

System Memory Requirements for Digital TV and Set-Top Platforms

This white paper provides background information on the memory requirements for Broadcom's video digital TV and set-top box back-end chips. The amount of memory needed will vary significantly, depending on the features implemented in the target system. The memory estimates use Broadcom's reference software and applications to generate the sample systems. The customer-specific applications will have different results.

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Introduction

This document analyzes heap allocations, which are made using the BMEM memory manager. These allocations do *not* include the following:

- Boot loader
- Operating System
- Application Code and Data
- Porting Interface Code
- Porting Interface System-Memory Allocations (using BKNI_Malloc)

How to Estimate Memory Requirements

To estimate an application's memory requirements, Broadcom recommends using a three-step process.

- First, estimate overall memory usage with a Memory Usage Spreadsheet from Broadcom.
- Second, the system should be modeled using Broadcom reference software and applications.
- Finally, the target system should be built and analyzed.

The first two memory estimates are generated from models and, therefore, should be used with caution. For systems that approach the memory limits, the estimates should include a margin.

Spreadsheet Estimate

For many video back-end chips, a Memory Usage Spreadsheet is available that will generate a good starting estimate of the memory usage. As the first step in estimation, the spreadsheets show how features affect the overall memory requirements and allow experimentation. A sample spreadsheet is included in Appendix A of this white paper.

Prototype Using the Set-Top API and Broadcom Applications

The second step is to generate a more accurate memory estimate by using one of the Broadcom applications, such as Brutus™. These applications can be configured to model the target system and then used to experiment on and analyze the effect on memory usage.

For example, Broadcom's Brutus and Settop API can be customized at compile-time by modifying the file:

```
BSEAV/api/src/magnum/board/bsettop_bsp_<CHIP>.h
```

Once this file is modified so that Brutus matches the target system, the actual memory allocations can be observed by using the BDBG interface, which the BMEM module uses to print out heap status.

A simple technique to see the memory allocation is:

```
export msg_modules=BMEM  
settop brutus
```

Implement the Target System

The final step is to implement the target system. Building the system will probably uncover a few unexpected memory requirements, so the memory budget should include a margin of at least a few kilobytes.

Memory Consumers

The system memory requirements vary greatly depending on the chip used and the feature set implemented. The following sections provide a brief description of the major memory consumers.

Compressed Video Decoding

The video decoders are large memory consumers and can account for more than half the memory required. The amount needed depends on the codecs supported (MPEG-2, AVC, AVS), the levels and profiles supported, the support for high definition streams, the number of simultaneous decodes, and the support for still-image decoding.

Firmware

By default, firmware is compiled into the application, which means it must be counted. As an example, 1 MB should be reserved for the FW to support a single AVD core

Decoder Memory

The decoder takes a single block of memory and internally allocates decode buffers, internal processing buffers, data structures, and other items.

The XVD Porting Interface allows the application to configure the usage and changes the amount of memory allocated accordingly. Sample memory requirements for the primary decode are shown in Table 1.

Table 1: Sample BCM7401 Video Decoder Memory Sizes

Codecs	Decoder Memory Needed (MB)
AVC/MPEG/VC1 SD/HD (default)	30
MPEG SD	6
MPEG SD/HD	23
MPEG/VC1 SD/HD	30
AVC/MPEG/VC1 SD	12

See the file `bsettop_base_xvd_74xx.c` for example XVD PI configuration code.

Compressed Data and Index Table Buffers

The number of required Compressed Data Buffers (CDB) and Index Table Buffers (ITB) depends on the chip and the number of simultaneous decodes supported by the system. Sample memory requirements are given in Table 2.

Table 2: Sample CDB and ITB sizes

Chip	Buffer Description	CDB (MB)	ITB (MB)
7401	Single decode	1.5	0.5
7405	Primary decode	1.5	0.5
7405	Secondary decode	1.0	0.13

For IP set-top systems, the CDB is used for jitter management, which doubles its sizes.

Still Image Decode

If the video decoder supports the still image decode feature, it will require additional memory. This feature can be configured for high definition (HD) or standard definition (SD) images. As an example, an HD frame buffer requires 3 MB of memory, the PPB requires 1 KB, and an ITB requires an even smaller amount of memory.

Compressed Audio Decoding

The audio decoders are configurable and use varying amounts of memory depending on the codecs supported, the bit rates supported, and the number of simultaneous decodes. Specific chips will have varying requirements.

Firmware

The audio decoders require firmware which is compiled in the application and counts against memory usage. Typically the audio firmware consumes 0.8 to 1 MByte of memory.

Compressed Data and Index Table Buffers

The number of required Compressed Data Buffers (CDB) and Index Table Buffers (ITB) depends on the chip and the number of simultaneous decodes supported. The decoders also require ring buffers for decode and PCM playback.

As an example, each context on the BCM7405 requires 256 KB for the CDB and 64 KB for the ITB. If only MPEG and AC3 are needed, it is possible to reduce the CDB to 128 KB.

Video Features

The Broadcom Video Network (BVN) is responsible for taking video, sourced from analog and digital sources, and formatting it for the displays. The BVN includes scalers, noise reduction, capture engines, and playback engines.

For current cable and satellite chips, the memory is allocated in discrete-sized SD or HD buffers that hold entire frames of video data. The number of buffers required depends upon the number of independent video outputs, PIP/POP support, de-interlacing support, high definition support for the streams and display device, and support for system-level lip sync.

Table 3 shows the typical number of buffers required for various feature sets. The values for a specific chip may vary. The bsync lib, mentioned below, maintains lip-sync by compensating for the different decoding times for the audio and video codecs. This feature requires additional video buffers.

Table 3: Sample BCM7405 Set-Top Video Buffering Requirements

Configuration	HD Buffers	SD Buffers
Dual HD/SD CMP, MAD, bsync, PIP(Default)	3	15
Dual HD/SD CMP, MAD, bsync	3	12
Dual HD/SD CMP, MAD	2	10
Dual HD/SD CMP, bsync	3	6
Dual HD/SD CMP	2	4
Single HD CMP, MAD	2	6
Single HD CMP	2	0
Single SD CMP	0	2

For television and set-top box chips with advanced video processing features, estimating the memory requirement is much more difficult. The larger number of features such as 1080p 60-Hz resolution, 10-bit video, 4:4:4 video, and de-interlacing can have complex interactions that affect the memory requirements. An accurate estimation requires a detailed analysis.

Table 4 lists the memory requirements for several generic systems.

Table 4: Sample Television Video Requirements for TV Applications

Configuration	Memory Required
BCM3552 32-bit 64-MB DDR, 1366x768, no PIP, no VCR	18.1
BCM3553, 64-bit 64-MB DDR, 1920x1080, no PIP, no VCR	31.9

Transport

The transport block receives incoming compressed data streams and demultiplexes the audio, video, and data content. It also handles network security and Personal Video Recording (PVR) functions.

The transport hardware is chip-specific but typically can require from 2 MB to 17 MB of memory. IP video functions can double the transport requirements.

Table 5: Sample BCM7405 Transport Memory Requirements

Transport Feature	Memory Needed (MB)
RS	0.80
XC	0.85
Message FIFO	0.13
PVR- Record FIFO	10.50
PVR- Playback FIFO	4.00

Graphics

Graphics features have a significant effect on the system memory. The height, width, and bit depth of the required graphics support, double buffering, and the number of displays directly impact the system memory requirements.

For example, two 960x1080 32 bpp HD graphics surfaces will consume:

$$2 * 960 * 1080 * \frac{32}{8} = 7.91 \text{ MB}$$

Figure 1: Sample Graphics Memory Required

Sample Memory Requirements

The following section provides memory requirements for common system configurations of several chips. Memory required by a specific customer system will vary from these estimates.

BCM3563 Systems

Table 6: Sample BCM3563 Memory Requirements

Summary	Configuration	Memory 0 Required	Memory 1 Required
Full system	HD/SD output+MAD+PIP MPEG/AC3/AAC/AC3+/DDP audio decode	52.1 MB	14.9 MB

BCM7400 Systems

Table 7: Sample BCM7400 Memory Requirements

Summary	Configuration	Main Bank	Bank 1	Bank 2
Full system with PVR	HD/SD output (dual compositor)+MAD+PIP AVC/MPEG/VC1 HD+SD second video decode MPEG/AC3/AAC/AC3+/DDP audio decode 2 playback 3 records 4 input bands	61.95 MB	24.33 MB	24.33 MB
Full system without PVR	HD/SD output (dual compositor) AVC/MPEG/VC1 HD/SD video decode MPEG/AC3/AAC/AC3+/DDP audio decode 1 input band	46.84 MB	24.33 MB	24.33 MB

BCM7401 Systems

Table 8: Sample BCM7401 Memory Requirements

Summary	Configuration	Heap Memory Required
Full system with PVR	HD/SD output (dual compositor) AVC/MPEG/VC1 HD/SD video decode MPEG/AC3/AAC/AC3+/DDP audio decode 1 playback 2 records 2 input bands	66 MB
Full system without PVR	HD/SD output (dual compositor) AVC/MPEG/VC1 HD/SD video decode MPEG/AC3/AAC/AC3+/DDP audio decode 1 input band	55 MB
7038-equivalent System with PVR (no advanced codecs)	HD/SD output (dual compositor) MPEG HD/SD video decode MPEG/AC3 audio decode <ul style="list-style-type: none"> • 1 playback • 2 records • 2 input bands 	58 MB
BCM7038-equivalent system without PVR (no advanced codecs)	HD/SD output (dual compositor) MPEG HD/SD video decode MPEG/AC3 audio decode <ul style="list-style-type: none"> • 1 input band 	49 MB
Minimum MPEG/SD system without PVR	SD output (single compositor) MPEG SD video decode (no MAD) MPEG/AC3 audio decode <ul style="list-style-type: none"> • 1 input band 	17 MB

BCM7405 Systems

Table 9: Sample BCM7405 Memory Requirements

Summary	Configuration	Heap Memory Required
Full system with PVR	HD/SD output (dual compositor)+MAD+PIP AVC/MPEG/VC1 HD+SD second video decode MPEG/AC3/AAC/AC3+/DDP audio decode <ul style="list-style-type: none"> • 1 playback • 2 records • 2 input bands 	73.87 MB
Full system without PVR	HD/SD output (dual compositor) AVC/MPEG/VC1 HD/SD video decode MPEG/AC3/AAC/AC3+/DDP audio decode <ul style="list-style-type: none"> • 1 input band 	55 MB

Appendix A: Spreadsheet Example

Figure 2 shows the memory estimation spreadsheet for the BCM7405.

7405 Memory Requirements			
Instructions: Mark the form and fill in the boxes on the left-hand side. Read heap allocation on right-hand side.			
<input type="button" value="Reset to SetTop API Defaults"/>	<input checked="" type="checkbox"/> UNIFIED MEMORY	Main Bank	16-Bit Bank 1
		Total Allocations	76.23 0.00
General Options			
<input type="checkbox"/> IP Settop (w/ Net DMA)			
Video Decoder 0 (XVD)			
<input checked="" type="checkbox"/> MPEG	<input checked="" type="checkbox"/> SD Still Picture	FW	1.00
<input checked="" type="checkbox"/> Advanced Codecs	<input checked="" type="checkbox"/> HD Still Picture	Heap	31.46 0.00
<input checked="" type="checkbox"/> HD	<input checked="" type="checkbox"/> Advanced Codec Still Support	Still Heap	4.07 0.00
<input checked="" type="checkbox"/> HD+SD	<input type="checkbox"/> Stripe Width 64 <input checked="" type="checkbox"/> Stripe Width 128	CDB	1.50
<input checked="" type="checkbox"/> 6 Up CIF	<input type="checkbox"/> Multiple 32 <input type="checkbox"/> Multiple 64 <input checked="" type="checkbox"/> Multiple 128	ITB	0.38
<input checked="" type="checkbox"/> 12 Up QCIF		Still CDB	1.00
<input checked="" type="checkbox"/> Broadcom Trickmodes		Still ITB	0.13
Video Decode 1 (XVD) Not Available			
<input type="checkbox"/> Enabled	<input type="checkbox"/> SD Still Picture	FW	
<input type="checkbox"/> MPEG	<input type="checkbox"/> HD Still Picture	Heap	
<input type="checkbox"/> Advanced Codecs	<input type="checkbox"/> Advanced Codec Still Support	Still Heap	
<input type="checkbox"/> HD	<input type="checkbox"/> Stripe Width 64 <input type="checkbox"/> Stripe Width 128	CDB	
<input type="checkbox"/> Dual SD	<input type="checkbox"/> Multiple 32 <input type="checkbox"/> Multiple 64 <input type="checkbox"/> Multiple 128	ITB	
<input type="checkbox"/> 6 Up CIF		Still CDB	
<input type="checkbox"/> 12 Up QCIF		Still ITB	
<input type="checkbox"/> Broadcom Trickmodes			
Audio Decode (RAP)			
<input checked="" type="checkbox"/> MPEG L1/2		FW code + data	1.00
<input checked="" type="checkbox"/> AC3		Decode CDB	0.25
<input checked="" type="checkbox"/> AAC		Decode ITB	0.13
<input checked="" type="checkbox"/> AC3+(DDP)		Passthrough CDB	0.13
<input checked="" type="checkbox"/> AAC+		Passthrough ITB	0.06
<input checked="" type="checkbox"/> MPEG L3			
<input checked="" type="checkbox"/> Compressed Output (SPDIF or HDMI)			
<input checked="" type="checkbox"/> Second Decoder			
Display (VDC)			
<input type="checkbox"/> 656 Input	<input type="checkbox"/> B7DC Settings	VBI	0.06
<input checked="" type="checkbox"/> MAD	<input type="checkbox"/> SD buffers 16	RUL's	0.67
<input type="checkbox"/> SD display	<input type="checkbox"/> HD buffers 3	Buffer Memory	10.88
<input type="checkbox"/> HD Display	HD size 2073600		
<input checked="" type="checkbox"/> SD and HD display	SD size 345600		
<input checked="" type="checkbox"/> PIP			
<input checked="" type="checkbox"/> +/- 20 msec overall			
Transport (XPT), not including decode CDB/ITB			
Total # of Inband Parsers (IBP)	4	RS Buffer	0.80
IBP's to Decode and/or Record	4	XC Buffer	0.85
IBP's to Message Filter	4	Message FIFO	0.13
# of Message Buffers	32	Record FIFO	10.50
Msg Filter FIFO (MB)	0.004	Playback FIFO	4.00
# of Records	3		
Record Data FIFO (MB)	3		
Record SCT FIFO (MB)	0.5		
# of Playbacks	2		
Playback FIFO (MB)	2		
Remux	0		
Graphics (VDC/GRC)			
HD bpp	32	HD graphics	5.93
HD width	720	SD graphics	1.32
HD height	1080		
HD buffers	2		

Figure 2: Sample BCM7405 Memory Usage Spreadsheet

Appendix B: Glossary

Table 10: Glossary of Acronyms

Acronym	Description
bpp	Bits per pixel
CDB	Compressed Data Buffer
HD	High Definition
ITB	Index Table Buffer
MAD	Motion-adaptive deinterlacer
MVD	PI module responsible for video decoders on Minititan systems
PI	Porting Interface
PIP	Picture-in-Picture
POP	Picture-outside-Picture
PPB	Picture Parameter Block
SD	Standard Definition
XVD	PI module responsible for video decoders on AVD systems



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