

Collaborative Refinement of the Tapeless HD Camcorder

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To realize a practical tapeless HD/SD camcorder for broadcast ENG applications, new technologies have been developed, including new compression technology and further refinement of non-linear recording technology.

The camera exploits the key attributes of the latest 2/3-inch format sensors, high sensitivity and SNR for low light shooting, quick turn on, and low power consumption. Detail enhancement and color reproduction are optimized by the camera DSP. Meta-data can be input at the camera via USB interface and is supported throughout the workflow.

Compression is software based allowing development of different compressions with the same chip set. An Open Codec philosophy is adopted to provide compatibility with editing systems of various manufacturers. The compression has the flexible support for multi-format HD, as well as, SD formats. High quality HD and SD recording is achieved in a lightweight camcorder with traditional ENG size and construction.

The new HD/SD camcorder utilizes new removable non-linear media, a refined version of the media used for several years in the corresponding tapeless SD camcorders. The media size is reduced, capacity increased to 64G of solid-state RAM memory, and interface to the editor simplified.

A new tapeless camcorder is under development at Ikegami, this time in collaboration with Toshiba. Both companies have areas of expertise, Ikegami in camera processing and tapeless camcorders, and Toshiba in flash memory and servers. This collaborative effort is being used to design the camcorder, studio and field recorders, and the non-linear media used in all units. The primary application is for broadcast news and production. Technology in the camcorder includes the latest digital camera front end, software programmable codec, and flash memory based media in the form of a removable pack.

The 2/3-inch optical format gives users a wide selection of lens choices. On the camera side this format gives the best overall combination of high sensitivity and low noise, especially important for news applications working under all lighting conditions, including work at night in very low light. 14-bit analog-to-digital conversion is used to optimize gradation, important for the dark areas of the picture. After video processing there is frame memory for the Freeze Mix function allowing live video to be matched to a previously recorded frame of video. There is also down conversion to 480i or 576i for SDTV applications.

Video processing takes place in an ASIC Application Specific Integrated Circuit, equivalent to 3.3 million gates in a single IC. Up to 38-bits are used for some non-linear processes. As a forth generation ASIC, it is referred to as Chip C4. The input is parallel digital operating at the sensor clock frequency of 74.25MHz giving a one-to-one

relationship between the DSP and the pixels of the sensors. To address white spots, the ASIC includes a pixel correction system. Also incorporated are four lines of delay. Together with 0 line delay, a total of five lines are used for the generation of the vertical detail. There is also separate detail generated for the viewfinder to assist the operator in finding the correct focus.

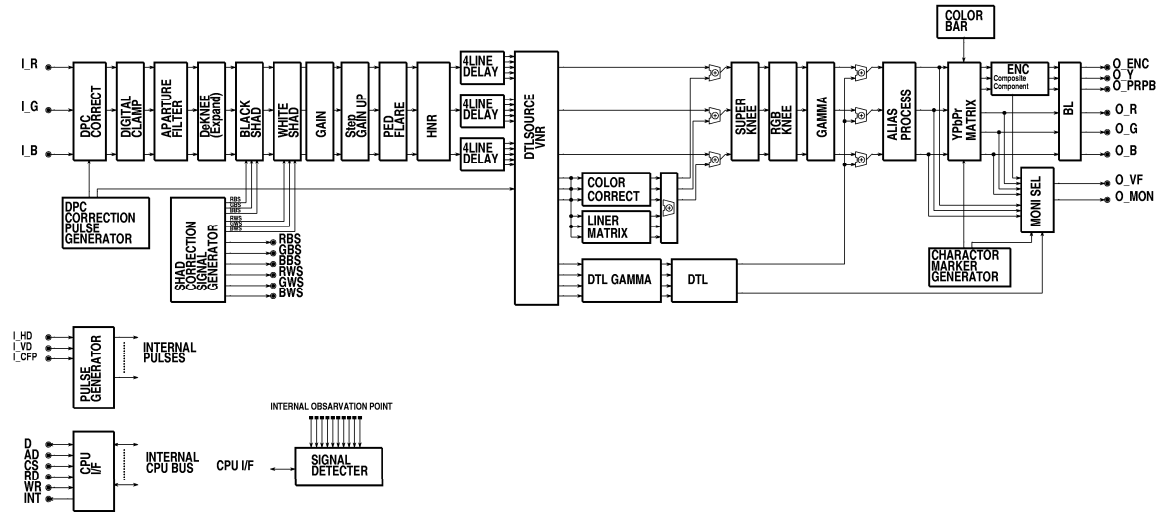


Figure 1 – Digital Video Processing ASIC

The generation of detail enhancement lends itself well to the digital domain with a wide range of functions included. The Skin Detail feature, introduced on the HK-327 back in the late 80s, continues as a key function to flatter the talent by softening the complexion even to a point beyond full deletion of the detail enhancement in the skin tone color. Slim Detail, not practical in analog, makes use of multiple delays to develop a thinner horizontal and vertical edge signal. Also multiple delays allow for boosting of a relatively wide range of frequencies. A new function is the addition of Knee Detail to increase the differentiation of the compressed video in the knee area. Previously there was Knee Aperture producing horizontal edge enhancement, but with Knee Detail both the horizontal and vertical transitions are edge enhanced.

Although the primary application for the camera is field recording, it is also possible to add system accessories for live applications. A fiber extension system and studio viewfinder permit multi-camera live shooting in the studio or field. With its built-in compression producing an MPEG2 transport stream, it may be possible to use the camcorder in a wireless configuration with just an RF transmitter added.

The more typical application will be in conjunction with its built-in non-linear recorder. HD recording can be accomplished with video from the camera or from the external input. The recorder will accept different HD formats including 720p and 1080i at 59.94 or 50 Hz. SD recording is also available with the camera's HDTV signal down converted prior to compression. Four audio signals are available for recording; and in the case of external input, the embedded audio signals of the HD SDI are recorded as an MXF audio file. The user interface for the recorder includes a color LCD panel and keyboard. On

the LCD the operator can view live and recorded video, thumbnails of recorded clips, and the recorder menu.

The ever evolving compression standards have often forced customers to invest in expensive new equipment. To address this challenge, a DSP based advanced compression system has been created that provides a dramatic increase in raw processing power. The breakthrough in DSP performance combined with highly specialized software algorithms achieves broadcast quality video processing (encoding, decoding, artifact mitigation, etc.) with high flexibility to support different compression formats. The first compression will be MPEG2 for both HD and SD recording with planning for additional compression types in the future, for example H.264. Also the file format can be changed by the recording software, so in the future additional file formats are possible, for example Quick Time.

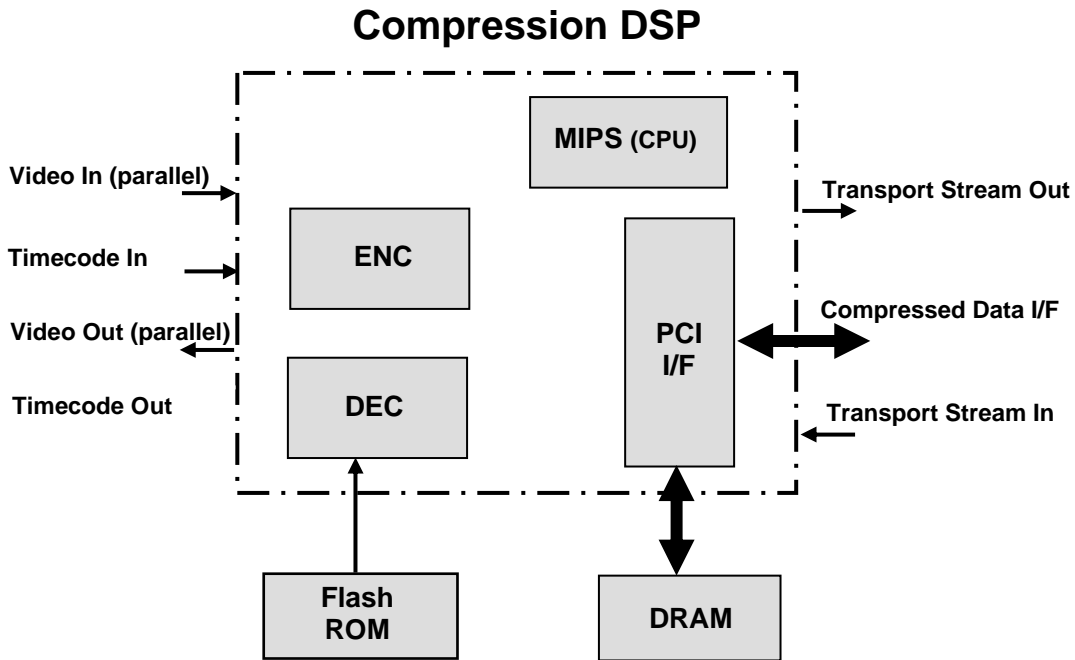


Figure 2 – Compression Engine

Three types of MPEG2 compression are planned at the time of product introduction. For HDTV recording I-frame only MPEG2 at 100Mbps and long-GOP MPEG2 at 50Mbps can be selected. For SDTV IMX MPEG2 at 30Mbps can be selected. The sampling and color resolutions are outlined in the following chart.

	I-Fame only HD	Long-GOP HD	IMX30 SD
Bit Rate	100 Mbps	50 Mbps	30 Mbps
Video Sampling	4:2:2	4:2:2	4:2:2
Video Depth	8 bit	8 bit	8 bit
Audio Sampling	48 KHz	48 KHz	48 KHz
Audio Depth	16 bit	16 bit	16 bit

Figure 3 – MPEG2 Compression

Meta-data can be input via the USB interface using a notebook PC or PDA. When the operator installs meta-data, the camera keeps the data. And when the video is recorded, the meta-data is stored in the media as an XML file. The contents of the XML file are text format, and can later be read with a pc.

Proxy recording is optionally available. It provides a lower resolution MPEG4 recording on the media in parallel to the high resolution MPEG2 recording. The resolution is selectable depending on the application. The proxy is available on the media pack and a dub can be made to a USB flash drive.

A key system component is the tapeless recording media. Our previous generation tapeless camcorders have used removable packs with either HDD or Flash Memory, but for cost and capacity reasons, the prior emphasis has been on the HDD versions. For this product range new 16, 32, and 64GB Flash Memory packs are introduced. With increased capacity and improved price, this introduction marks a transition to solid state. Both serial ATA and USB2.0 interfaces are included, as is a status display indicating remaining capacity. The physical size and weight are also reduced.

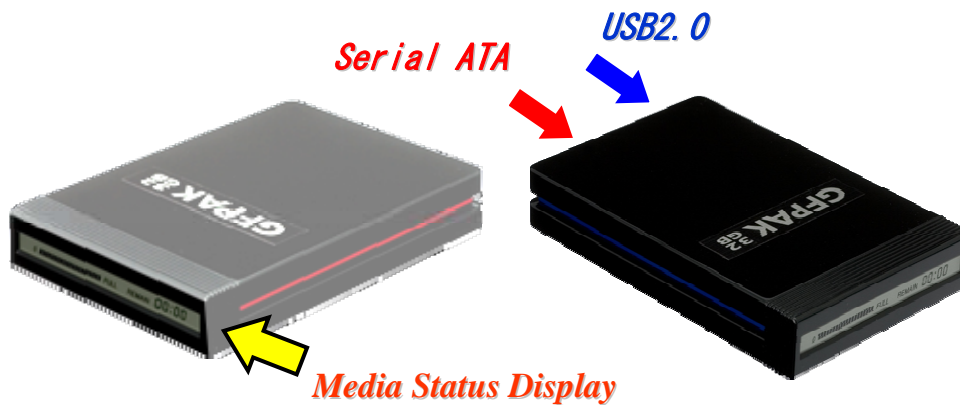


Figure 4 – Removable Flash Memory Pack

Attributes of solid state flash memory include fast access time, high reliability with no moving parts and built-in error correction, and low power consumption. Flash memory has a long life with over 100,000 rewrites possible. Environmental characteristics are excellent including a wide temperature range, resistance to shock and vibration, and freedom from G-force restrictions typically encountered with spinning media.

The flash memory packs provide adequate recording times in each of the available compression formats. Up to two hours of HDTV recording is available with the 64GB pack. The roadmap for flash memory indicates strong growth in capacity in the coming years.

Capacity	Recording Time		
	IMX30 (SDTV)	MPEG-HD (Long GOP 50Mbps)	MPEG-HD (I Frame 100Mbps)
16GB	55min	32min	16min
32GB	110min	64min	32min
64GB	220min	128min	64min

Figure 5 – Recording Times

For applications requiring continuous recording, the camcorder includes built-in flash memory in addition to the removable pack. A 512MB cache memory allows the pack to be replaced with uninterrupted recording. It is also used as a buffer for quick start recording, and used for the “retroloop” feature so media is not wasted while waiting for an important event to occur.

Several editing scenarios are possible. For the field and simple applications, the pack can be connected directly to the editor via a USB cable. It is then available to be mounted as an external drive, and the clips can be imported. The clips do not need to be transferred or transcoded, so editing can start almost immediately. The compression codec is Open to permit use of NLEs from various manufactures. MXF file format with OP-atom wrapper is used.

Editing can also be done using either the studio or field recorders, although more typically the recorder can be used to ingest the clips from the packs for subsequent access by various editors on the network. The studio recorder includes 128GB of internal flash memory in addition to the removable pack. This provides 4 hours of temporary storage (in 50Mbps HDTV recording). Two inputs and two outputs are supported with applications including recording external video signals and chase (delayed) playback. This multitask capability will significantly reduce the overall workflow time.

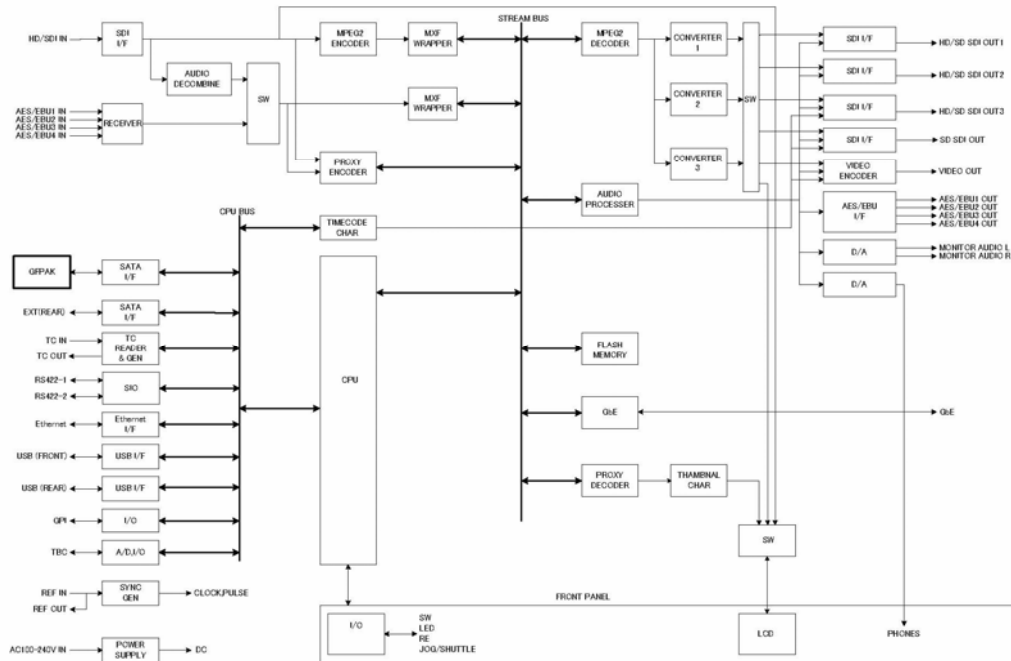


Figure 6 – Flash Memory based Recorder

The recorders use the same compression and support multi-format HD and SD. Up/down/cross conversion are included, as well as, inputs and outputs for 8 channels of audio and timecode. File transfer is via Gbit Ethernet 200Mbps. User interface includes a jog/shuttle knob and 3.5-inch color LCD panel for thumbnail, video, and playlist viewing, and In/Out editing.



Figure 7 – Studio Recorder and Camera

In summary an overall efficient tapeless workflow is achieved by combining this new camcorder, studio and field recorders with other MXF compatible products.