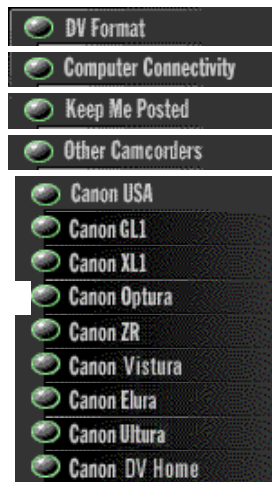
Television, which began life in the 1930s, and which grew to become the major focal point of family life in the second half of this century, gave birth to the Video Age in the 1970s, with the invention and mass appeal of the consumer video cassette recorder (VCR). Our view of culture and society has been completely transformed because of this relatively simple and accessible medium. The VCR and the camcorder have created new definitions for the way we see ourselves and added a variety of new terms and expressions to our language.

Now the Video Age is going through a major revolution with the arrival of digital video. This momentous development will bring new opportunities, creativity and a wealth of new technology to our fingertips. Video as we know it will be replaced with a new focus, as the advantages of digital video are universally recognized.

But revolution by its very nature is about upheaval and confusion, as people have to learn new ideas and a new language. There is both information and misinformation to wade through, and relatively simple principles have been made unnecessarily complicated, intimidating, or (worse still) boring. It is our aim to bring this subject to you in a clear and concise way, so you can easily understand the potential of digital video.

2. Why Go Digital?

Simply put, video has taken us a remarkable distance in a relatively short period of time. We have grown used to the ability to connect a fairly inexpensive VCR to our TV, and to



record programs on an inexpensive video tape. It is this low cost/high benefit situation that will keep what is called analog video in use for many years to come. Now analog technology has been surpassed.

The reason for this is that recording video digitally delivers remarkably better picture quality, sharper images and better color reproduction. And isn't that kind of improvement what we're always looking for? On top of that, digital copies of digital videos are unrecognizable from the original, which makes editing and image manipulation -- even at the level of the average camcorder user -- so much easier and with higher quality than that delivered by analog video technology.

Before we go any further, it is essential that we understand the difference between analog and digital video, otherwise the digital revolution will pass us by.

With analog video, light and sound are captured and recorded as electrical signals, transmitted as waves that can be represented by the up and down movement of a line. These signals look like mountain peaks and valleys, with variations in the height of the mountain and the depths of the valley, and variations in the distances between peaks and between valleys. With light, those variations are the differences between dark and very bright, as well as colors; and with audio, the differences are between no audible sound and very loud sound. Another way of looking at these waves is to imagine them as waves on the ocean -- infinitely variable -- going from dead calm to large waves. There is just as much variation in the electrical signals captured on analog.

The problem with analog recording is that it is hurt by interference which can reduce the quality of the electrical signal and make the recorded picture quality far worse than what was captured by the camera or VCR. Going back to our mountain analogy, the interference can change the height of the mountain tops and the depths of the valleys -- make them seem higher or lower -- changing the actual recording so that it no longer accurately represents the true image.

Analog video is also affected by timing errors, so what should be a straight vertical line, such as a telephone pole, will play back wavy instead.

Digital recordings don't have to deal with the wide variations found in analog recording. Digital recording is binary, with its electrical signals consisting of just two values, "on" or "off" ('1' or '0') -- there's a signal there, or there isn't. Should there be interference, while it may alter the strength of the "on" or "off" signal, the circuitry of the digital equipment can still tell whether the signal is "on" or "off" -- that's all it has to do. In a language of 1s and 0s, a message can be translated clearly. This makes digital recording almost immune to signal problems, and results in the highest quality picture and audio. This is a major advantage over analog. Digital is the language of computers. Computers easily store and transfer binary signals, from machine to machine, disk to disk, hard drive to floppy disk -- without distortion. It is exactly the same with digital video.

3. Digital Video - Where did it come from?

The digital video revolution is now in full swing. The boom in personal computers has created a voracious appetite for all things digital, but there have been other factors involved in this revolution:

1. technological advances -- giving manufacturers the ability to make digital video equipment;
2. more efficient manufacturing -- delivering more affordable products;
3. business and consumer demand.

Research on digital video and development of digital video products began many years ago, and by the late 1980s was progressing well on several fronts. In 1994, a standard was created for a recording format, and work on consumer digital video by several manufacturers was streamlined into a single effort -- shortformed here to DVC (Digital Video Cassette). This immediately brought the efforts of more than 50 companies into focus, leading to the introduction of the first consumer DVC format products in late 1995.

While digital video originated as a professional technology, and continues to increase in importance in that sector, the latter stages of the 1990s will see its expansion into all corners of the prosumer and consumer arenas.

4. The DV advantage

4.1 Let's compare digital video to analog

video

The image from a digital video product is a significantly better picture than that available from an analog video product. Digital video has approximately twice the horizontal resolution that can be produced by a standard VHS video cassette recorder. The resolution of a DV standard image is about 25% better than that from an S-VHS or Hi-8 camcorder or deck. While resolution is dependent on a products components and circuitry, standard VHS and 8 mm video are capable of delivering about 250 lines of horizontal resolution, with S-VHS and Hi-8 at about 400-420 lines. The DV format is capable of delivering over 500 lines on horizontal resolution (of course, actual performance will depend on the individual camcorder model).

Another way to look at digital video's image superiority is to note that an NTSC digital video signal contains three times the data of its analog counterpart, a PAL digital video signal contains six times the data of its analog counterpart . Digital video will deliver the absolute best consumer video quality. Interestingly, DVC has almost the same resolution as analog Betacam, a very popular professional video format -- an amazing quality jump for consumer equipment.

4.2 Color rendition advantage

Horizontal resolution is not all that goes into making a superior image; color resolution (or rendition) is also very important. Color rendition refers to the ability to accurately reproduce colors, without smear or blur.

Analog can have trouble with color blur and color noise, but digital video does not. In a video image, color smear or blur is when, for example, the red of a woman's lipstick seems to smear beyond her lips, while color noise is indicated by random sparkles in the picture.

Because there is neither color blur nor noise, digital video delivers a far more life-like video image on the screen. This will be especially evident in images shot on a camcorder, and with images played on large screen TVs. What you will see is much sharper subject edges and clearer color reproduction.

4.3 Audio Comparison DVC & Analog

Digital technology has already made its impact in the area of sound with the acceptance of CDs (Compact Discs) in the mass market. People's demands, when listening to music or watching television are higher than ever. Their

expectations for sound quality with Digital Video are equally as high.

The DVC standard ensures that audio quality matches that of an audio CD or, as you might guess, digital audio tape (DAT), since the audio portion of the digital video signal is itself recorded digitally.

Both CDs and DAT are superior to analog audio tape, since both CDs and DAT record digitally. As explained previously, analog recordings work with electronic signal variations (remember the mountain peaks and valleys analogy?). Not all the variations get recorded, and those that do are often subjected to interference, sometimes minor, sometimes major. Digital recordings, because they have to handle only "on" and "off" electrical signals, produce significantly superior sounding audio.

Most analog video tape recorders use analog sound. Digital video tape records digital sound, for significantly better audio quality than analog video. The digital video standard includes Pulse Code Modulation (PCM) audio recording, with two recording modes, either 16-bit stereo for highest quality, or two 12-bit stereo channels (total of four channels). Both modes deliver more than the normal, natural range of sound audible to human beings, ranging from quiet to the full output of a symphony orchestra, without distortion and without noise.

4.4 Compatibility and Copying

Digital video equipment is backward compatible, in that you can transfer a video from digital to analog equipment. That means that if you have a DVC recording you can copy it to a traditional VCR. All digital video equipment has analog video outputs (either S-video and/or composite video) found on current analog equipment, so you can play a digital video on a regular TV, or transfer a digital video onto an analog VCR. Most digital camcorders also have a digital output connector called IEEE 1394.

A DV cassette of either standard or mini size will not fit into any non-DV format's equipment. Cassettes used in other formats will not fit in DV equipment.

If you record using a digital video camcorder, you can then copy the video onto a VHS or Super-VHS VCR, 8 mm or Hi-8 camcorder, or any of the broadcast formats, such as 3/4-inch

or Betacam, if they have the appropriate input connectors. Keep in mind, though, that because the digital signal must be converted to an analog signal, and an analog signal cannot contain as much information as a digital signal, there will be some loss in signal quality in the newly-made analog copy. Any further copies made from this analog copy will show the same quality loss as with normal analog copying. This copy can be made using S-video connectors or RCA-type connectors (some new DVC camcorders use a mini plug instead of RCA connectors). No special connections are needed to make this kind of copy.

Anyone who has copied an analog video tape (VHS or 8 mm, for example) will know that a copy (called second generation) made from the original will have worse picture quality than the original. Make a copy (called third generation) from the copy, and picture quality suffers even more. Each generation away from the original creates a progressively worse copy. Eventually, the image breaks up. How many generations away from the original this takes depends on the quality of the original and the equipment used.

The digital video signal is a robust signal, free of the problems encountered by an analog signal when it is copied. Using digital connecting cables (IEEE 1394), you can dub multiple generations without signal or quality loss. If a digital video signal is being transferred, say from a DVC camcorder to a DVC VCR, the signal does not go through any conversion process, it flows directly from tape to tape as a digital signal. The appropriate comparison is with copying computer files, since the data storage is digital in both instances. The same applies if the signal is transferred from tape to computer; the signal does not go through any conversion process, therefore there is no signal loss.

4.5 Copyright

Digital video camcorders (at present) do not have an analog line in. That would let you record onto DVC from a VHS VCR or 8 mm camcorder. The reason is copyright. If you could copy to DVC, then you would be able to make any number of perfect digital copies from the copy, which has the potential for copyright violation.

DVC VCRs with an analog line-in connection are being manufactured with a copy prevention system that interacts with the copy

guard systems in pre-recorded videos (such as those you can rent from your local movie shop). Videos you have made will not have this prevention system, so there will be no problems making copies from your home-made VHS or 8 mm movies onto DVC VCR.

Pre-recorded DVC tapes also will have a copyright protection scheme to prevent unauthorized copying.

4.6 Editing Overview

The digital video standard specifies certain system requirements that make editing digital video much easier than editing analog video. For example, digital video recording equipment must record specific data on the tape, including a time code, an index of the start and stop points of each recording, the date and time, and photo print information. And, of course, DVC's greatest advantage in editing is that the DVC copies of DVC originals are exact copies with no loss.

4.7 Computer Connection

Perhaps the most intriguing aspect of digital video is the ability to transfer the signal to computer. Transferring an analog video signal to computer requires the translation of that signal into a digital form so it can be read by the computer. Depending on the quality of the equipment used, this leads to varying degrees of quality loss. When the digital data on the computer is sent back to the analog VCR for recording, it must be converted back into an analog signal, causing further signal loss and a further reduction in quality. The final analog tape contains a video signal that is significantly poorer in quality than the original analog video.

This problem doesn't exist with digital video. Signal quality does not deteriorate regardless of how many times it is moved between tape and computer, even if the video is edited or manipulated (for example: special effects). Getting the digital video signal onto computer requires the use of the proper computer equipment and cables, designed specifically to handle digital video (IEEE 1394).

If you transfer the digital video on your computer to digital video tape, there will be no quality loss, but if the transfer is to an analog VCR, there will be losses, simply because the analog tape cannot handle the large quantities of data held in the digital signal.

5. The Physical Side of Digital Video

5.1 Cassette Design (smaller is better)

At the heart of the digital video format is a new cassette. In fact, there are two cassette sizes. Currently, the first allows for recording up to four and a half hours (4h30min) of video, while the latter will hold a maximum of one hour of video. The cassette that is the main focus of our attention here is the second one, and it is called the mini-DV cassette (mini DVC). As its name implies, it is small -- 2.6 x 1.9 x 0.5 inches (66 x 48 x 12.2 mm). In comparison, an 8 mm cassette is 3.7 x 2.5 x 0.6 inches (95 x 62.5 x 15 mm). A VHS cassette is 7.4 x 4.1 x .98 inches (188 x 104 x 25 mm). The mini-DV cassette takes up less than half the overall space (43.4%) of an 8 mm cassette. The mini-DV cassette was designed for use in smaller, portable equipment such as camcorders, and the DV standard cassette for digital video VCRs and broadcast equipment.

The tape inside the cassette for VHS is 1/2-inch (12.7 mm) wide, 8 mm tape, as its name implies, is 8 mm (or slightly less than 1/3-inch) wide, while DV tape is 6.35 mm (1/4-inch) wide.

The tape cassette housing itself protects the tape until it is pulled into the record/play mechanism. The DV cassette uses a reel lock system to prevent tape sagging and other tape damage. The tape is therefore not only protected within a robust shell, but the tape also is wound neatly within the cassette for best alignment during both recording and playback. The locking tape door opens to expose the tape only when the cassette is in the machine, minimizing the entry of dust.

5.2 Cassette Labeling

The label on each cassette will identify it as a digital video tape, whether it is a mini or standard DVC tape, and show the recording time in minutes. So, a 60 minute mini-DV cassette will read: DV M 60. A two hour standard cassette will read: DV 120. This labeling is the same whether the tape is for NTSC or PAL recording.

As with analog tapes, professional quality digital video tapes will carry a different label. Only use tapes recommended by the camcorder or VCR manufacturer.

5.3 Record Prevention

Like other video formats, the standard and mini-DV cassettes have record-prevention

tabs. These tabs are similar to those found in the 8 mm and Hi-8 formats -- the tabs are movable -- unlike the break-off tabs of the VHS cassette. In contrast to an 8 mm cassette, however, a DV cassette shows an open hole to prevent recording, while a closed hole allows recording.

5.4 ID Holes

Just as an 8 mm cassette has certain identification holes on its bottom surface, a DV cassette also has ID holes on the cassette bottom. These holes indicate tape thickness, cassette grade, and tape grade. The camera or VCR, using this information, will adjust its circuits to obtain a near perfect match between the tape and the recording/playback system.

5.5 MIC (Memory in Cassette)

One unique feature of the DV cassette is that you can buy cassettes containing a memory chip. This feature is abbreviated to MIC (memory in cassette). Cassettes containing the chip are more expensive, but allow greater convenience. Whether a cassette contains a chip or has ID holes will depend on the individual tape manufacturers and their marketing strategies. Cassettes with a chip will be marked to indicate this. The chip can record information such as a table of contents, date search, and photo search. There also is some room for future expansion of capabilities. The chips in professional cassettes have more memory than those in consumer tapes.

The data that will be written on the memory chip will depend on the equipment manufacturer, and may include information about the camcorder settings or lens settings, for example.

5.6 The DV Tape Itself

The digital video standard uses an entirely new tape structure and formulation. Although there are some similarities with certain Hi-8 tapes, digital video tape is superior, made to last longer, and better able to stand up to repeated use without failure. Because of the way the internal mechanisms of digital video equipment work with the tape, digital video tape is stronger than Hi-8 tapes, and much stronger than VHS tapes.

DVC tape is an advanced form of metal evaporated (ME) tape. While ME-type Hi-8 tape is the best in that format, the ME tape used in digital video is superior. The magnetic

layer is double coated to give higher output and less noise. A hard layer of carbon is placed over the magnetic portion of the tape to give maximum protection and prevent the tape from wearing out over long periods of use. It's the same idea as applying black topping to a driveway; the black topping helps protect the underlying surface, helps prevent damage to it. As well, a new type of back coating is applied to the tape, reducing friction, providing more stable tape movement, and reducing jitter.

Digital video could not work without DVC ME tape. It allows the recording of a large amount of data, with higher output and lower noise, and protects the data with a protective coating and friction reduction. Digital video would be impractical without this new tape formulation.

Comparing tape widths: VHS tape is 1/2-inch (12.7 mm) wide, 8 mm tape is 8 mm (slightly less than 1/3-inch) wide, and DVC tape is 6.35 mm (1/4-inch) wide.

5.7 Handling precautions

The precautions for handling digital video tape are not that much different from any tape product (video or audio). The main ones are:

Day to day

1. Do not touch the tape
2. Always put the cassette in its case
3. Do not subject the tape to shock or impact (dropping it)
4. Do not expose the tape to strong magnetic fields
5. Do not leave in a car (because of the heat, cold, vibration)
6. Do not use the tape if it has gotten wet or has had anything spilled on it
7. If the cassette is cold, let it warm up for at least 2 hours before using
8. Do not store the cassette in hot, humid or dusty locations
9. Do not leave the cassette in the DV recorder
10. Never disassemble the cassette

Long term storage

Follow the Day to Day rules plus

1. Always store the tape vertically, tape rewound, and the tape in its case
2. If you are storing for a long time, occasionally fast forward and rewind the tape.

6. Down to Digital Video Details

Let's rev things up and give you the full picture, the secret of digital video recording. Yes, the people who figured out how to handle digital video brought a lot of brainpower to bear on the problem of getting the signal on the tape, combining the sciences of mathematics, engineering and physics to get it to work. The joy of it is, explaining it in ordinary terms is fairly easy, now that they've got it all figured out.

Before we can begin our journey, some basics about video theory have to be covered. Remember that digital video is built on present day video technology. It will be easier to understand DVC if you understand how video works.

6.1 Video Primer

Research into creating what we now know as television began in the early years of this century, but it wasn't until the 1940s that competing and incompatible broadcast technologies were standardized, and TV's remarkable growth began. This is the basis for all video display systems, including computer monitors and consumer digital still cameras.

There is an interesting similarity between the way television works and the way a movie is projected in a theater. When you watch a movie, you are actually seeing 24 separate pictures flash on the screen in front of you every second. But they appear so fast on the movie screen, your brain cannot process them as individual pictures. Instead, they come together as a single image, showing movement. If you have seen movies from the early days of the cinema, you will notice "flicker." The image on the screen flickers because movies were shot at 16 pictures per second, and your eye and brain can process these as just barely noticeable individual pictures shown on the screen.

A television picture is made up of 30 complete pictures per second in North America, 25 per second in Europe. In both movies and television (video), each individual picture is called a frame.

The picture you see on a television set is actually being projected on the back of the screen you're watching, but there isn't a movie projector inside your TV. An electronic device shoots an electron beam at the back of the TV screen, beginning at the top left corner (as you face the screen), continuing in a left-to-right

motion all the way down the screen. Let's use the analogy of a artist setting up a canvas and having a spray can of paint. Pointing the can at the top of the canvas and spraying from right to left (remember, we're painting the inside of the screen, so everything is backwards), the artist stops spraying at the end of the line (the edge of the canvas). The artist then moves the spray can back and sprays another line under the first one, doing this again and again until the entire canvas has been "painted" with paint, line by line. Basically, that's how television images get "painted" on the screen -- but at a speed much faster than possible with the spray can of paint.

The TV's electron beam also varies in strength, depending on the brightness of the picture it is trying to "paint." The stronger the beam, the more light is seen on the screen. In essence, that's how a black and white TV works. A color TV uses three electron guns, one each for red, blue and green -- the primary colors. Each gun paints its own color. When all three guns paint the same area, you get white -- it's an additive color system.

When the TV standards were being adopted many years ago, everyone had their own idea about which standard to adopt. Some countries decided they would establish their own individual television systems. For that reason, there are now three major TV standards in the world, with several variations of those. And they are incompatible. In North America, Japan and some other countries, the television paints 525 lines (called scan lines) for each picture. This standard is called NTSC (National Television Standards Committee). The system used in England and much of Europe & Asia is called PAL (Phase Alternating Line), with 625 scan lines and 25 frames per second. France went its own way and developed SECAM (Se'quentiel Couleur 'a Memorie), also used in some other countries.

There is one important point that has to made here: In NTSC, of the 525 scan lines, only 480 lines are picture information, and in PAL's 625 scan lines, only 576 lines are picture information. The other lines are used for internal timing.

The NTSC system is also called the 525/60 system, PAL and SECAM are called a 625/50 system, the first number from the number of scan lines, the second . . . well, read on.

Remember the flicker of early movies? The same thing happened with television in its development days, but with TV, it was the top half of the picture that flickered. Even though the electron beam that was painting the picture did it very quickly, it just wasn't fast enough. By the time the beam was painting the bottom of the screen, the top half of the screen was starting to fade before it could be replaced by the next frame. The solution was to cut the picture in horizontal strips and number them (1 to 480 for NTSC and 1 to 576 for PAL), projecting the odd numbered strips first, then projecting the even numbered ones, doing this for every frame. It happens so fast, we can't see it. Each half a frame is called a field, or, putting it another way, two fields are interleaved to make a frame. This system is called interlaced scanning, and is used in every television system in the world. In computer monitors, and in the future High Definition TV standard, there is also non-interlacing (which is what TV started out as), made possible by almost 80 years of advances in electronics.

So, to get back to 525/60 and 625/50, the 60 and 50 refers to the number of fields per second (two fields make a frame, and there are 30 frames per second in NTSC TV and 25 frames per second in PAL and SECAM).

6.2 Why will NTSC and PAL continue?

There are just too many television sets and VCRs in use worldwide for NTSC and PAL to be abandoned. As a result, digital video camcorders will be made in both NTSC and PAL forms. SECAM camcorders are not usually made, since it is easy to convert PAL to SECAM. This should all change if the television sets come with a digital input (IEEE 1394). The television set will do the conversion in a digital world. A good example of how this is happening, is being able to show computer information on a television set (web style television).
