Panasonic DVCPRO – from DV to HD

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The transition to DTV has begun and even consumers realize that DTV does not always mean HDTV. While some broadcasters are providing limited HDTV, libraries of SDTV exist and continue to grow. Systems designed to aid the conversion to DTV are needed by broadcasters, post and other video professionals. DVCPRO HD provides a cost effective, logical, and predictable migration to DTV and HDTV. Realizing that archive material can be brought up to a "common denominator" format appropriate for HDTV broadcast, broadcasters see this "integrated" conversion of HD and SD as critical. For example, historical news footage could easily be upconverted from 480 to 1080 to match the studio cameras and production switcher to produce an evening newscast.

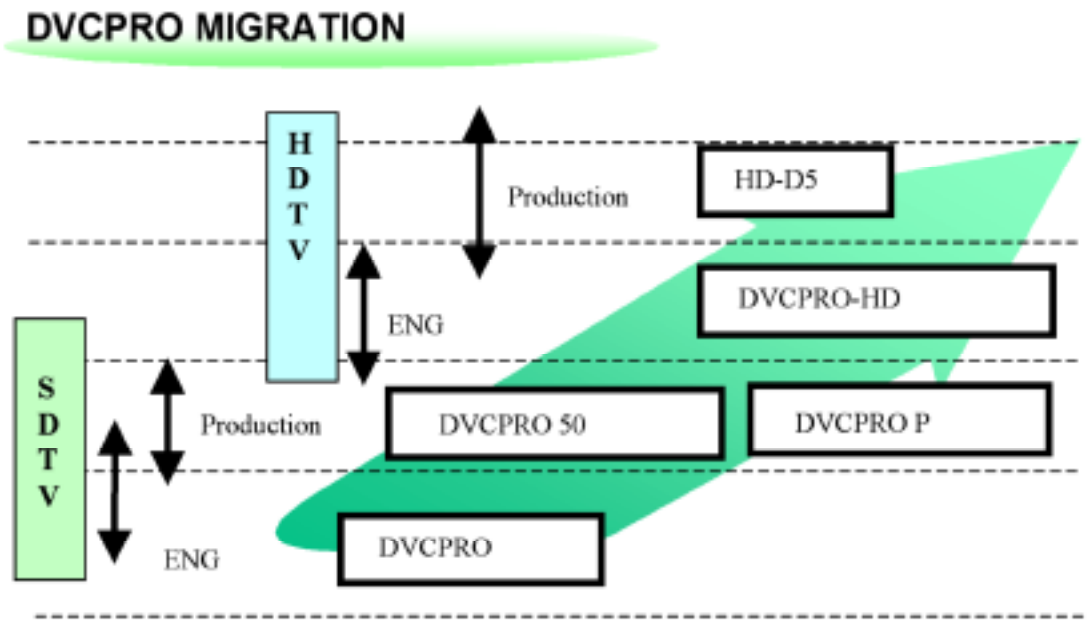
The introduction of DVCPRO-HD brings a video recording format to the industry that has the picture quality required for high definition TV, the audio channels needed for DTV, and the economics required to be the solution for local broadcasters. Because broadcast stations need to be able to make the change from SDTV to HDTV with efficiency and at their own pace, DVCPRO-HD has backward compatibility with the digital DVCPRO and DVCPRO 50 equipment that is already present in many stations. The same videotapes used for DVCPRO and DVCPRO 50 can be used for DVCPRO-HD, allowing easy co-existence. Knowing that the transition to HDTV must be facilitated, and knowing that DVCPRO users will be building archives prior to that transition, DVCPRO-HD has provided internal space for an optional up or down converter. This allows the VTR itself to convert existing material from SDTV to HDTV, eliminating concerns about integration of archival material and system design. DVCPRO-HD is the format that fulfills the promise of digital television.

The allure of DVCPRO HD is that it is a genuine HD-level format, compatible with all DV, DVCAM and DVCPRO DTV-level iterations. DVCPRO DV compression is ideal for not only acquisition, but NLE and server-based systems as well. While the DVCPRO compression algorithm has been developed for video tape recording, it is now expanding into a variety of media and as a transmission system, making the DVCPRO family a viable hierarchy of formats and equipment for the foreseeable future.

DVCPRO FAMILY CONCEPT – A Migration Path to DTV

DV compression technology, originally developed for consumer digital video, was adopted as the compression algorithm for DVCPRO to create a high performance, cost effective ENG System. DVCPRO, a non-proprietary format standardized as SMPTE D-7 has been widely adopted domestically and internationally. Well accepted by many broadcasters and program producers, it has become a de-facto standard over the last three years. Two years ago, the family expanded to incorporate DVCPRO 50. This 50Mbps upwardly compatible format provides the wider chroma bandwidth and transparent minimal compression required for EFP production purposes.

DVCPRO-HD uses newly developed technology based on the DVCPRO algorithm to expand the video data rate to 100Mbps, maintaining upward compatibility into HDTV in the same fashion as DVCPRO 50.



Panasonic VTR Migration Path

DVCPRO-HD is not suited to all applications requiring HDTV recording; Panasonic has developed the D-5 high definition recording system for those applications requiring full bandwidth resolution at 10-bit depth with minimum compression. Film mastering may require the use of a 24 frame recording system that can slew to 25 frame to facilitate high quality conversions between parts of the world using 60-Hertz and 50-Hertz video systems. The new D-5 HD recorder, AJ-HD3700 is a multiple format VTR capable of providing video recording service in the most demanding HD and SD environments.

DVCPRO COMPRESSION – The Broadcast production Standard

While MPEG-2 compression technology will be used for digital broadcast transmission, it is not appropriate for video manipulation and editing because it uses frame correlation. As others have noted elsewhere[2], MPEG-2 generally uses inter-frame compression that creates large delays in the compression and decompression process. Intra-frame compression is more appropriate for these processes, but even MPEG-2 4:2:2 Profile I frame only schemes are not symmetrical and are not truly constant bit rate.

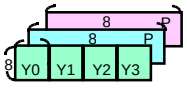
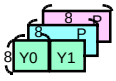
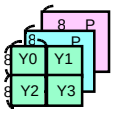
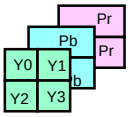
DVCPRO, DVCPRO 50, and DVCPRO-HD use a symmetrical feed-forward intra-frame compression design that minimizes the picture degradation when the video signal is dubbed. This compression algorithm is precisely defined and is ideally suited for either a linear recording system (such as a VTR) or disk-based systems (such as a server or NLE system).

The DVCPRO video compression is Discrete Cosine Transfer (DCT) based, generating a series of coefficients that represent the image and transforming it from the spatial raster-based domain to the frequency domain. This video data is then reduced in bit rate by applying quantizing tables to the DCT coefficients based upon image complexity and

adding Variable Length Coding (VLC) to the result. The video signal is separated to 8x8 pixel blocks, and the luminance block and chrominance blocks for each PR and PB create a macroblock. Video segments, wherein the compression is performed, are constructed of multiple macroblocks. One can observe that if an error occurs in the compression signal the impact is contained within one video segment and will not propagate to the other video segments. The figure below shows the macroblock construction of DVCPRO, DVCPRO 50 and DVCPRO-HD.

It is the mild frame-bound 5:1 compression that makes DVCPRO excel, and this is accomplished by the adroit use of a technique called chroma sub-sampling to reduce the amount of video data to be compressed. Constraining the overall amount of "digits" in the color signal prior to compression results in better performance than the traditional NTSC or PAL with which broadcasters are well accustomed. However, less compression is better, and many users are accustomed to the ITU-R Rec. 601 4:2:2 signal structure and believe it an important factor in image quality. In that light, DVCPRO was extended to DVCPRO 50 with full 4:2:2 detail while still using the same algorithm to create the lower and effectively lossless 3.3:1 compression ratio. DVCPRO 50 uses dual compression chip sets operating in parallel, each processing a 2:1:1 stream to generate the 4:2:2 signal. DVCPRO-HD uses newly developed LSI devices with the same core algorithm to reduce the data to 385Bytes, yielding a 6.7:1 compression ratio.

The decompression process is simply the reverse of compression. Unlike MPEG-2, the DVCPRO-HD codec is symmetrical, and the same LSI devices are used for compression and de-compression. In the case of digital broadcast transmission asymmetry is not a problem. The complex and expensive encoder in the broadcast station allows simple and inexpensive decoders in the home. In the production environment symmetrical design is a big advantage because latency is minimal and identical, and every piece of equipment can contain both encoder and decoder without an economic premium.

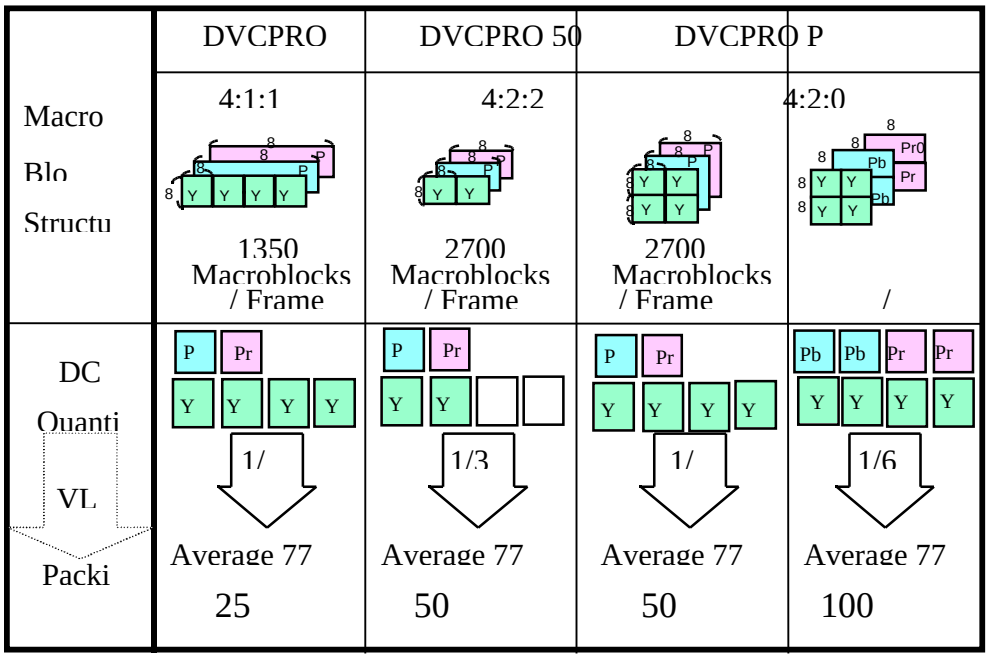
	DVCPRO	DVCPRO50	DVCPRO P	DVCPRO HD
Video Format	480i		480p	1080i
I/O Signal	SMPTE125M Y : 13.5MHz Cr/Cb : 6.75MHz	SMPTE125M Y : 13.5MHz Cr/Cb : 6.75MHz	SMPTE293M Y : 27MHz Cr/Cb : 13.5MHz	SMPTE274M Y : 74.25MHz Cr/Cb : 37.125MHz
Macro Block Structure	4:1:1 	4:2:2 	4:2:0P 	4:2:2 
Compression Rate	1/5	1/3.3	1/5	1/6.7
Video Signal Rate	25 Mb/s	50 Mb/s	50 Mb/s	100 Mb/s
PCM Audio	2Ch 16bits 48kHz	4Ch 16bits 48kHz	4Ch 16bits 48kHz	8Ch 16bits 48kHz
Number of Tracks/ Frame	10	20	20	40
Recording Time	Max 184 min.	Max 92 min.	Max 92 min.	46 min. (L size) Longer Times Under Study

DVCPRO Implementations of DV-Compression

QUANTIZATION – Optimized for Production and Editing

The key to the DV compression process is a feed-forward technique wherein the image is compressed in trial form to determine the degree of compression that maximizes the use of the data space available. The algorithm first performs a complexity estimation to determine which set of quantizing tables are most appropriate for each video segment. It then calculates the amount of resultant compressed data for a range of quantization tables, and finally selects the appropriate tables for the actual compression process. In turn, this means fixed block sizes and fixed frame sizes perfect for video production and editing. This coherent, compatible structure extends across the entire DVCPRO family for 25, 50, and 100 Mbps data rates.

DV-compressed component signals are nearly transparent and facilitate audio/video file exchange between equipment of various manufacturers. The computer industry, given its foundation in files and data, developed a model for digital transfers in which transparent migration of material was the norm. A file is a string of digital words that, through a flow control exchange or protocol between the devices, allows the data to be sent, receipt acknowledged, and re-sent if needed. One can expect this file transfer protocol (FTP) to impact television system design in the near future in both real time and non-real time file transmission, and DVCPRO HD data easily fits in the emerging high speed network technology like fibre channel and gigabit Ethernet. Standard definition DV compressed video can easily be transported over common interface protocols like IEEE1394 and SDTI.



DVCPRO / DVCPRO50 / DVCPRO-P / DVCPRO-HD

FILE TRANSFER PROTOCOLS AND STREAMS – Industry-Standard Networkability & Compatibility

It is shown above that DV-compressed component signals yield transparency and facilitate audio/video file exchange between equipment of various manufacturers. That digital transfer may be done as a stream or a file. The careful application of files and streams (because the constraints and benefits are different) and the use of each in the appropriate parts of the total system are some of the key elements of successful system design.

While the replacement of analog video with digital video allowed perfect copies or transfers to be made, the process still required human supervision. A stream is a continuous signal, similar to traditional real time audio or video in that there is little or no communication between sender and receiver. Streams of data move between equipment, but there is no inherent monitoring of the process to assure a complete and perfect transfer. In the digital domain, a stream can be compressed or uncompressed, and real time or faster than real time.

In contrast, the computer industry, given its foundation in files and data that are largely unintelligible in raw form to humans, developed a model for data or file transfer in which transparent migration of material was the norm, and only the failure of a transfer was reported and required intervention. A file is a string of digital words that can be interrupted by other signal traffic and, through a flow control exchange or protocol between the devices, the data can be sent, receipt acknowledged, and re-sent if needed. One can expect this file transfer protocol (FTP) to impact television system design in the near future.

Since DVCPRO is intrinsically suitable for either file or stream transfer to move signals among systems transparently, Panasonic is working in parallel on multiple developments for broadcast infrastructures. Despite the widespread desire for an FTP-type computer network infrastructure, facilities with large investments in serial digital SDI (colloquially known as “601” or “259”) as well as all-analog facilities both exist. Panasonic actively participated in the SMPTE SDTI harmonization effort, which generated a multi-layer SDTI standard including SMPTE 305M. This protected the users' investment in SDI routers and other infrastructure elements, as well as preserving technology like EDH and embedded multi-channel audio. Based upon that standard, we have introduced 1X and 4X (e.g., the AJ-D780 4X VTR) SDTI digital transfer of audio and compressed video that capitalizes on the SDI systems already in place. In addition, the outputs of the various elements can be integrated in the analog domain. For those facilities and systems where servers form the core of operations, we believe FTP over TCP/IP networks will emerge as the appropriate infrastructure technology, and we continue to develop interfaces, software and products based on this technology that utilize 100 Base T Ethernet, Fibre Channel, and Gigabit Ethernet in conjunction with our DVCPRO partners.

DVCPRO NEWS AUTOMATION SYSTEM – The Complete System

Using the technology described above, Panasonic has developed a complete, end-to-end, turnkey client server system for news post production and distribution. DVCPRO files move transparently between clients and server faster than real time, and the server supports multiple broadcast audio/video inputs and outputs in addition to the multiple clients.

The process begins with the DVCPRO newsBYTE, an integrated Windows NT editing workstation specifically designed for news. NewsBYTE has an internal 4X fast transfer deck that allows fast, lossless input of field material, efficient timeline editing of clips, real time effects for enhanced production values, and fibre channel network connection to the server for transfer of the finished story. It can "book-end," do "rubber-band" audio, add graphics and titles, and control an external VTR for integration of "legacy" material.

The server is a Silicon Graphics Origin 200 GigaChannel main unit plus an expansion unit to allow both PCI and XIO devices, and uses the IRIX operating system and the XFS real time file system to store and play out DVCPRO native files. DIVO I/O boards use SMPTE 259 connections, and have internal, integrated DVCPRO codecs to support intake or playout of video stored as DV files. Audio is handled independently through PCI adapter boards. Automation control is via Louth or Odetics protocol, and each video port can be addressed as a conventional RS-422 VTR. Fibre channel networking supports faster than real time IP file transfer (FTP) for up to six newsBYTE clients, and archive transfer is via streaming

SDTI is used for lossless transfers at 4X to or from DVCPRO tape. The system uses dual system disks, which are highly redundant and faults tolerant. Two server units can be integrated into one system providing double the audio/video I/O ports and support for up to 16 newsBYTE clients.

Storage is provided by a Ciprico FibreStore array consisting of 18 high speed 18 GB hard drives with redundant "hot swap" power supplies and fault monitoring. This standard storage holds 24 hours of DVCPRO material on line (about 1 week of news stories for most stations), and can be expanded. A RAID 3 configuration is available that allows hot disk swap as well as prioritized and scheduled data rebuild for minimum impact on operations and maximum reliability.

DIGITAL LIBRARIES AND ARCHIVES - Systems for Near-Line and Deep Archive

It is crucial to understand the role of transparent, lossless transfer in the context of digital archive storage and retrieval. Material in the server must be able to be transferred to and from an archive while maintaining the original quality, for the quantity of material will always grow to exceed the capacity of the disks. This transfer can also be done as FTP or streams (SDTI), and may be stored as raw data or compressed video and audio. Since DVCPRO allows transparent transfer, many users find it convenient to be able to retrieve

an archive tape and use it directly. The archive process can be accomplished with a single 4X VTR (AJ-D780), or automated with the DVCPRO Micro Cart that holds 35 large cassettes, or the DVCPRO Smart Cart which, in conjunction with 4X DVCPRO VTRs, allows larger-scale archives to be created to operate either in real time or faster-than real time. In addition, Panasonic has constructed a very large-scale (10,000 cassettes) library robotic system in Japan that will form the technology foundation for development of a dual-mode storage format in conjunction with either FTP or SDTI transparent data transfer. The first mode will be storage of standard DVCPRO, and the second mode will employ the DVCPRO DATA format to allow a more computer-like data storage model. While the physical media is in the DVCPRO form factor, the digital data storage is audio/video format independent. The cost-effectiveness and transfer rate of the DVCPRO 20 and 40 MByte cassettes has fostered significant interest in this system.

CONCLUSION – DVCPRO, The Best Choice for Broadcasters and Video Professionals

DVCPRO and DV based video equipment has been widely accepted (over 100,000 units in use world-wide) by video professionals, broadcasters and program producers domestically and internationally, and is a non-proprietary format standardized as SMPTE D-7. The format offers digital component quality at analog prices, recording on robust, industry-standard metal particle tape. It offers size advantages for acquisition and archiving, and it utilizes a low-cost, widely available compression engine with fully defined performance. Numerous companies offer compatible products based on the same compression, giving high-speed, transparent digital connections to disk-based editing systems and servers. It offers video-industry-standard features and SDI/SDTI connections with a bridge to the computer industry through IP networking, FTP file transfer, and IEEE 1394.

DVCPRO has been proven to be extensible with the wide availability of fully compatible DVCPRO 50 products that work in either 25 or 50 Mbps mode. Some models operate in either interlace or progressive scan video modes as well. The recent introduction of DVCPRO HD indicates that DVCPRO will have a role in HDTV for cost-effective field acquisition, and the structural relationship among the 25, 50, and 100 Mbps DVCPRO formats assures customers a logical progression and migration to DTV. While more than one video compression type will be widely used to satisfy different applications, the DV compression technique was conceived as a DTV platform for video recording and digital video bit stream management. This means DVCPRO will not become obsolete as the legacy DVCPRO continues into the DTV era.