

# Demystifying Cinepak For Sega

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# Contents

<b>1</b>	<b>Overview</b>	<b>4</b>
<b>2</b>	<b>History</b>	<b>5</b>
<b>3</b>	<b>File Format</b>	<b>6</b>
<b>4</b>	<b>Decoding</b>	<b>11</b>
4.1	Early Versions . . . . .	11
4.2	Version 1.2 . . . . .	11
4.3	Version 1.3 . . . . .	11
4.4	Modified Versions . . . . .	12
<b>5</b>	<b>Problems</b>	<b>13</b>
5.1	Single Palette . . . . .	13
5.2	Frame Rate . . . . .	13
5.3	Encoder Wasting Space . . . . .	13
<b>6</b>	<b>How To Use Cinepak In Homebrew</b>	<b>15</b>
<b>7</b>	<b>Video Game Usage</b>	<b>17</b>
7.1	Joe Montana's NFL Football . . . . .	17
7.2	Dracula Unleashed . . . . .	18
7.3	ESPN Baseball Tonight . . . . .	19
7.4	NHL 94 . . . . .	20
7.5	Mighty Morphin Power Rangers . . . . .	21
<b>8</b>	<b>Acknowledgements And Thanks</b>	<b>22</b>
<b>9</b>	<b>Disclaimers</b>	<b>23</b>



# List of Figures

3.1	How an 8x8 tile is broken up into 4x2 tiles . . . . .	10
3.2	How an 8x8 tile is broken up into 2x2 tiles . . . . .	10
7.1	Screenshot of TITLE.MVD from Joe Montana's NFL Football	18
7.2	Screenshot of 50201864.MVD from Joe Montana's NFL Football	18
7.3	Screenshot of VIDEOTTL from Dracula Unleashed . . . . .	19
7.4	Screenshot of VIDEO00 from Dracula Unleashed . . . . .	19
7.5	Screenshot of HOCKEY.SEG from NHL 94 . . . . .	20
7.6	Screenshot of HIT03.SEG from NHL 94 . . . . .	20
7.7	Screenshot of GOAL02.SEG from NHL 94 . . . . .	20
7.8	Screenshot of PR01.VID from Mighty Morphin Power Rangers	21

# Chapter 1

## Overview

The text “Cinepak for Sega” on the back of Sega CD has intrigued us all (otherwise why are you reading this?). Well this report will hopefully answer all your Cinepak questions. It provides a brief history before Cinepak for Sega existed and why Cinepak for Sega was desired. It includes a detailed description of the file format, descriptions of the Cinepak code revisions, problems seen in the Cinepak code, and problems with the Cinepak encoder. And lastly, it will give an overview of the Cinepak for Sega aspects in all the known games it is in.

There are four main aspects of the Cinepak for Sega: encoder, a Cinepak file, the MAINPLAY code, and the SUBPLAY code. The encoder is the program that generates the Cinepak file. The Cinepak file contains all the data to display the Cinepak movie. The MAINPLAY code is the program on the Sega Genesis main processor to decode the movie. The SUBPLAY code is the program on the Sega CD main processor to decode the movie.

# Chapter 2

## History

When home consoles moved from cartridges to CDs there was a huge increase in memory available. So early Sega CD games started using this extra space for CD quality music and videos. The CD quality music was a great addition for video games. However, the early video on the Sega CD games weren't so great at the beginning. There was a variety of formats used, and since most of the formats had little or no compression, the video was typically a small size or at a low frame rate. What was needed was a format with good image compression that could be decoded by the Sega CD processors.

To get better video quality, a good compression scheme for the image data was required. This is why Cinepak for Sega was developed. Cinepak was a general purpose video codec for 1x CD-ROM bitrates and decoding on slower processors. Since the Sega CD used the Sega Genesis VDP, this caused restrictions on the image quality. Converting the general purpose Cinepak files to the Sega Genesis VDP would have been impossible since the Sega Genesis VDP could not display the color depth required by the general purpose Cinepak. So Cinepak for Sega was developed to use the same ideas as the general purpose Cinepak codec but instead tailor the image data to the Sega Genesis VDP format. Typically, Cinepak for Sega's compressions of the image data being 35% to 70% of the original image data size. This amount of compression allowed for larger images or quicker frame rates. And since this was a generic codec that Sega provided to developers, it allowed many game developers to easily add video to their Sega CD games.

# Chapter 3

## File Format

Cinepak for Sega files come in many varieties. The most popular file extension is “SEG” though several other file extensions are used (“BIN”, “LIB”, “MVD”, “RES”, “S”, “SEG”, “VID”, or no extension). Also, the “SEG” file extension is used by other Sega CD movie formats.

Many games use a distinct file name for each Cinepak for Sega movie. Some games use a large file to contain multiple Cinepak for Sega. Regardless, each Cinepak for Sega movie data must start on CD sector boundary.

Table [3.1](#) shows the fields in the header for the Cinepak file.



Byte Location	Field Description
0-3	“FILM” identifier
4-7	Length of FILM chunk
8-11	FILM format version
12-15	Unused (always seen as zero)
16-19	“FDSC” Identifier
20-23	Length of FDSC chunk (always 20)
24-27	FOURCC of video codec
28-31	Height in pixels
32-35	Width in pixels
36-39	“STAB” identifier
40-43	Length of STAB chunk
44-47	Frame rate base frequency
48-51	Number of entries in STAB
52-67	First STAB entry

Table 3.1: File Format Headers

The Cinepak for Sega file always starts with the 4 ASCII character string “FILM”. This is used by the SUBPLAY code to verify a Cinepak file was correctly specified and being loaded.

For each Cinepak for Sega file there is a FOURCC for the video codec 4 ASCII character string. For “Seg3”, it always has 3 palettes per image frame. For “Seg4”, it always has 4 palettes per image frame. For the other values (0x00000000, “SEGA”, “sega”, and “SeGa”) there seems to be no common features. There are no requirements for this field since the decoder does not check this field.

The frame rate base frequency is used to determine when an image frame should be shown. To determine the start time of a frame in seconds divide the image start time by the frame rate base frequency. Note, later versions of Cinepak for Sega decoder assumed the frame rate base frequency is 600.

Table 3.2 shows the STAB entry format for an audio entry. Typically, audio entries are 0x4000 bytes long. The audio data is 8-bit signed magnitude 16276 Hz PCM data.

Byte Offset	Field Description
0-3	Sample Data Offset (From Start Of Sample Data)
4-7	Sample Data Length
8-11	0xFFFFFFFF
12-15	0x00000001

Table 3.2: STAB Entry: Audio

Table 3.3 shows the STAB entry format for an image entry. Image entries contain a palette, an optional palette map, and compressed tile data. The frame start is used to determine when the frame should be sent. The frame duration is not used by the decoder. Table 3.4 shows the format of the image data.

Byte Offset	Field Description
0-3	Sample Data Offset (From Start Of Sample Data)
4-7	Sample Data Length
8-11	frame start
12-15	frame duration

Table 3.3: STAB Entry: Image

Byte Offset	Field Description
0-1	“SM” Identifier
2-3	Palette Count Minus One (lowest two bits)
4-7	Byte Count Of Decoded Data
8-9	Frame Width In Tiles
10-11	Frame Height In Tiles
	Palette Data
	Palette Map Data (if multiple palettes)
	4x2 Codebook Length
	4x2 Codebook Data
	2x2 Codebook Length
	2x2 Codebook Data
	Method Flags
	Vector List

Table 3.4: Image Data

The palette count is the number of palettes for this frame. All Cinepak for Sega movies had the same number of palettes per frame even though it could be optimized to use less frames.

The palette data is the palette data for the frame. The size of the palette data is 32 times the palette count (since each palette takes 32 bytes). Note, the first palette index of each palette is ignored. The palette is in the Sega VDP format (four bits zero, 3 bits blue, 1 bit zero, 3 bits green, 1 bit zero, 3 bits red, 1 bit zero).

The palette map is only used when multiple palettes are used. It uses 2 bits for each tile to indicate the palette each tile should use. It uses the 2 most significant bits first and works to the least significant bits. The first tile is the upper left tile, and the order proceeds from left to right, then does the same for each row from top to bottom. Even when two palettes are used, two bits are used for each tile even though they could have only used one bit to make the palette map half the size.

The 4x2 codebook length and 2x2 codebook length is a 32 bit value. The 4x2 codebook data uses up to 256 entries and each entry is four bytes. The 2x2 codebook data uses up to 256 entries and each entry is two bytes. Each codebook entry is encoded starting from the top left corner, proceeding left to right, and then top to bottom.

The method flags uses the same format as the palette map. Each 2 bit method flag value indicates the type of compression for the tile.

A 2 bit method flag value of 0 means the tile is unchanged (from two frames ago due to double buffering).

A 2 bit method flag value of 1 means the tile is uncompressed and 32 bytes are used in the vector list.

A 2 bit method flag value of 2 means the tile is compressed using the 4x2 codebook. Figure 3.1 shows visually how the tile is compressed using the 4x2 blocks. Each of the 8 bytes from the vector list point to a 4x2 codebook entry (4 bytes) with the tile data for that 4x2 block. When you combine these together, you get the full 32 bytes for the tile data. The compression results from the reuse of the same 4x2 block data within this tile or with other tiles using 4x2 codebook compression.

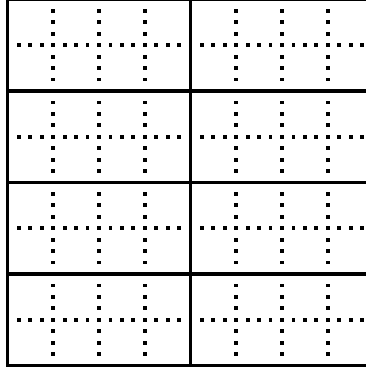


Figure 3.1: How an 8x8 tile is broken up into 4x2 tiles

A 2 bit method flag value of 3 means the tile is compressed using the 2x2 codebook. Figure 3.2 shows visually how the tile is compressed using the 2x2 blocks. Each of the 16 bytes from the vector list point to a 2x2 codebook entry (2 bytes) with the tile data for that 2x2 block. When you combine these together, you get the full 32 bytes for the tile data. The compression results from the reuse of the same 2x2 block data within this tile or with other tiles using 2x2 codebook compression.

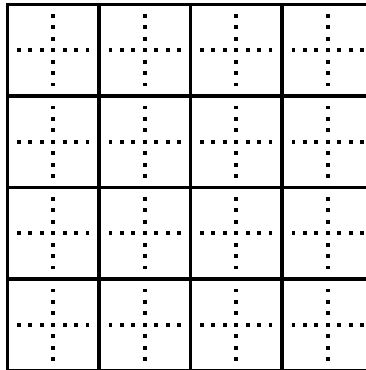


Figure 3.2: How an 8x8 tile is broken up into 2x2 tiles

# Chapter 4

## Decoding

There are many versions of the MAINPLAY and SUBPLAY code.

### 4.1 Early Versions

The early versions did not have a version labeled in the code. This version used the frame rate base frequency (later versions assumed a value of 600). This version also had some debug print information left in.

### 4.2 Version 1.2

This is the most common version. It is labeled as “CINEPAK VER 1.2”. This is the first version that uses a fixed frame rate base frequency of 600 (ignores the field in the Cinepak file). Ecco: The Tides of Time contained the official SUBPLAY.BIN distributed by Sega. ESPN National Hockey Night and ESPN Baseball Tonight contained the official MAINPLAY.BIN distributed by Sega.

### 4.3 Version 1.3

This was the latest labeled version and is labeled with “CINEPAK VER 1.3”. It supports an interleaved STAB (which allows longer movies since the entire STAB does not need to be stored in Sega CD program RAM).

## 4.4 Modified Versions

Code Monkeys Ltd created their own variants of the Cinepak. Tomcat Alley used some variation of the format and the original Cinepak decoder is not easily locatable in the ISO.

Code Monkeys Ltd further modified the Cinepak code for Surgical Strike and Wirehead. It allowed longer movies by reducing the STAB entry to 3 bytes (type information byte and 2 bytes for length of sample).

Mighty Morphin Power Rangers also modified the code, but used the same Cinepak file format.

# Chapter 5

## Problems

There are several problems for Cinepak for Sega.

### 5.1 Single Palette

The SUBPLAY properly ignores the palette map when a single palette is used, but the MAINPLAY still expects a palette map and causes tile data corruption. Therefore you need to specify a dummy second palette if only one palette is needed.

### 5.2 Frame Rate

The Sega CD PCM audio rate is  $\frac{12.5MHz}{384}$ . The decoder plays at half the native PCM audio rate. It is 16276 Hz, but the decoder assumes it should be 16000 Hz. Since it uses the audio to sync the frame, it can be off by  $\frac{16276}{16000}$ . Later versions of Cinepak slightly modify this value to be closer to 16276 but it still has a margin of error.

### 5.3 Encoder Wasting Space

The encoder used to make the original Sega CD Cinepak movies had several deficiencies.

It always used a fix number of palettes even the decoder allows a variable number of palettes for each frame. This only wastes 32, 64, or 96 bytes per

frame when a frame does not need as many palettes as other frames.

Even though the decoder allowed tile reuse from two frames ago, the original encoder never reuses these tiles. The amount of data this wastes is dependent on how many tiles can be reused, so movies with many reusable tiles like the Star Wars Chess game would have really benefited from the tile reuse aspect.

The encoder also fills the entire codebook tables even when the all the codebook entries. This can waste anywhere from zero to 1532 bytes (for a black screen).



## Chapter 6

# How To Use Cinepak In Homebrew

You need to include the MAINPLAY module. Both the MAIN and SUB processors need to run the MAINPLAY and SUBPLAY modules at (around) the same time. So when using in anything more complex than a demo, you need to properly synchronize the MAIN and SUB programs.

Prior to calling the MAINPLAY module, your MAIN program needs to set up certain VDP aspects. Cinepak only sets tile data, palette data, and tile map data and uses the scroll plane A. This allows the user program to still use the unused portion of scroll plane A, the entire scroll plane B, and sprites.

You call the MAINPLAY module by jumping to the starting address of the MAINPLAY module. When calling the MAINPLAY module, you pass a 4 byte address on the stack to indicate the user Vint routine. If this 4 byte address is zero, it indicates there is no user Vint routine. The user Vint routine is called every time the Cinepak Vint is ran (this can have issues due to the DMA transfers that can occur when a Vint occurs).

Prior to calling the SUBPLAY module, your SUB program only needs to make it sets up SUB side Vint. Cinepak sets up all the aspects of the PCM and CD reading.

Similar to the MAINPLAY module, you call the SUBPLAY module by jumping to the starting address of the SUBPLAY module. There are many parameters to push on the stack prior to calling the SUBPLAY module. The following stack values are in the order you push them to the stack. The first 4 byte value is the address of the user Vint routine (similar to the MAINPLAY

user Vint routine). The second 4 byte value is either a zero or one to indicate the tile priority of the tiles used for the Cinepak tiles. The third 4 byte value is the VRAM tile data start address. The fourth 4 byte value is the VRAM tile map start (this has to have space for two consecutive tile maps since the data is double buffered). The fifth 4 byte value is the x coordinate in terms of tiles (so a 2 means the movie upper left corner is 16 pixels from the left side of the screen). The sixth 4 byte value is the y coordinate in terms of tiles (so a 3 means the movie upper left corner is 24 pixels from the top of the screen). The seventh 4 byte value is length of the heap (example: 0x4B000). The eighth 4 byte value is the starting address of the heap (example: 0xF000). The ninth 4 byte value is the sector start of the Cinepak movie. The last value is a 2 byte value to indicate the cinepak action (0 means open, 1 means task, 2 means close).

A simple call to SUBPLAY involves calling with the open action. Then loop with the task action. Then when finished, call the close action. See the Cinepak demo for a full example.

# Chapter 7

## Video Game Usage

### 7.1 Joe Montana's NFL Football

Joe Montana's NFL Football is a football game.

Joe Montana's NFL Football used an early version of the Cinepak for Sega codec. On the back cover, it declares "Featuring Cinepak for Sega". The back cover also states "Sega, Sega CD, TruVideo, and welcome to the next level are trademarks of Sega." and the TruVideo aspect of this phrase is missing from similar text on the CD. "Cinepak is a trademark of Supermac Technology, Inc." is written on both the back cover and the CD. The back cover also advertises the following:

**Genuine Joe Montana Video!** Strategize with the NFL's greatest QB via real video.

Each Cinepak movie is in its own file on the CD and uses the MVD as the file extension.

The title video was 240x150 with 10 FPS and three palettes. It plays when you first start the game and displayed the title of the game, along with the NFL logo and spinning football helmets.



Figure 7.1: Screenshot of TITLE.MVD from Joe Montana's NFL Football

When you call a timeout during a game, videos of Joe Montana giving you advice is shown. There are 70 144x128 25 FPS videos, two 144x128 30 FPS videos, and two corrupt video files. The instruction manual states:

In Joe Montana's NFL Football, you can get expert coaching from Joe Montana in do-or-die situations. You have the option to "Ask Joe!" any time you call a time out (3 times each half). Joe analyzes the game situation, then advises you via TruVideo on play calling and strategy.



Figure 7.2: Screenshot of 50201864.MVD from Joe Montana's NFL Football

## 7.2 Dracula Unleashed

Title video with logos and credits. (could really benefit from reusing tiles).



Figure 7.3: Screenshot of VIDEOTTL from Dracula Unleashed



Figure 7.4: Screenshot of VIDEO00 from Dracula Unleashed

## 7.3 ESPN Baseball Tonight

Each team has an intro and the video is all the same, just different audio.

## 7.4 NHL 94



Figure 7.5: Screenshot of HOCKEY.SEG from NHL 94



Figure 7.6: Screenshot of HIT03.SEG from NHL 94



Figure 7.7: Screenshot of GOAL02.SEG from NHL 94

## 7.5 Mighty Morphin Power Rangers



Figure 7.8: Screenshot of PR01.VID from Mighty Morphin Power Rangers

## Chapter 8

# Acknowledgements And Thanks

I would like to acknowledge Mike Melanson from multimedia.cx who provided a good overall description of the Sega FILM file format that I used as a starting point in my research. I would like to acknowledge Tasco Deluxe for provided a further Cinepak for Sega breakdown. Both of these documents was useful in helping me quickly disassemble the Cinepak for Sega code since they provided such a good understanding of the file format. My research should hopefully fill some of the unknown aspects of the file format. I would also like to acknowledge the members of the Sonic Retro and Sega-16 communities for discussions and feedback.

I would also like to thank my kids who enjoyed watching some of the early demos I made using Cinepak. I would also like my wife for understanding having a hobby is important.



# Chapter 9

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