A Single Chip Video CD with Hi-Fi Audio for Consumer Applications

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What is Video CD?
Standard reproduction system for combining full motion pictures together with high quality audio using the Compact Disk format
- Based on the CD Bridge format
- Video CD disc can contain more than 70 minutes of data

Video + Audio Compression employs the ISO MPEG1 Standard
- Maximum bitrate = 1,377,600 bits/sec.
- Audio is layer II, sampled at 44.1 KHz

Supported by JVC, Matsushita, Philips, & Sony
- Referred to commonly as the “White Book”
Video CD Applications

Video-CD is suitable for a wide range of Video Products
- Video-CD Players (Karaoke Machines)
- CD-I Players with Digital Video Extension
- Computers equipped with CD-ROM drives & MPEG Decoders
- Modified CD Players with a Digital Output and an Add-On Video-CD Adaptor

Video-CD 1.1 introduced in September, 1993
Video-CD 2.0 introduced in March, 1994

Video-CD 2.0 Feature Extensions

1. Add high resolution (704 x 480 or 704 x 576) still pictures for best quality stills on NTSC or PAL TVs.

2. Add new audio quality modes:
   - LOW 128 kBIT/64 kBIT (stereo mono)
   - MIDDLE 192 kBIT/96 kBIT
   - HIGH 384 kBIT/192 kBIT

3. Add new playback control modes
Multimedia Playback Processor (MPP) System

**TDM:** General Purpose 16 Mbit/sec. serial link

**AUDIO:** Bidirectional serial port designed for seamless interfacing w/ DACs + ADCs for the transfer of PCM audio data

**VIDEO OUT:** YUV/RGB output display of frames stored in DRAM

**DRAM Iface:** Connects to ordinary 70ns PAGE-Mode DRAMs

**Peripheral Bus:** Microprocessor code store (for standalone boot) and interface to auxiliary system slave devices.

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**MPP Block Diagram**

- **RISC**
  - 40 MIPS 32-BIT RISC
  - On-chip Instruction ROM, Customized Code in external EPROM
  - 10 DMA channels

- **VP DSP**
  - 80 MHz SIMD machine with 128-BIT ALU, 64-bit MAC
  - Vertical pixel processing
  - On-chip microcode store (ROM/RAM)

- **Video Output**
  - On-Screen Display (OSD)
  - Decimation + Interpolation Filters for CCIR601/SIF conversion @ 60 frames/sec.
  - Temporal, block edge, + interlacing filters
  - Arbitrary image scaling for PAL/NTSC disc translation
Video Output/Post Processing

- Noise Reduction Filter

\[
\text{Pel}(i) = A\text{NewPel}(i) + (1-A)\text{Pel}(i-1),
\]

\[
\text{Pel}(i) = \text{Pel}(i-1) + A(\text{New Pel}(i) + \text{Pel}(i-1))
\]

Assume \( B = (A-1) \)

\[
\text{Pel}(i) = \text{NewPel}(i) + B(\text{NewPel}(i)-\text{Pel}(i-1))
\]

- Luma Interlacing/Chroma Interpolation

**LUMA**

<table>
<thead>
<tr>
<th>DMA Data</th>
<th>Data Out to Scalers Field 1</th>
<th>Data Out to Scalers Field 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line 0</td>
<td>3/4 Line0 + 1/4 Line1</td>
<td>1/4 Line0 + 3/4 Line1</td>
</tr>
<tr>
<td>Line 1</td>
<td>3/4 Line1 + 1/4 Line2</td>
<td>1/4 Line1 + 3/4 Line2</td>
</tr>
<tr>
<td>Line 2</td>
<td>3/4 Line2 + 1/4 Line3</td>
<td>1/4 Line2 + 3/4 Line3</td>
</tr>
</tbody>
</table>

**CHROMA**

4:2:0 Data From DRAM

- L1 Y0 Y1 Y2 Y3 Y4 ...
- CH1 U0A V1A U2A V3A U4A ...
- L2 Y0 Y1 Y2 Y3 Y4 ...
- L3 Y0 Y1 Y2 Y3 Y4 ...
- CH2 U0B V1B U2B V3B U4B ...

The interpolated chroma looks like:

- L1 Y0 Y1 Y2 Y3 Y4 ...
- CH1 U0A V1A U2A V3A U4A ...
- L2 Y0 Y1 Y2 Y3 Y4 ...
- CH2 U01 V11 U21 V31 U41 ...
- L3 Y0 Y1 Y2 Y3 Y4 ...
- CH3 U02 V12 U22 V32 U42 ...

Pixel delayed 1 frame
Video Post-Processing Components

- Horizontal Scaling

On-Screen Display

4 Modes of Operation

1. Bypass
2. 2 BITS/PIXEL - LUT for 3 colors, 1 transparent out of a palette of 8192 possible colors (5 BITS Y, 4 BITS U, 4 BITS V), 8 Blending values from 1/8 to 8/8 in LUT for each color
3. 4 BITS/PIXEL - Same as #2, except palette has 15 colors, 1 transparent
4. 8 BITS/PIXEL - 4 BITS for LUT (16 colors), 1 BIT transparency, + remaining 3 used for 1/8 to 8/8 mix value

Audio Post-Processing

- Audio Scaling - "KEY UP/KEY DOWN"
  - Use RISC Engine to process 16-BIT Decoded PCM Samples before they are sent to the DAC
RISC-Derived Special Effects

- Overcome Interval Jump with Amplitude Smoothing
  - This method is sufficient for key up/key down in the following range with 1/16 resolution:

- Programmable Reverberation
- MIC Echo
- Surround Sound

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Example of Audio Scaling in C

```c
#define SCALE_PCM do {
    idx = beg >> KEY_SHIFT;
    ptmp = (short*)((long*)last_pcm_in + idx) ;
    sv  = (long)(*(ptmp)) ; lv = (long)(*(ptmp+2)) - sv;
    dvm = (sv + ((((beg & KEY_MASK) * lv) >> KEY_SHIFT)));
    sv  = (long)(*(ptmp+1)) ; lv = (long)(*(ptmp+3)) - sv;
    dvl = (sv + ((((beg & KEY_MASK) * lv) >> KEY_SHIFT)));
    if ( cp1 < FADE_RANGE ) {\n        dvm = (dvm * cp1) >> FADE_SHIFT;\n        dvl = (dvl * cp1) >> FADE_SHIFT;\n    }\n    if ( cp1 > (PCM_NUM_PER_BUFFER - FADE_RANGE )) {\n        dvm = (dvm * (PCM_NUM_PER_BUFFER - cp1)) >> FADE_SHIFT;\n        dvl = (dvl * (PCM_NUM_PER_BUFFER - cp1)) >> FADE_SHIFT;\n    }\n    CLIPP(dvm); CLIPP(dvl); \n    *pout = (dvm << 16) | (dvl & Oxffff); \n} while (0)
```
MPP Technology Overview

Technology: 0.5μm CMOS triple layer metal
Chip Size: 6.98mm x 6.98mm
Transistor Count: 0.9M
Clock Frequency: 40MHz RISC clock, 80MHz DSP + Video
Power Supply: 5V, 3.3V
Power Dissipation: < 1.5W @ 5V
Package Type: 208 PQFP
Samples: NOW
Production: NOW

Digital Video Disc (DVD) Format

- High quality video (MPEG 2 coding) (better than LD)
- Large capacity (5-10 GBytes) - 2 hour movies
- Theatre Quality Audio (multi-channel)
- Multi-function
  - Interactiveness
  - Multi-aspect

MPP functionality will support these requirements
Conclusions

- The MPP’s application requires a high degree of integration, excellent video and audio quality, low power, and low overall system cost
- Including an embedded RISC in parallel with a DSP and dedicated hardware can be cost effective
- Video post-processing in hardware
- Audio post-processing in software
- Other system functions are integrated as the RISC MIPS increase:
  - CD Block Decoder functions
  - CD Microcontrol functions
  - Bitstream error suppression/recovery