Chapter 1

Introduction

A few short years ago, the applications for video were somewhat confined—analog was used for broadcast and cable television, VCRs, set-top boxes, televisions, and camcorders. Since then, there has been a tremendous and rapid conversion to digital video, mostly based on the MPEG-2 video compression standard.

Today, in addition to the legacy DV, MPEG-1, and MPEG-2 audio and video compression standards, there are three new high-performance video compression standards. These new video codecs offer much higher video compression for a given level of video quality.

- **MPEG-4.2.** This video codec typically offers a 1.5–2× improvement in compression ratio over MPEG-2. Able to address a wide variety of markets, MPEG-4.2 never really achieved widespread acceptance due to its complexity. Also, many simply decided to wait for the new MPEG-4.10 (H.264) video codec to become available.

- **MPEG-4.10 (H.264).** This video codec typically offers a 2–3× improvement in compression ratio over MPEG-2. Additional improvements in compression ratios and quality are expected as the encoders become better and use more of the available tools that MPEG-4.10 (H.264) offers. Learning a lesson from MPEG-4, MPEG-4.10 (H.264) is optimized for implementing on low-cost single-chip solutions and has already been adopted by the DVB and ARIB.

- **SMPTE 421M (VC-1).** A competitor to MPEG-4.10 (H.264), this video codec also typically offers a 2–3× improvement in compression ratios over MPEG-2. Again, additional improvements in compression ratios and quality are expected as the encoders become better.
Many more audio codecs are also available as a result of the interest in 6.1- and 7.1-channel audio, multi-channel lossless compression, lower bit-rates for the same level of audio quality, and finally, higher bit-rates for applications needing the highest audio quality at a reasonable bit-rate.

In addition to decoding audio, real-time high-quality audio encoding is needed for DVD, HD DVD and Blu-ray recorders and digital video recorders (DVRs). Combining all these audio requirements mandates that any single-chip solution for the consumer market incorporate a DSP for audio processing.

Equipment for the consumer has also become more sophisticated, supporting a much wider variety of content and interconnectivity. Today we have:

- **HD DVD and Blu-ray Players and Recorders.** In addition to playing CDs and DVDs, these advanced HD players also support the playback of MPEG-4.10 (H.264), and SMPTE 421M (VC-1) content. Some include an Ethernet connection to enable content from a PC or media server to be easily enjoyed on the television.

- **Digital Media Adapters.** These small, low-cost boxes use an Ethernet or 802.11 connection to enable content from a PC or media server to be easily enjoyed on any television. Playback of MPEG-2, MPEG-4.10 (H.264), SMPTE 421M (VC-1), and JPEG content is typically supported.

- **Digital Set-Top Boxes.** Cable and satellite set-top boxes are now including digital video recorder (DVR) capabilities, allowing viewers to enjoy content at their convenience. Use of MPEG-4.10 (H.264) and SMPTE 421M (VC-1) now enables more channels of content and reduces the chance of early product obsolescence.

- **Digital Televisions (DTV).** In addition to the tuners and decoders being incorporated inside the television, some also include the digital media adapter capability. Support for viewing on-line video content is also growing.

- **IPTV Set-Top Boxes.** These low-cost set-top boxes are gaining popularity in regions that have high-speed DSL and FTTH (fiber to the home) available. Use of MPEG-4.10 (H.264) and SMPTE 421M (VC-1) reduces the chance of early product obsolescence.

- **Portable Media Players.** Using an internal hard disc drive (HDD), these players connect to the PC via USB or 802.11 network for downloading a wide variety of content. Playback of MPEG-2, MPEG-4.10 (H.264), SMPTE 421M (VC-1), and JPEG content is typically supported.

- **Mobile Video Receivers.** Being incorporated into cell phones, MPEG-4.10 (H.264) and SMPTE 421M (VC-1) is used to transmit a high-quality video signal. Example applications are the DMB, DVB-H and DVB-SH standards.
Of course, to make these advanced consumer products requires more than just supporting an audio and video codec. There is also the need to support:

- **Closed Captioning, Subtitles, Teletext, and V-Chip.** These standards were updated to support digital broadcasts.

- **Advanced Video Processing.** Due to the wide range of resolutions for both content and displays, sophisticated high-quality scaling and motion adaptive deinterlacing are usually required. Since the standard-definition (SD) and high-definition (HD) standards use different colorimetry standards, this also needs to be corrected when viewing SD content on an HDTV or HD content on an SDTV.

- **Sophisticated Image Composition.** The ability to render a sophisticated image composed of a variety of video, OSD (on-screen display), subtitle/captioning/subpicture, text, and graphics elements.

- **ARIB and DVB over IP.** The complexity of supporting IP video is increasing, with deployments now incorporating ARIB and DVB over IP.

- **Digital Rights Management (DRM).** The protection of content from unauthorized copying or viewing.

This book can be used by engineers who need or desire to learn about video, VLSI design engineers working on new video products, or anyone who wants to evaluate or simply know more about video systems.

### Contents

The book is organized as follows:

Chapter 2, an *Introduction to Video*, discusses the various video formats and signals, where they are used, and the differences between interlaced and progressive video. Block diagrams of DVD players and digital set-top boxes are provided.

Chapter 3 reviews the common *Color Spaces*, how they are mathematically related, and when a specific color space is used. Color spaces reviewed include RGB, YUV, YIQ, YCbCr, xvYCC, HSI, HSV, and HLS. Considerations for converting from a non-RGB to an RGB color space and gamma correction are also discussed.

Chapter 4 is a *Video Signals Overview* that reviews the video timing and the analog and digital representations of various video formats, including 480i, 480p, 576i, 576p, 720p, 1080i, and 1080p.

Chapter 5 discusses the *Analog Video Interfaces*, including the analog RGB, YPbPr, S-Video, and SCART interfaces for consumer and pro-video applications.

Chapter 6 discusses the various *Digital Video Interfaces* for semiconductors, pro-video equipment, and consumer equipment. It reviews the BT.601 and BT.656 semiconductor interfaces; the SDI, SDTI, and HD-SDTI video interfaces; and the DVI, HDMI, and IEEE 1394 consumer interfaces.

Chapter 7 covers several *Digital Video Processing* requirements such as 4:4:4 to 4:2:2 YCbCr, YCbCr digital filter templates, scaling,
interlaced/noninterlaced conversion, frame rate conversion, alpha mixing, flicker filtering, and chroma keying. Brightness, contrast, saturation, hue, and sharpness controls are also discussed.

Chapter 8 provides an NTSC, PAL, and SECAM Overview. The various composite analog video signal formats are reviewed, along with video test signals. VBI data discussed includes timecode, closed captioning and extended data services (XDS), widescreen signaling and teletext. In addition, PALplus, RF modulation, BTSC, and Zweiton analog stereo audio and NICAM 728 digital stereo audio are reviewed.

Chapter 9 covers digital techniques used for the Encoding and Decoding of NTSC and PAL color video signals. Also reviewed are various luma/chroma (Y/C) separation techniques and their trade-offs.

Chapter 10 discusses the H.261 and H.263 video compression standards used for video teleconferencing.

Chapter 11 discusses the Consumer DV video compression standards used by digital camcorders.

Chapter 12 reviews the MPEG-1 video compression standard.

Chapter 13 discusses the MPEG-2 video compression standard.

Chapter 14 discusses the MPEG-4 video compression standard, including MPEG-4.10 (H.264).

Chapter 15 discusses the ATSC Digital Television standard used in the United States.

Chapter 16 discusses the OpenCable™ Digital Television standard used in the United States.

Chapter 17 discusses the DVB Digital Television standard used in Europe and Asia.

Chapter 18 discusses the ISDB Digital Television standard used in Japan.

Chapter 19 discusses IPTV. This technology sends compressed video over broadband networks such as Internet, DSL, FTTH (Fiber To The Home), etc.

Finally, Chapter 20 is a glossary of over 400 video terms. If you encounter an unfamiliar term, it likely will be defined in the glossary.
Standards Organizations

Many standards organizations, some of which are listed below, are involved in specifying video standards.

Advanced Television Systems Committee (ATSC)
www.atsc.org

Association of Radio Industries and Businesses (ARIB)
www.arib.or.jp

Cable Television Laboratories
www.cablelabs.com

Consumer Electronics Associations (CEA)
www.ce.org

Digital Video Broadcasting (DVB)
www.dvb.org

Electronic Industries Alliance (EIA)
www.eia.org

European Broadcasting Union (EBU)
www.ebu.ch

European Telecommunications Standards Institute (ETSI)
www.etsi.org

International Electrotechnical Commission (IEC)
www.iec.ch

Institute of Electrical and Electronics Engineers (IEEE)
www.ieee.org

International Organization for Standardization (ISO)
www.iso.org

International Telecommunication Union (ITU)
www.itu.int

Society of Cable Telecommunications Engineers (SCTE)
www.scte.org

Society of Motion Picture and Television Engineers (SMPTE)
www.smpte.org

Video Electronics Standards Association (VESA)
www.vesa.org