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## SEGA SATURN TECHNICAL BULLETIN #1

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** June 2, 1995  
**Re:** Saturn CD Drive Duty Ratio Restrictions

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When developing CD-ROM software for the Saturn, note the following restriction:

The duty ratio of the Saturn CD drive must be 33% or less after approximately 10 minutes.

This restriction is due to a CD drive limitation.

• Duty Ratio Definition:  $\text{Duty ratio} = [\text{seek time} / (\text{seek time} + \text{nonseek time})] \times 100$

**Note:** Nonseek time refers to the time used for operations other than seek (such as play or pause).

## **SEGA SATURN TECHNICAL BULLETIN #2**

**To: Sega and Third Party Developers**  
**From: Developer Technical Support**  
**Date: June 2, 1995**  
**Re: Preemphasis Prohibited**

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The use of "preemphasis" is strictly prohibited, regardless of whether an SCSP is used.  
**(Mandatory)**

Reason:

In the Saturn, the digital-to-analog converter (DAC) at the final level controls the emphasis. Therefore, when a preemphasized CD-DA is played, the sound output from the SCSP is also deemphasized.

## SEGA SATURN TECHNICAL BULLETIN #3

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** June 2, 1994  
**Re:** Information Regarding CD Burning

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1. If any hardware and/or software other than those listed below are needed, approval from Sega must be acquired first. Materials related to the approval process will be distributed at a later date.
  - Write-once writer
    - Yamaha CD Expert CDE 100
  - Write-once writing software
    - SEGACDW.EXE
  - Media
    - Sega private media: Model number CDM12PS71 (with Sega Saturn logo)
    - Sega MEGA CD-R 1.25 m/s (blue-labeled disc with Sega logo for MEGA-CD)

**WARNING: MEGA CD-R cannot be used for quadruple-speed write operation.**

**Note:** The product names and model numbers provided above are those sold by the distributors.

2. The following is a sample Script file for building a write-once SEGA Saturn CD. Please note that the first file in the script **MUST** be named 0.

```
Disc SAMPLE.DSK
CatalogNo 0
Session CDROM
LeadIn MODE1
EndLeadIn
SystemArea IP.BIN
  Track MODE1
    Volume ISO9660 SAMPLE.PVD
      PrimaryVolume 0:2:16
      EndPrimaryVolume
    EndVolume
  File 0
```

```
File A.BIN
  FileSource TEST.BIN
  EndFileSource
EndFile
File SDDRVS.TSK
  FileSource SDDRVS.TSK
  EndFileSource
EndFile
File NEWMAP.TSK
  FileSource NEWMAP.TSK
  EndFileSource
EndFile
Directory SMPD101
  File SMP001.DAT
    FileSource SMP101.DAT
    EndFileSource
  EndFile
  File SMP002.DAT
    FileSource SMP002.DAT
    EndFileSource
  EndFile
EndDirectory
Directory SMPD102
  File SMP003.DAT
    FileSource SMP003.DAT
    EndFileSource
  EndFile
EndDirectory
PostGap 300
EndTrack
Track CDDA
  Pause 150
  File CDDA1
    FileSource SND8_1.DAT
    EndFileSource
  EndFile
EndTrack
Track CDDA
  File CDDA2
    FileSource SND8_3.DAT
    EndFileSource
  EndFile
EndTrack
LeadOut CDDA
  Empty 300
EndLeadOut
EndSession
EndDisc
```

## **SEGA SATURN TECHNICAL BULLETIN #4**

**To: Sega and Third Party Developers**  
**From: Developer Technical Support**  
**Date: June 2, 1995**  
**Re: Saturn Software Development Standards**

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SEGA Saturn Software Development Standard (Ver1.10 10/18/94 version) / ST-151-R3-SB-102794 is available.

### What is Software Development Standard?

Software Development Standard is a document that covers the standard for achieving consistency in Saturn games of SEGA brand. The contents of the document must be understood, before game development starts. Please note that the games in which standardized items are not adhered to, cannot be released.

## SEGA SATURN TECHNICAL BULLETIN #5

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** June 2, 1995  
**Re:** Error Checking for Data Errors

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When creating a CD-ROM for Saturn, always execute a read retry to ensure that there are no data errors. (**Mandatory**)

Explanation:

Although CD-ROMs have a high error correction ability, uncorrectable errors may occur due to drive deterioration, scratches or dust on the disc, or an eccentric disc.

Therefore to ensure that there are no data errors, in addition to implementing the "method for increasing the ECC count," always execute a read retry.

However, note that executing a retry during debugging may obscure error causes.

## **SEGA SATURN TECHNICAL BULLETIN #6**

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** June 2, 1995  
**Re:** Saturn System Functions

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The following table lists system libraries and object files for security codes and area code groups that are provided by SEGA. Use these files without any modifications when accessing resources for the items listed in the table.

Item	Corresponding library	Corresponding function
Creating a vector table	System program	Registration and referencing of the interrupt processing routine
Accessing a SCU interrupt mask register	System program	Setting, referencing, and modification of the SCU interrupt mask
Using a simple semaphore	System program	Simple semaphore operation
Switching the system clock	System program	System clock switching
Modifying the priority of the SCU interrupt routine	System program	Priority modification of the SCU interrupt routine
Starting the CD multiplayer	System program	Execution of CD multiplayer activation
Operating the power-on clear memory function	System program	Power-on clear memory operation
Accessing the SMPC	SMPC interface	–
Accessing a backup (main unit, cartridge, and serial)	Backup library	–
Accessing a CD block	CD communication interface	–
Registering security code or area code groups	<ul style="list-style-type: none"><li>• Security codes</li><li>• Area code groups</li></ul>	–

- For details on each function, see the "Disc Format Standard Specification V.1.0 (ST-040-R3-011805, 12/94)" and the "Saturn System Library User's Manual Version 1.0 (ST-162-R1-092994)" in the "Programmer's Guide Volume 1."

## SEGA SATURN TECHNICAL BULLETIN #7

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** June 2, 1995  
**Re:** Saturn Disc Format Specification Change

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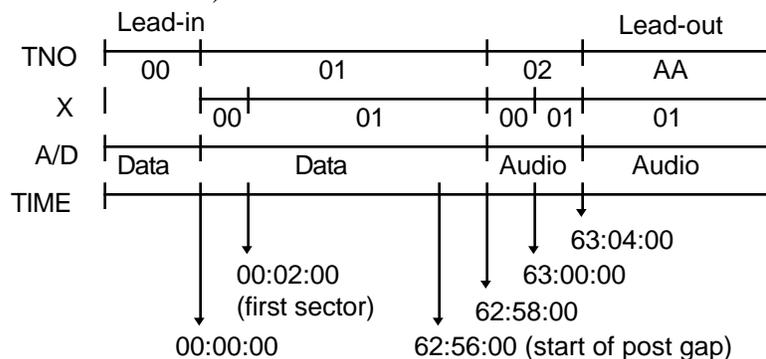
The standard specifications for the Sega Saturn disc format will be changed as follows:

Target: Disc Format Standard Standard Specification Version 0.9

1. Recording range in program area

	ABS TIME	LSN	FAD
First frame	00:00:00	-	0
First sector	00:02:00	0	150
Last sector	63:01:74	283500	283650
Last frame	63:03:74	-	283800
Read out area start time	63:04:00		

- The first frame and first sector must be the times shown above. The last sector and last frame must be the times shown above or smaller values.
- 2. The following figure is an image of the tracks when the data track is maximized (audio track is minimized).



- The portion of the track that can actually be used as the data sector is from the first sector to one sector before the start of the post gap (approximately 566 megabytes).

For each minute that the audio track usage time increases, the data sector decreases by 9 megabytes.

## **SEGA SATURN TECHNICAL BULLETIN #8**

To: Sega and Third Party Developers  
From: Developer Technical Support  
Date: June 2, 1995  
Re: CD Communication Interface Update

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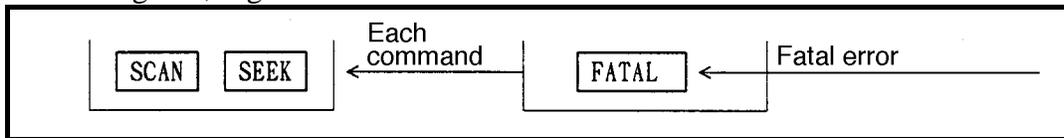
This Saturn technical bulletin is an update to the Saturn “CD Communication Interface User’s Manual Version 0.9 “, which can be found in the “System Library User’s Guide (ST-162-060294).”

CD Communication Interface: Supplemental Material

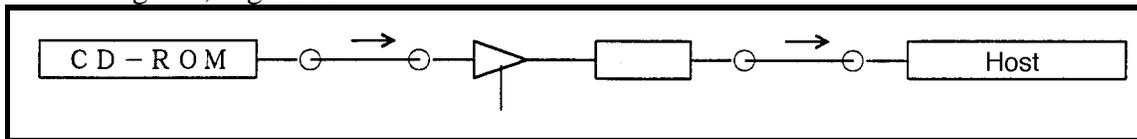
◆ Errata

Page	Location	Error	Correction
41–42	Figures 5.1, 5.2	MPEG buffer	MPG sector buffer
44	Figure 5.5	$\sum_{p=20} N_p$	$\sum_{p=0} N_p$
77	No. 1.5 No. 1.6	WAIT results in <OPEN> or <NODISC> status.	WAIT is returned during TOC read. In <OPEN> or <NODISC> status, all information that can be obtained becomes FFFFFFFFH.
78	No. 1.7	Standby time (lower 8 bits)	Standby time (lower 16 bits)
82	No. 2.1 (3)	Move the pickup */	Do not move the pickup */
85	No. 3.2	Subcode flag (lower bit)	Subcode flag (lower 8 bits)
94	No. 6.6 (3)	Becomes CDC_SOPS_END.	Becomes CDC_SPOS_END.
100	No. 8.4 Example	CdcFile file[256]	CdcFile file[254];

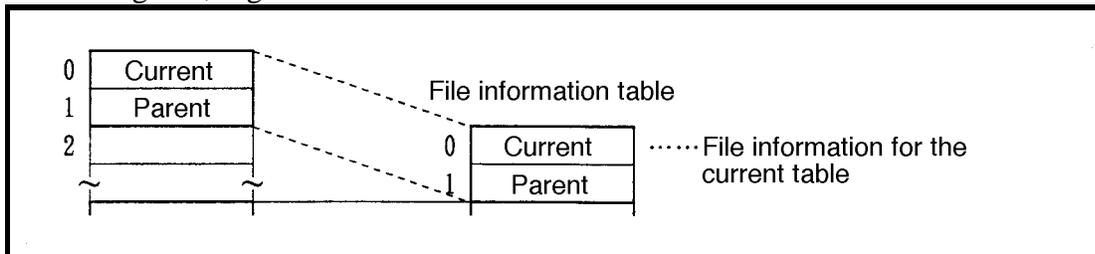
- Page 35, Figure 4.2



- Page 42, Figure 5.2



- Page 51, Figure 6.2



◆ Modifications

Page	Modification description
31	The description in "3.3 (3) Periodic response" was corrected and supplemented.
37–38	The contents of "4.2 CD Drive Operation" were modified.
39	In "4.3 Subcodes," the figure number was changed from Figure 4.4 to Figure 4.5.
63	The return code (CdcRet) of the CD communication function was discontinued.
63	Error code CDC_ERR_PTYPE was discontinued.
78–79	The specifications for the CD block initialization function (CDC_CdInit) were changed.
83	A remark was added for the play position seek function (CDC_CdSeek).
100	The specifications of the get function for hold file information (CDC_GetFileScope) were modified.
102	The specifications of the get function for the data transfer register pointer (CDC_GetDataPtr) were changed.
103	The specifications of the get function for the MPEG register pointer (CDC_GetMpegPtr) were changed.

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(3) Periodic response

The periodic response is the response that the CD block returns based on the CD drive communication timing. This response allows the host to obtain information (status and CD report) without issuing a command.

The communication cycle with the CD drive is updated periodically. (The update timing for the SCDQ flag is the same.)

Update cycle for the periodic response	{	• Standard-speed play: 13.3 ms
	}	• Double-speed play: 6.7 ms
	[	• Other: 16.7 ms or less

The periodic response is not updated during command or response processing. After a response is read by a command, the response is updated at the next CD drive communication timing and can be obtained.

[Note]

The update cycles shown here for the scheduled response (SCDQ flag) are the normal values. The update cycles may increase depending on the CD drive and other communication conditions (for example if communication with the CD drive fails because of disc scratches).

- Pages 37 to 38
- #### 4.2 CD Drive Operation

##### (1) Frame address for <PLAY> status

The frame address (current FAD) reported during CD play indicates the sector being read. The sector of the current FAD is not yet stored in the CD buffer and cannot be fetched. The host can access the sector immediately preceding the current FAD (for a CD-ROM).

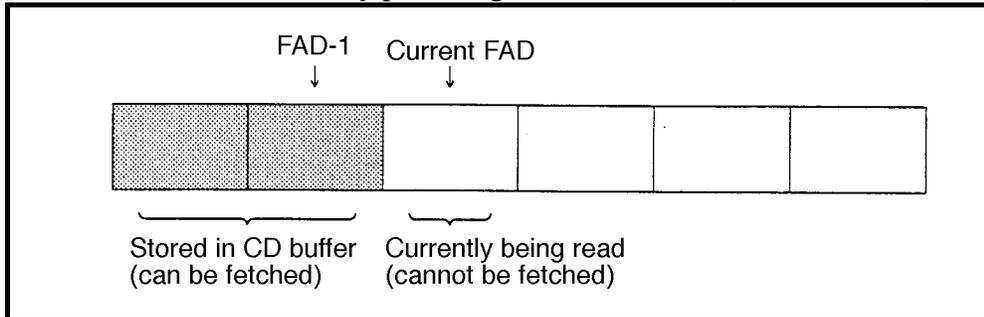


Figure 4.3 Sector indicated by the current FAD

After play ends, the FAD becomes the "end position + 1." (If the end position is disc end, the same processing occurs and the FAD points to the lead-out area.)

##### (2) Transition from <PLAY> status and sector storage

When the status is switched from <PLAY> to another status, whether the sector being read is stored is undefined. If the status is switched to a status other than <BUSY>, the sector that should be stored is fixed.

At <PLAY> status, issue the PAUSE command. When the status switches to <PAUSE>, the FAD indicated by the "storage sector + 1" is reported.

##### (3) Repeat processing in CD play operation

As described below, repeat processing takes place when the current position moves out of the play range during CD play.

- After the end position frame is played (FAD = end position + 1)
- If the FAD ends up outside the play range after the play range is changed
- If pause release (play restart) is executed while the pause is outside the play area

Both the repeat notification count (OH to EH) and the maximum specification count (OH to FH) are displayed with 4 bits. The repeat processing sequence (repeat processing determination) is as follows:

- If the repeat count is less than the maximum repeat count, repeat is performed. The CD drive seeks the start position and switches to <PLAY> status. If the repeat count is less than EH (14), the repeat count is incremented by 1.
- If the repeat count is greater than or equal to the maximum repeat count, repeat is not performed. The <PAUSE> status occurs at the current position, and the PEND bit of the interrupt cause register becomes 1.

If the play range or maximum repeat count is changed, the repeat count is cleared to 0. Both the repeat count and the play range are not affected by tray opening/closing or a seek operation during play.

(4) Play range and frame address

If the user executes CD play without moving the pickup, operation switches to <PLAY> status if the current position is within the new play range. If the user executes CD play during <PLAY>, operation remains in <PLAY> status.

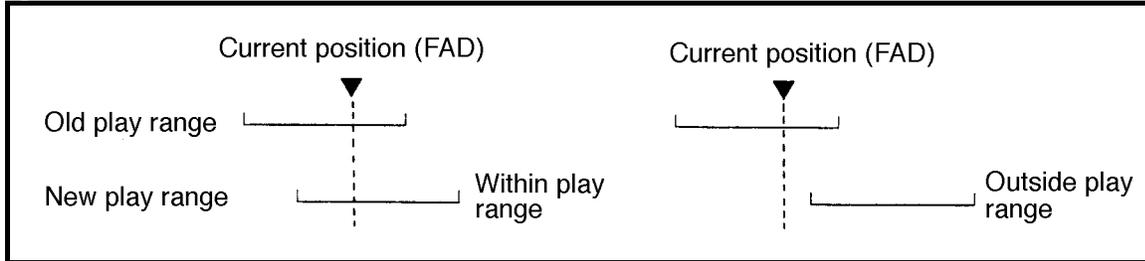


Figure 4.4 Relationship between play range and current position

The FAD moves outside the play range (FAD < start position, FAD > end position) when the following operations are performed:

- When play end, play range modification, seek, or scan play is executed
- When pause release is executed while the pause is outside the play area

The operation outside the play range depends on whether or not there is a repeat.

For example, if play ends without a repeat, operation switches to <PAUSE> status at "FAD=end position + 1," and the PEND rank switches to 1.

Table 4.5 Operation outside the play range

Operation (command)	No repeat		With repeat	
	Status	PEN D	Status	PEN D
End of CD play	<PAUSE> at FAD = end position + 1	1	Seek to start position, then <PLAY> (repeat operation)	0
CD play (play range modification, pause release)	<PAUSE> at current position			
Seek	<PAUSE> at target position	1	<PAUSE> at target position	0
Scan play	<PAUSE> at any position	1	<PAUSE> at any position	0

A PEND flag value of 0 indicates no change.

(5) Seek to home position (stop)

When seek to home position is executed, the status of the CD block switches as follows:

- Rotation of the disc motor stops, and the pickup moves to the inside wait position.
- The CD drive status switches to <STANDBY>, and the report becomes a meaningless value (string of FFH values).
- When the status switches from home position <STANDBY> to <PAUSE>, the pickup moves to the beginning of the disc.
- The play range, maximum repeat count, and repeat notification count values being held do not change.

(6) Pickup position in <STANDBY> status

- Transition from <PAUSE> status: Current position (report also remains the same)

- Seek to home position: Inside wait position (report is a meaningless value)

(7) CD read operation when the CD buffer is full

If the CD buffer becomes full, the operation status switches to <PAUSE>, and the BFUL flag in the interrupt flag register becomes 1.

- Page 63: Function specification

The data-type CD communication return code (CdcRet) will be discontinued. Delete the contents for (1) and (3) in Section 7.2.6. The error codes remain.

This modification changes the function specifications. The function value CdcRet becomes Sint32 and returns an error code. If the status is necessary when the command is issued, use the "previous CD status information retrieval" function (CDC\_GetLastStat).

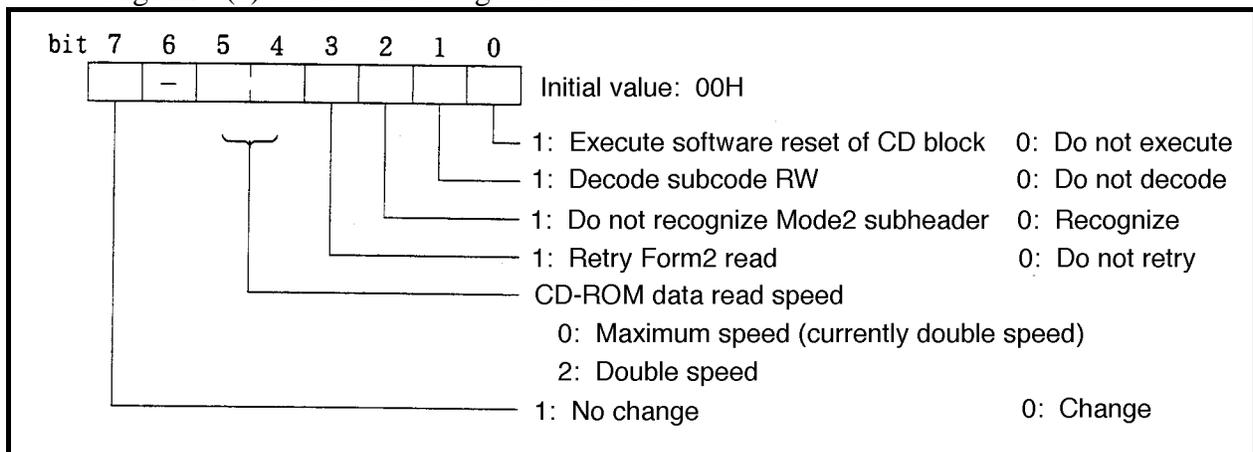
The CDC\_ERR\_PTYPE error code will be discontinued.

<Program Corrections>

Implement the following corrections:

Before correction	After correction
CdcRet ret;	Sint32 ret;
CDC_RET_ERR(ret)	ret
CDC_RET_STATUS(ret)	CdcStat stat; Execute CDC_GetLastStat(&stat); and reference CDC_STAT_STATUS(&stat).

- Page 78: (1) Initialization flag modification



[NOTE]

The standard speed for the CD-ROM data read speed cannot be specified.

- Page 78: (2) Standby time modification

Setting	Explanation
0000H	180 seconds: Initial value
003CH- 0384H	Transition time (second units): 60 seconds to 900 seconds (15 minutes)
FFFFH	This setting should not be changed.

- Page 79: Remark addition

To execute a software reset, wait about 1 millisecond and then issue a command within the CDC\_CdInit function.

- Page 83: Remark addition

If the stop command is used when CD play ends, access becomes slower when the CD is reaccessed. As long as access to the CD continues, normally use the pause command.

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Title	Function	Function Name [S-]	No.
Function specification	Gets the scope of the file information being held	CDC_GetFileScope	8.3

[Format] Sint32 CDC\_GetFileScope(Sint32 \*fid, Sint32 \*infnum, Bool \*drend)

[Input] None

[Output] fid: Identifier of first file being held  
infnum: Number of file information items being held  
drend: Last directory record hold flag

[Function value] Returns an error code.

[Function]

Returns the scope of the file information being held in the current CD block.

- (1) Last directory record hold flag

This flag reports that the scope of the file information being held includes the last directory record in the directory block. This flag can be used to determine whether there are subsequent directory records.

Constant name	Explanation
TRUE	The current CD block contains the last directory record.
FALSE	The current CD block does not contain the last directory record.

[Remark]

Because a file always has its own directory and a parent directory, these two directories are not included in the file information count.

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Title	Function	Function Name [--]	No.
Function specification	Gets the data transfer register pointer	CDC_GetDataPtr	9.1

[Format] Uint32 \*CDC\_GetDataPtr(void)

[Input] None

[Output] None

[Function value] Register pointer (address value)

[Function]

Gets the pointer to the data transfer register (DATATRNS).

- (1) Access methods

The CD communication interface provides three data transfer methods for the data transfer register and the MPEG register:

- DMA transfer by the SCU
- DMA transfer by the CPU
- Software transfer by the CPU

In DMA transfer and software transfer by the CPU, the registers must be accessed in long word (32 bits) units. In other words, the transfer data is arranged in long word (even-number of words) units.

Data accessed in long word units is stored in upper word-lower word sequence. When an odd-number of words are transferred, the last work of the last long word access is undefined.

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Title	Function	Function Name [--]	No.
Function specification	Gets the MPEG register pointer	CDC_GetMpegPtr	9.6

[Format]        Uint32 \*CDC\_GetMpegPtr(void)  
 [Input]        None  
 [Output]       None  
 [Function value]     Register pointer (address value)  
 [Function]  
 Gets the pointer to the MPEG register (MPEGRGB).

The access methods for the MPEG register are the same as for the data transfer register. For notes on this function, see the notes for getting the data transfer register pointer.

## SEGA SATURN TECHNICAL BULLETIN #9

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** June 2, 1995  
**Re:** Size Value for Saturn Memory Manager

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The size value displayed in the SEGA Saturn Memory Manager must be calculated in the following manner:

(1) Formula for deriving the "Size" value:

$$\text{Value} = ([\text{number of bytes used}] + 32) / 64)$$

The resulting value is rounded up to the nearest whole number.

(2) Unit name for the "Size" value:

Although there is no name given for the "Size" value shown in the Memory Manager, ALWAYS use the term "block" as the unit of measure when referring to this value within an application.

(3) Important !

The size of a file stored in a SEGA Saturn storage device varies depending on the device type (such as the internal backup RAM, backup RAM cartridge, and other memory expansion peripherals such as the SEGA Saturn floppy disc drive). Because of this, there will be cases when the "Size" value that was increased and the "Memory Available" value that was decreased do not match. That is, the total sum of the "Size" values and the "Memory Available" value do not match with the total available memory size.

## **SEGA SATURN TECHNICAL BULLETIN #10**

**To: Sega and Third Party Developers**  
**From: Developer Technical Support**  
**Date: June 2, 1995**  
**Re: SCU Specification Changes**

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Attached is the "SCU Specification Changes/Notes (Ver. 1)."

This material describes restrictions and notes that results from changes to the SCU specifications. Be sure to read this material as it contains important information.

Note

This material supplements the "SCU User's Manual /Ver. 2(ST-097-R3-052594)" in the "Hardware Manual Volume 1," which you should already have. Please file this material together with that manual.

**SEGASATURN**

**SCU SPECIFICATION CHANGES/NOTES**

**Ver. 1**

**October 16, 1994  
Technical Support  
Sega Enterprises, Ltd.**

## **0. Preface**

This document describes specification changes and notes related to the SCU of SEGA SATURN. This information is not included in the current distribution of the "SCU User's Manual /Ver. 2(ST-097-R3-052594)." Therefore be sure to compare the contents of the current manual with the information presented in this document, and note the changes.

[Modification History]

4/07/1994 Preliminary version

5/24/1994 2nd preliminary version (Addition of No. 35 and No. 36)

6/14/1994 Version 1 (Correction of No. 35 and No. 36)

## 1. List of Latest SCU Specifications

No. 01	A-bus write prohibited for SCU-DMA
No. 02	VDP2 area read prohibited for SCU-DMA
No. 03	Write access to VDP1 register restricted to word (2-byte) units
No. 04	WORKRAM-L usage from SCU disabled (Note)
No. 05	Required use of cache-through addresses for access to SCU registers
No. 06	Read and write of unused areas (such as address 25FE00ACH) are prohibited
No. 07	Write to interrupt status register (25FE00A4H) is prohibited
No. 08	A-bus and B-bus access from CPU prohibited during DMA operation of A-bus B-bus
No. 09	Setting prohibited for A-bus advance read enable bit
No. 10	Address change for A-bus interrupt acknowledge register (address 25FE00A8H)
No. 11	Restriction on write to A-bus setting registers (addresses 25FE00B0H and 25FE00B4H)
No. 12	Activation of A-bus B-bus from SCU-DMA on standby during CPU write to A-bus or B-bus
No. 13	Deletion of DMA status register (addresses 25FE0070H to 25FE007CH)
No. 14	Deletion of DMA forced termination register (address 25FE0060H)
No. 15	Read of transfer byte count in DMA transfer register prohibited
No. 16	Restriction on read address addition value for DMA based on access address
No. 17	Value of address addition value bit when read address update bit is set in DMA
No. 18	Restriction on write address addition value in DMA based on access address
No. 19	Value of address addition value bit when write address update bit is set in DMA
No. 20	Concurrent use of two channels in DMA
No. 21	Specification changes to DMA activation method
No. 22	Specifications for DMA activation triggers that occur during DMA execution
No. 23	Write to register of corresponding level is prohibited DMA activation
No. 24	Nonoccurrence of illegal DMA interrupt during DMA execution in indirect mode
No. 25	Specification changes for DMA indirect mode table
No. 26	Clearing the program termination interrupt flag at DSP activation
No. 27	Restriction on address addition value during DSP DMA instruction transfer from B-bus to DSP data RAM
No. 28	Delay in DMA activation startup if break is executed during debugging with ICE
No. 29	BREQ enabled status necessary when debugging with ICE
No. 30	Notes on using the timer 0 compare register (address 25FE0090H)
No. 31	Notes on using the timer 1 set data register (address 25FE0094EH)
No. 32	Notes on read access of A-bus and B-bus areas (2000000H to 5FFFFFFH)
No. 33	Initial value of A-bus refresh at power on reset (address 25FE00B8H)
No. 34	Initial value of SDRAM selection bit (address 25FE00C4H)
No. 35	Prohibition of DMA level 2 activation during DMA level 1 execution
No. 36	Notes on reading the DSP program control port (address 25FE0080H)

## 2. Latest Specification Reference List by SCU Item

1 Items related to the entire DMA	
Item No.	01 02 04 08 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 35

2 Items specific to the DMA indirect mode	
Item No.	24 25

3 Items related to DSP	
Item No.	16 20 26 27 36

4 Items related to the external area (A-bus)	
Item No.	01 08 09 10 11 12 17 18 19 32

5 Items related to the B-bus (VDP1, VDP2, and SCSP) areas	
Item No.	02 03 08 12 17 18 19 32

6 Items related to interrupts	
Item No.	07 30 31

7 Specification changes for SCU registers	
Item No.	07 09 10 11 13 14 15 23 24

8 Items related to debugging	
Item No.	28 29

### 3. Latest SCU Specifications

No. 01	A-bus write prohibited for SCU-DMA
--------	------------------------------------

The SCU-DMA cannot be used to write to the A-bus

No. 02	VDP2 area read prohibited for SCU-DMA
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The SCU-DMA cannot be used to read from the VDP2 area.

No. 03	Write-access to VDP1 register restricted to word (2-byte) units
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Execute write-access to the VDP1 register in word (2-byte) units. Access in long word (4-byte) and byte units is prohibited.

Read-access to VDP1 can be performed in byte or long word units.

No. 04	WORKRAM-L usage from SCU disabled (Note)
--------	--

The only WORKRAM that the SCU-DMA can use is WORKRAM-H (SDRAM: 1 megabyte). The SCU-DMA cannot use WORKRAM-L (DRAM: 1 megabyte).

No. 05	Required use of cache-through addresses for access to SCU registers
--------	---

When accessing SCU registers, always use cache-through addresses. If cache addresses are used, a read-prohibited register may be accessed because the CPU operates as follows when the cache is full:

- When data at address 0H is read with a cache address  
Address 4H read → address 8H read → address CH read → address 0H read → cache registration
- When data at address 4H is read with a cache address  
Address 8H read → address CH read → address 0H read → address 4H read → cache registration
- When data at address 8H is read with a cache address  
Address CH read → address 0H read → address 4H read → address 8H read → cache registration
- When data at address CH is read with a cache address  
Address 0H read → address 4H read → address 8H read → address CH read → cache registration

No. 06	Read and write of unused areas (such as address 25FE00ACH) are prohibited
--------	---

Read and write to unused areas are prohibited. Read and write are prohibited especially for address 25FE00ACH.

No. 07	Write to interrupt status register (25FE00A4H) is prohibited
--------	--

When data is written to the interrupt status register, the bit that should be raised to indicate an error occurrence is sometimes not raised. For this reason, write to the interrupt status register is prohibited.

No. 08	A-bus and B-bus access from CPU prohibited during DMA operation of A-bus B-bus
--------	--

Access to the A-bus and B-bus from the CPU is prohibited during DMA operation of the B-bus from the A-bus or DMA operation of the A-bus from the B-bus. The reason is that the system may hang during wait state even when SDRAM refresh does not occur.

No. 09	Setting prohibited for A-bus advance read enable bit
--------	--

The A-bus advance read function was deleted. Set the following register bits, which are described in Ver. 2 (5/31/94) of the current manual, to 0:

- A-bus setting register [CS0, 1 space] (address: 25FE00B0H; register: ASR0)  
→ Set bit 31 and bit 15 to 0.
- A-bus setting register [CS2, reserved space] (address: 25FE00B4H; register: ASR1)  
→ Set bit 31 and bit 15 to 0.

No. 10	Address change for A-bus interrupt acknowledge register (address 25FE00A8H)
--------	---

The address for the A-bus interrupt acknowledge register was changed to 25FE00A8H. This change is implemented in Ver. 2 (5/31/94) of the current manual.

No. 11	Restriction on write to A-bus setting registers (addresses 25FE00B0H and 25FE00B4H)
--------	---

Data can be written to the A-bus setting registers only when the A-bus is not being accessed. Before writing to the A-bus setting registers, first execute a dummy read of the A-bus.

No. 12	Activation of A-bus B-bus from SCU-DMA on standby during CPU write to A-bus or B-bus
--------	--

Write processing to the A-bus and B-bus from the CPU has priority over SCU-DMA activation between the A-bus and B-bus. For example, if the A-bus executes SCU-DMA activation for VDP2 (B-bus) while the CPU is executing a continuous write to VDP1 (B-bus), SC-DMA is not activated until the continuous write ends.

However, during SCU-DMA activation, CPU access to the A-bus and B-bus is queued.

No. 13	Deletion of DMA status register (addresses 25FE0070H to 25FE007CH)
--------	--

Address setting values for a terminated DMA and the function that returns the level 0, 1, or 2 status were deleted.

Part of this specification change is implemented in the Ver. 2 (5/31/94) of the current manual. (Read address, write address, and transfer byte count for a terminated DMA have been deleted.)

No. 14	Deletion of DMA forced termination register (address 25FE0060H)
--------	---

The function of the DMA forced termination register was deleted. Do not write to this register.

No. 15	Read of transfer byte count in DMA transfer register prohibited
--------	---

If the transfer byte count of the DMA transfer register is read, the read value is not guaranteed. This register is a write-only register and cannot be read.

(Address level 0 25FE0008H: D0C; level 1 25FE0028H: D1C; level 2 25FE0048H: D2C)

No. 16	Restriction on read address addition value for DMA based on access address
--------	--

The values that can be set to the read address addition value differ depending on the address to be accessed. This specification applies also to the DMA instruction of DSP.

External area 4 (A-bus I/O area) → Values 0B and 1B can be set.

Other areas → Only value 1B can be set.

(Address level 0 25FE000CH: D0RA; level 1 25FE002CH: D1RA; level 2 25FE004CH: D2RA)

No. 17	Value of address addition value bit when read address update bit is set in DMA
--------	--

When the read address update bit (\*1) is 1, the read address addition bit (\*2) must be 1.

\*1 Read address update bit

Address level 0 25FE0014H: D0RUP; level 1 25FE0034H: D1RUP; level 2 25FE0054H: D2RUP

\*2 Read address addition bit

Address level 0 25FE000CH: D0RA; level 1 25FE002CH: D1RA; level 2 25FE004CH: D2RA

No. 18	Restriction on write address addition value in DMA based on access address
--------	--

The values that can be set to the write address addition value differ depending on the address to be accessed. This specification applies also to the DMA instruction of DSP.

WORKRAM-H	→ Value 010B can be set.
External areas 1 to 3	→ Value 010B can be set.
External area 4 (A-bus I/O area)	→ Values 000B and 010B can be set.
VDP1, VDP2, SCSP	→ All values can be set.

(Address level 0 25FE000CH: D0WA; level 1 25FE002CH: D1WA; level 2 25FE004CH: D2WA)

No. 19	Value of address addition value bit when write address update bit is set in DMA
--------	---

When the write address update bit (\*1) is 1, the write address addition value bit (\*2) must be set according to the bus space to be accessed, as follows:

External areas 1 to 4 (A-bus)	→ Set 010B.
VDP1, VDP2, SCSP (B-bus)	→ Set 001B.
WORKRAM-H (C-bus)	→ Set 010B.

\*1 Write address update bit

Address level 0 25FE0014H: D0WUP; level 1 25FE0034H: D1WUP; level 2 25FE0054H: D2WUP

\*2 Write address addition value bit

Address level 0 25FE000CH: D0WA; level 1 25FE002CH: D1WA; level 2 25FE004CH: D2WA

No. 20	Concurrent use of two channels in DMA
--------	---------------------------------------

Up to two channels can be used concurrently with the DMA priority sequence guaranteed. If three channels are used concurrently, the priority sequence is ignored. (The DMA instruction of DSP is counted as a channel.)

No. 21	Specification changes to DMA activation method
--------	--

The DMA activation method was changed, and DMA enable bits were added.

Activation cause	DMA activation condition
000	Enable bit =1 and VBLANK-IN
001	Enable bit =1 and VBLANK-OUT
010	Enable bit =1 and HBLANK-IN
011	Enable bit =1 and timer 0
100	Enable bit =1 and timer 1
101	Enable bit =1 and SCSP request
110	Enable bit =1 and script draw termination
111	Enable bit =1 and DMA activation bit = 1

These changes have been implemented to Ver. 2 (5/31/94) of the current manual.

No. 22	Specifications for DMA activation triggers that occur during DMA execution
--------	--

If a DMA activation trigger occurs during DMA execution, the trigger is held until the DMA being executed ends. Then the held activation is executed.

For example, if H blank is set to activate DMA and a data size larger than can be transferred in one line (up to the next H blank) is set, operation becomes unstable.

When executing this type of DMA execution, be sure to check the data size to be transferred.

The trigger is held for only one execution.

No. 23	Write to register of corresponding level is prohibited during DMA activation
--------	--

The selection register for DMA mode, address update, and activation factor (\*1) and the DMA set register (2) cannot be rewritten during DMA activation of the corresponding level. If either of these registers is rewritten, the system hangs.

\*1 Selection register for DMA mode, address update, and activation factor  
Address level 0 25FE0014H, level 1 25FE0034H, level 2 25FE0054H

\*2 DMA set register  
Address level 0 25FE000CH, level 1 25FE002CH, level 2 25FE004CH

No. 24	Nonoccurrence of illegal DMA interrupt during DMA execution in indirect mode
--------	--

The DMA illegal interrupt status bit (bit 12) of the DMA status register (address 25FE00A4H) is not issued during DMA execution in indirect mode.

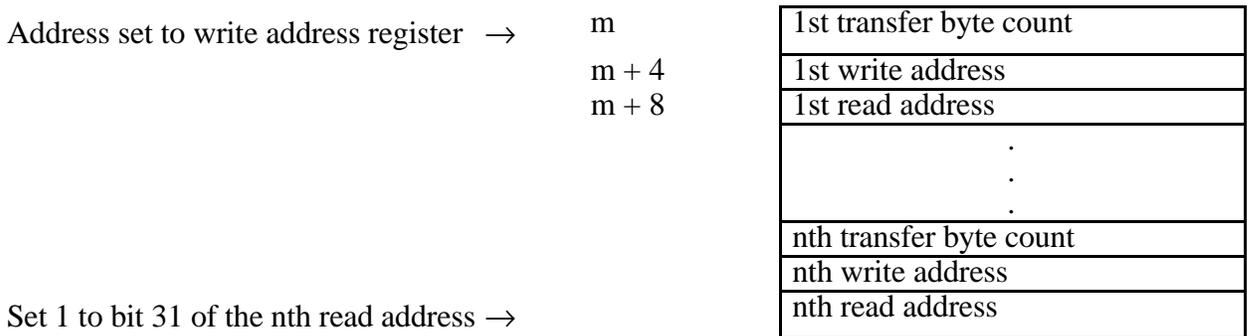
When using the DMA in indirect mode, do not reference the DMA illegal interrupt status bit.

No. 25	Specification changes for DMA indirect mode table
--------	---

The specifications for the DMA indirect mode table were changed as follows:

[Changes]

- The table structure was changed from a 4-long word structure to a 3-long word structure.
- The read and write addresses were reversed.
- Based on the table size ( $n \times 12$  bytes), the table start addresses ( $m$  value in the figure below) must be placed on a 32-, 64-, 128-, 256-, 512-, 1024-, ...- byte boundary. An example is shown below.
- Table size is 24 bytes or less: Place the start address on a 32-byte boundary.
- Table size is 252 bytes or less: Place the start address on a 256 byte boundary.
- Table size is 1020 bytes or less: Place the start address on a 1024-byte boundary.
- Always set 1 to bit 31 of the final (nth) read address.



Set 1 to bit 31 of the nth read address →

(Address level 0 25FE0004H, level 1 25FE0024H, level 2 25FE0044H)

No. 26	Clearing the program termination interrupt flag at DSP activation
--------	---

When activating DSP, set 0 to the program termination interrupt flag (bit 18: E) of the DPS program control port (address 25FE0080H). When the flag is 1, the DSP program termination interrupt is not issued even if the DSP program is terminated with the ENDI instruction.

No. 27	Restriction on address addition value during DSP DMA instruction transfer from B-bus to DSP data RAM
--------	--

When a DSP DMA instruction (DMA or DMAH) is used to transfer data from the B-bus to the DSP data RAM, the address addition value must be 010B.

No. 28	Delay in DMA activation startup if break is executed during debugging with ICE
--------	--

The SCU-DMA operates only when the CPU is operating. If a break occurs during debugging on the ICE, start of SCU-DMA operation is delayed. When the ICE execution status is parallel mode (prompt is #), the SCU-DMA operates normally.

No. 29	BREQ enabled status necessary when debugging with ICE
--------	---

When using the SCU-DMA under an ICE, set E (always enabled) as the input state of the BREQ (bus permission request) signal of the EXECUTION\_MODE (EM) command.

In the ICE E7000 system, no change is necessary because the BREQ default is E.

No. 30	Notes on using the timer 0 compare register (address 25FE0090H)
--------	---

Although 10 data bits can be set to the register, an interrupt will not occur if improbable data is set. Always set a value in the usable range.

For NTSC non-interlaced (one screen 263 lines, effective screen 224 lines), for example, interrupts occur as follows:

- T0C9-0 = 1 → Interrupt occurs at the beginning of the HBLANK-IN immediately before the first line of the effective screen.
- T0C9-0 = 2 → Interrupt occurs at the beginning of the HBLANK-IN immediately before the first two lines of the effective screen.
- T0C9-0 = 224 → Interrupt occurs at the beginning of the HBLANK-IN immediately before the last line of the effective screen.
- T0C9-0 = 225 → Interrupt occurs at the beginning of the HBLANK-IN immediately after the effective screen ends.
- T0C9-0 = 263 → Interrupt occurs at the beginning of the HBLANK-IN immediately before the line preceding the effective screen.
- T0C9-0 = 264 to 1023 → Interrupt does not occur.
- T0C9-0 = 0 → Interrupt occurs at the same timing as VBLANK-OUT.

No. 31	Notes on using the timer 1 set data register (address 25FE0094EH)
--------	---

The value of the timer 1 set data register is loaded to timer 1 when both of the following conditions are satisfied: timer 1 is stopped and HBLANK-IN occurs.

If a data value larger than the number of counts in one line is set to the timer 1 set data register, a timer 1 interrupt no longer occurs at each line.

[Range for number of counts]

If one line is 320 dots: 1 to 1AAH

If one line is 352 dots: 1 to 1C6H

If one line is 424 dots: 1 to D3H

If one line is 426 dots: 1 to D4H

(Note that if 0 is specified as the number of counts, the value becomes 512.)

No. 32	Notes on read access of A-bus and B-bus areas (2000000H to 5FFFFFFH)
--------	--

In read access to the A-bus and B-bus area (2000000H to 5FFFFFFH), the internal CPU operation is different from the external operation. Even if the SH2 executes read access in byte or word (2-byte) units, the external operation becomes long word (4 -byte) access.

If byte-unit read of a continuous area is executed for the A-bus and B-bus area, processing takes longer than byte-unit write.

In write access, the internal operation and the external operation are the same (If the area is accessed in byte units, the external access is also byte access.

No. 33	Initial value of A-bus refresh at power on reset (address 25FE00B8H)
--------	--

At power on reset, the initial value of the A-bus refresh output effective bit changes to effective state (ARFEN=1). This bit should not be changed by the user.

No. 34	Initial value of SDRAM selection bit (address 25FE00C4H)
--------	--

At power on reset, the SDRAM selection bit is 2M bit $\times$ 2 (RSEL = 0). The bit must be reset to RSEL = 1 so that the value changes to 4M bit $\times$ 2. This setting change is executed within the boot ROM. User modification is not necessary.

No. 35	Prohibition of DMA level 2 activation during DMA level 1 execution
--------	--

A operation error may occur if DMA level 2 is activated during DMA level 1 activation. To prevent such operation errors, do not activate DMA level 2 during DMA level 1 operation.

When the DSP program control port is read, note that the following phenomena occur:

- The V flag (overflow flag) is cleared.  
The V flag cannot be checked during DSP execution.
- A DSP termination interrupt factor may not occur.  
If the program termination interrupt flag is monitored (read) during DSP execution, the DSP termination interrupt may not occur. Therefore, do not read this address in programs that obtains DSP termination with an interrupt.

## **SEGA SATURN TECHNICAL BULLETIN #11**

**To: Sega and Third Party Developers**  
**From: Developer Technical Support**  
**Date: June 2, 1995**  
**Re: Disc Format Standards Specification Revision**

---

This report provides a material on the latest information on the boot system for the Sega Saturn.

The information presented in this material is included in the Development Tools Manual/Disc Format Standard Specifications." However, this information is provided first because revision of the standard specification has been delayed.

Notes:

1. The boot system information (Saturn Boot ROM Ver. 0.9 User's Manual [ST-079B-R1-062294]; Rel.2 is printed in red) included in the current "Programmer's Guide Volume 1/Disc Format Standard Specifications" is old and should not be used.
2. After the distribution of the "Disc Format Standard Specifications (Rel. 3) (ST-079B-R3-011895)," the information described in the standard specifications will be the formal information.

Normal Info

Material name: SEGASATURN Software Library  
MPEG Library Ver. 1.00 Disk version 2/10/95

Information type: If the current version has no bugs, it will also be used in  
Software Library Release 4.

Presentation purpose: Early presentation

Attachment: MPEG Library External Specifications Ver. 1.00 01/31/95  
(1 copy)  
This material is the pre-edited manuscript.

# BOOT SYSTEM

## Introduction

This document prescribes conventions that must be followed when writing an application software uses the boot system. CDs that do not follow these standards will not be recognized as a Game-CD. All applications software that operate in this game system must follow these standards.

This document is an excerpt of the Disc Format Standard Specifications(ST-040-R3-011895) and describes only the important information. Be sure to also read the contents of the Disc Format Standard Specifications(ST-040-R3-011895).

## 1. System Area

The system area is that area that is located at the beginning of the CD-ROM.

The data written to the system area includes system information for application startup and the initial program. These data items must be placed contiguously in the system area as the initial program (IP). The IP consists of the boot codes and the application initial program (AIP). The boot codes include IDs, such as the game name, and a security code. The AIP includes code for the initial program.

**Figure 1 IP structure**

Structure		Size	Remarks	
IP	Boot code	System ID	100H	Game name, product number, version, etc.
		Security code	D00H	Security code
		Area code group	20H-100H	Area code group
	Application initial program	20H-71E0H	Initial program, file system, etc.	

## 2. System ID

The system ID is the first data located in the system area.

**Figure 2 System ID structure**

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
00H	Hardware identifier															
10H	Manufacturer ID															
20H	Product number										Version					
30H	Release date								Device information							
40H	Target area symbol												Space			
50H	Compatible peripheral															
60H	Game name															
70H																
80H																
90H																
A0H																
B0H																
C0H																
D0H	Reserved															
E0H	IP size				Reserved				Stack-M				Stack-S			
F0H	1st read address				1st read size				Reserved				Reserved			

### 3. System ID Description

- Conventions

#### Allowed characters

The characters that can be used in the system ID are all ASCII code alphanumeric characters. For some items, the following characters can also be used: ., /, -, and :.  
Unless otherwise indicated, both uppercase and lowercase characters can be used.

#### Entries

- Unless otherwise indicated, left-justify all entries. Do not add preceding spaces.
- Unless otherwise indicated, fill all unused spaces with ASCII code 20H.

#### Representation definition

In the following descriptions, "Δ" and "space" represent ASCII code 20H.

#### Other

Fill reserved areas with 00H.

- Item Description

#### Hardware identifier (start address: 00H)

Definition	Unique ID of the hardware
Allowed characters	<u>Uppercase</u> letters only
Number of characters	16
Entry description	Enter "SEGAΔSATURNΔ" (required).

#### Manufacturer ID (start address: 10H)

Definition	Manufacturer ID specified by SEGA
Allowed characters	Alphanumeric only
Number of characters	16
Entry description	

- SEGA brand: Enter "SEGAΔENTERPRISES" (16 characters fixed).
- Third party brand: Enter "SEGAΔTPΔKAISHA-A" (16 characters).  
For KAISHA-A, enter the individual company code assigned to the third party.  
Example) "SEGAΔTPΔT-999ΔΔΔ"  
Rule: Left-justify the underlined portion in the example. File the remaining portion with spaces to make 16 characters.

#### Product number (start address: 20H)

Definition	Product number specified by SEGA
Allowed characters	Alphanumeric only
Number of characters	10
Entry description	Fill the remaining portion with spaces.
Entry example	<ul style="list-style-type: none"><li>• SEGA brand title: "GS-9099ΔΔΔ"</li><li>• Third party title: "T-99901GΔΔ"</li></ul>

Version (start address: 2AH)

Definition	Application version
Allowed characters	Uppercase "V", numbers, and "." (period)
Number of characters	6
Entry description	Enter "V", followed by a one-digit number, ".", and a three-digit number. The final release is V1.000.
Entry example	Sample disc: "V0.801" Master disc: "V1.000"

Release date (start address: 30H)

Definition	Date when the master disc (write-once disc) was created
Allowed characters	Numbers only
Number of characters	8
Entry description	YYYYMMDD (year, month, day)
Entry example	"19940912" (September 12, 1994)

Device information (start address 38H)

Definition	Device information. For a CD, enter the disc number within the set.
Allowed characters	Alphanumeric, "/" and "-"
Number of characters	8
Entry description	Fill the remaining portion with spaces.
Entry example	First CD in a set of 1: "CD-1/1ΔΔ" Second CD in a set of 3: "CD-2/3ΔΔ"

Target area symbol (start address: 40H)

Definition	Area symbol of the area where the application is to be used																
Allowed characters	Uppercase letters found in the character list below																
Number of characters	10																
Entry description	Multiple symbols can be entered. Do not insert spaces or commas between area symbols. Fill the remaining portion with spaces. For an application to be run on hardware sold in Japan, enter "J" as the area symbol. For an application to be run on hardware sold in North America, enter "U" as the area symbol. For an application to be run on hardware sold in Europe, enter "E" as the area symbol																
	<ul style="list-style-type: none"><li>Area symbol list</li></ul> <table><tr><td>Japan</td><td>"J"</td></tr><tr><td>Asia NTSC (Taiwan, Philippines)</td><td>"T"</td></tr><tr><td>North America (U.S., Canada)</td><td>"U"</td></tr><tr><td>Central/South America NTSC (Brazil)</td><td>"B"</td></tr><tr><td>Korea</td><td>"K"</td></tr><tr><td>East Asia PAL (China, Middle/Near East)</td><td>"A"</td></tr><tr><td>Europe PAL</td><td>"E"</td></tr><tr><td>Central/South America PAL</td><td>"L"</td></tr></table>	Japan	"J"	Asia NTSC (Taiwan, Philippines)	"T"	North America (U.S., Canada)	"U"	Central/South America NTSC (Brazil)	"B"	Korea	"K"	East Asia PAL (China, Middle/Near East)	"A"	Europe PAL	"E"	Central/South America PAL	"L"
Japan	"J"																
Asia NTSC (Taiwan, Philippines)	"T"																
North America (U.S., Canada)	"U"																
Central/South America NTSC (Brazil)	"B"																
Korea	"K"																
East Asia PAL (China, Middle/Near East)	"A"																
Europe PAL	"E"																
Central/South America PAL	"L"																
Entry example	Application to be operated in Japan, Taiwan, and Korea (and not in other areas): "JTKΔΔΔΔΔΔΔΔ" NOTE: The areas and area codes entered in this field must be entered in the area code group. (See item 5, "Area Codes.")																
Supplement	The hardware has "area symbol" information, which differs for each sales area. The application operates if the "area symbol," the "area symbol in the corresponding area symbol," and the "area code" all match.																

Compatible peripheral (start address: 50H)

Definition	Information on <u>fully compatible input peripheral</u>
Allowed characters	Alphanumeric only
Number of characters	16
Entry description	Multiple peripheral characters can be added. Do not insert spaces or commas between characters. Fill the remaining portion with spaces. <ul style="list-style-type: none"><li>Character list<ul style="list-style-type: none"><li>Control pad "J"</li><li>Analog controller "A"</li><li>Mouse "M"</li><li>Keyboard "K"</li><li>Steering controller "S"</li><li>Multi-tap "T"</li></ul></li></ul>
Entry example	Application that is compatible with a standard joy pad and a mouse: "JM△△△△△△△△△△△△△△"
Supplement	If the number of peripherals increases, the number of characters can also be expected to increase.

For a definition of fully compatible, see the pad check items in the "Software Creation Standards."

Game name (start address: 60H)

Definition	Game name
Allowed characters	Letters only for the game name. Spaces can be used in the game name. To enter multiple titles, use a slash (/), hyphen (-), or colon (:), to delimit the titles.
Number of characters	112 characters
Entry description	If the name differs depending on the sales area, several titles can be entered. There are no detailed rules for entering multiple titles. However, someone looking at this section should be able to identify the titles. Fill the remaining portion with spaces.
Entry example	Multiple titles 1) "TITLE1/TITLE2/TITLE3△△△△" 2) "J:TITLE1△△U:TITLE2△△△△△△"

IP size (start address: E0H)

Definition	Size (byte count) of the initial program (IP)
Size	4 bytes
Description	Attach the AIP immediately after the boot codes to form a file. Specify the size of that file. All parameters must be aligned to long word boundaries (multiple of 4H).
Range	1000H to 8000H

Stack-M (start address: E8H)

Definition	Stack point address of the master SH2
Default (0 specification)	6001000H to 6001FFFH becomes the stack area.
Description	All parameters must be aligned to long word boundaries (multiple of 4H).

Stack-S (start address: ECH)

Definition	Stack point address of the slave SH2
Default (0 specification)	6000D00H to 6000FFFH becomes the stack area.
Description	All parameters must be aligned to long word boundaries (multiple of 4H).

1st read address (start address: FOH)

Definition	Transfer destination address of file that the boot system transfers to the work-RAM during display of the license SEGA logo.
Description	If 0H is specified, no data is transferred. For a CD, the file indicated by the file identifier [2] is transferred. All parameters must be aligned to long word boundaries (multiple of 4H).
Range	Larger than (6002000H + IP size) and smaller than (6100000 - 4).
Supplement	See item 7, "Application Initial Program and 1st Read File."

1st read size (start address: F4H)

Definition	This field is ignored for CDs.
Description	All parameters must be aligned to long word boundaries (multiple of 4H).

#### 4. Security Code

Place the security code immediately after the system ID. SEGA provides the code as an object code. Use the code without adding any changes. The code contains a program and data that display the SEGA license. If the application does not have a correct security code, it will not be recognized as a Sega Saturn CD and the game will not start.

Name of security code presentation file: Directory contents after the software library disc is installed

/SATURN/SEGALIB/LIB/ SYS\_SEC.OBJ

#### 5. Area Codes

Place the area codes immediately after the security code. SEGA provides these codes as object codes. Use the codes without adding any changes. Although there are eight area codes, one for each hardware sales area, enter the area codes for the "corresponding area symbols" of the system ID. When specifying multiple area codes, the specification sequences for the "corresponding area symbols" and the "area codes" do not need to match.

The area codes can be changed easily because each area code has the same size. Also a common disc can be created to link multiple area codes. (See item 9, "Program Samples.")

Name of area code presentation file: Directory contents after software library disc installation

/SATURN/SEGALIB/LIB/SYS\_ARE?.OBJ ; ? is character for corresponding area  
; 8 types

The following table shows the relationships between the hardware sale areas, area codes, and corresponding area symbols.

Target area	Hardware sales area	Area code file name
J	Japan	SYS_AREJ.OBJ
T	Asia NTSC region	SYS_ARET.OBJ
U	North America	SYS_AREU.OBJ
B	Central/South America NTSC region	SYS_AREB.OBJ
K	Korea	SYS_AREK.OBJ
A	East Asia PAL	SYS_AREA.OBJ
E	Europe PAL	SYS_AREE.OBJ
L	Central/South America PAL	SYS_AREL.OBJ

#### 6. Application Initial Program

Place the application initial program immediately after the area code group so that the program is executed immediately after area code execution. The program then proceeds under the control of the application.

#### 7. Application Initial Program and 1st Read File

Both the application initial program and the 1st read file are part of a system in which the boot ROM automatically transfers files from the CD-ROM. At activation, the application initial program and the 1st read file allow the application to transfer the specified file without incorporating a program.

- 1st read file

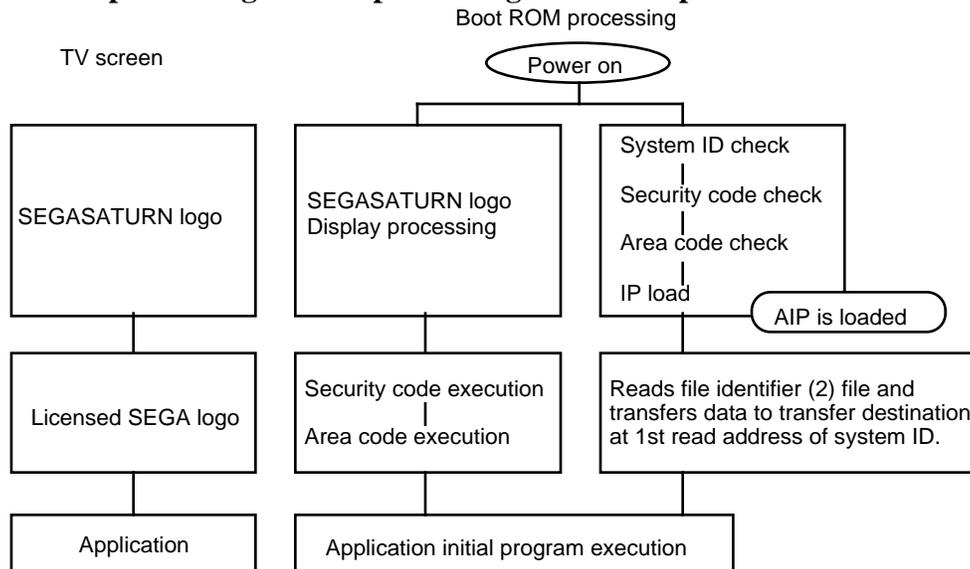
The 1st read file is the file (file identifier is [2]) that the boot system reads while the license SEGA logo is being displayed (during security code execution). The license SEGA logo display does not end until reading of the 1st read file ends. Therefore, the time of the license SEGA logo screen becomes longer as the size of the transfer file increases. The minimum time is two seconds; the maximum time is about 3.5 seconds. When the 1st read address is set, the 1st read file is only read. The file is not executed. Although specification of the 1st read file is not necessary, SEGA recommends that you use the file to use the display time of the license SEGA logo efficiently.

- Application initial program

For example, when a file system is placed in the application initial program, accesses to the CD can be performed easily in file units.

By using the application initial program and 1st read file effectively, you can create a highly efficient application.

### Conceptual diagram of processing after the power is turned on



## 8. IP Creation Method

- **SYS\_ID.SRC**

This is the assembler sample source program for system ID creation. Modify this program according to the application. (See item 3, "System ID Description.") Place this program at the beginning of the initial program.

Name of sample presentation file: Directory contents after software library disc installation  
/SATURN/SEGASMP/SYS/ SYS\_ID.SRC

- **SYS\_SEC.OBJ**

Security code object (See item 4, "Security Code.")

Link and incorporate this object in its existing format.

- **SYS\_ARE?.OBJ**

Area code objects (See item 5, "Area Codes.")

Link and incorporate these objects in their existing format.

Create the SYS\_IP.BIN file by linking these files in the following sequence:  
SYS\_ID.OBJ, SYS\_SEC.OBJ, SYS\_ARE?.OBJ

Place the file in the CD system area.

## 9. Sample Programs

```
=====
;      smp_id0.src -- System ID for SEGA          (Ver.1994-11-11)
;=====
      .SECTION SYSID, CODE, ALIGN=4
;
      .SDATA "SEGA SEGASATURN "      ;00:Hardware identifier (fixed)
      .SDATA "SEGA ENTERPRISES"     ;10:Manufacturer ID
      .SDATA "GS-9099 V1.000"       ;20:Product number, version
      .SDATA "19941122CD-1/1 "      ;30:Release date, device information
      .SDATA "JTUBKAEL "           ;40:Target area symbols
      .SDATA "J "                   ;50:Compatible peripheral
      .SDATA "GAME TITLE "         ;60:Game name
      .SDATA " "                   ;70:
      .SDATA " "                   ;80:
      .SDATA " "                   ;90:
      .SDATA " "                   ;A0:
      .SDATA " "                   ;B0:
      .SDATA " "                   ;C0:
      .DATA.LH'00000000,H'00000000,H'00000000,H'00000000      ;D0:
      .DATA.LH'00001000,H'00000000,H'00000000,H'00000000      ;E0:
      .DATA.LH'06010000,H'00000000,H'00000000,H'00000000      ;F0:
;
      .END
;===== End of file =====
.
```

```

;=====
;   smp_id1.src -- System ID for 3rd Party           (Ver.1994-11-11)
;=====
   .SECTION SYSID, CODE, ALIGN=4
;
   .SDATA "SEGA SEGASATURN "      ;00:Hardware identifier (fixed)
   .SDATA "SEGA TP T-999 "        ;10:Manufacturer ID
   .SDATA "T-99901G V1.000"      ;20:Product number, version
   .SDATA "19941122CD-1/1 "      ;30:Release date, device information
   .SDATA "JTUBKAEL "            ;40:Target area symbols
   .SDATA "J "                    ;50:Compatible peripheral
   .SDATA "GAME TITLE "          ;60:Game name
   .SDATA " "                      ;70:
   .SDATA " "                      ;80:
   .SDATA " "                      ;90:
   .SDATA " "                      ;A0:
   .SDATA " "                      ;B0:
   .SDATA " "                      ;C0:
   .DATA.LH'00000000,H'00000000,H'00000000,H'00000000      ;D0:
   .DATA.LH'00001000,H'00000000,H'00000000,H'00000000      ;E0:
   .DATA.LH'06010000,H'00000000,H'00000000,H'00000000      ;F0:
;
   .END
;===== End of file =====
.

```

```
;=====
;      smpsys.lnk -- SH Linkage Subcommand File for IP  (Ver.1994-11-11)
;=====
Input  sys_id_obj
Input  ../ /segalib/lib/sys_sec.obj
Input  ../ /segalib/lib/sys_arej.obj
Input  ../ /segalib/lib/sys_aret.obj
Input  ../ /segalib/lib/sys_areu.obj
Input  ../ /segalib/lib/sys_areb.obj
Input  ../ /segalib/lib/sys_arek.obj
Input  ../ /segalib/lib/sys_area.obj
Input  ../ /segalib/lib/sys_aree.obj
Input  ../ /segalib/lib/sys_arel.obj
Input  ../ /segalib/lib/sys_init.obj
Input  smpsys.obj
STart  SYSID(060020000)
Output sys_ip.abs
Print  sys_ip.map
EXIT
;===== End of file =====
.
```

```

;=====
;      sample0.scr -- CD-ROM                                (Ver.1994-11-11)
;Note: Sample script for CD-ROM (MODE1 + CD-DA) disc
;      For VCDPRE and VCDBUILD, use Ver. 3.10 or above
;      R: Required.
;      O: Optional, can be omitted.
;      N: Parameter cannot be modified. (Use without modification.)
;      Y: Parameter can be modified.
;      -: No parameter.
;      The first word in each line is the command name.
;      Do not change the command names.
;=====
Define      dirsmpdisc ./sample/                          ; O   Y
Disc       sample0.DSK                                   ;R    Y
Session    CDROM                                        ;R    N
LeadIn     MODE1                                       ;R    N
EndLeadIn  ;R -
;
SystemArea [dirsmpdisc]sys_ip.bin                       ;R    Y
;
Track      MODE1                                       ;R    N
          Volume      ISO9660 sample0.PVD              ;R    Y
          PrimaryVolume      00:02:16                 ;R    N
          SystemIdentifier    "SEGA SEGASATURN"        ;R    N
          VolumeIdentifier    "SAMPLE_GAME_TITLE"     ;R    Y
          VolumeSetIdentifier "SAMPLE_GAME_TITLE"     ;R    Y
          PublisherIdentifier  "SEGA ENTERPRISES,LTD." ;R    Y
          DataPreparerIdentifier "SEGA ENTERPRISES,LTD." ;R    Y
          CopyrightFileIdentifier "SMP_CPY.TXT"       ;R    Y
          AbstractFileIdentifier "SMP_ABS.TXT"        ;R    Y
          BibliographicFileIdentifier "SMP_BIB.TXT"   ;R    Y
          VolumeCreationDate  22/11/1994 00:01:02:00:36 ; O   Y
          VolumeModificationDate 22/11/1994 00:01:02:00:36 ; O   Y
          EndPrimaryVolume    ;R -
          EndVolume          ;R -
;
          File          SMP_CPY.TXT                    ;R    Y
          FileSource    [dirsmpdisc]smp_cpy.txt       ;R    Y
          EndFileSource ;R -
          EndFile       ;R -
          File          SMP_ABS.TXT                    ;R    Y
          FileSource    [dirsmpdisc]smp_abs.txt       ;R    Y
          EndFileSource ;R -
          EndFile       ;R -
          File          SMP_BIB.TXT                    ;R    Y
          FileSource    [dirsmpdisc]smp_bib.txt       ;R    Y
          EndFileSource ;R -
          EndFile       ;R -

```

```

;
      File          FILE0.BIN                ; O Y
      FileSource    [dirsmppdisc]file0.bin   ; O Y
      EndFileSource ; O -
      EndFile       ; O -
      ;
      ;          File to EndFile             ; O Y
      ;
      PostGap       150                      ;R N
EndTrack          ;R -
;
Track            CDDA                        ;R N
      Pause        150                      ;R N
      FileSource    [dirsmppdisc]sound0.da   ;R Y
      EndFileSource ;R -
EndTrack          ;R -
;
;          Track to EndTrack                ; O Y
;
LeadOut          CDDA                        ;R N
Empty            500                         ;R N
EndLeadOut       ;R N
EndSession       ;R N
;===== End of file =====
.

```

```

;=====
;      sample1.scr -- CD-ROM XA                                (Ver.1994-11-11)
;Note: Sample script for CD-ROM XA (MODE1 + MODE2 + CD-DA) disc
;      For VCDPRE and VCDBUILD, use Ver. 3.10 or above
;      R: Required.
;      O: Optional, can be omitted.
;      N: Parameter cannot be modified. (Use without modification.)
;      Y: Parameter can be modified.
;      -: No parameter.
;      The first word in each line is the command name.
;      Do not change the command names.
;=====
Define      dirsmpdisc ./sample/                               ; O  Y
Disc        sample1.DSK                                       ;R   Y
Session     SEMIXA                                           ;R   N
LeadIn      MODE1                                           ;R   N
EndLeadIn   ;R -
;
SystemArea  [dirsmpdisc]sys_ip.bin                            ;R   Y
;
Track       MODE1                                           ;R   N
           Volume      ISO9660 sample1.PVD                   ;R   Y
           PrimaryVolume      00:02:16                       ;R   N
           SystemIdentifier    "SEGA SEGASATURN"              ;R   N
           VolumeIdentifier    "SAMPLE_GAME_TITLE"           ;R   Y
           VolumeSetIdentifier "SAMPLE_GAME_TITLE"           ;R   Y
           PublisherIdentifier  "SEGA ENTERPRISES,LTD." ;R   Y
           DataPreparerIdentifier "SEGA ENTERPRISES,LTD." ;R   Y
           CopyrightFileIdentifier "SMP_CPY.TXT"             ;R   Y
           AbstractFileIdentifier "SMP_ABS.TXT"               ;R   Y
           BibliographicFileIdentifier "SMP_BIB.TXT"          ;R   Y
           VolumeCreationDate  22/11/1994 00:01:02:00:36    ; O  Y
           VolumeModificationDate 22/11/1994 00:01:02:00:36 ; O  Y
           EndPrimaryVolume     ;R -
           EndVolume            ;R -
;
           File          SMP_CPY.TXT                          ;R   Y
           FileSource     [dirsmpdisc]smp_cpy.txt             ;R   Y
           EndFileSource   ;R -
           EndFile        ;R -
           File          SMP_ABS.TXT                          ;R   Y
           FileSource     [dirsmpdisc]smp_abs.txt            ;R   Y
           EndFileSource   ;R -
           EndFile        ;R -
           File          SMP_BIB.TXT                          ;R   Y
           FileSource     [dirsmpdisc]smp_bib.txt            ;R   Y
           EndFileSource   ;R -
           EndFile        ;R -

```

```

;
    File          FILE0.BIN                ; O Y
    FileSource    [dirsmppdisc]file0.bin   ; O Y
    EndFileSource ; O -
    EndFile       ; O -
;
;      File to EndFile                    ; O Y
;
    PostGap       150                      ;R N
Endtrack        ;R -
;
Track          MODE2                      ;R N
    PreGap       150                      ;R N
    Extent       ;R -
    FileInterleave 13                    ; O Y
        File     INTFILE0.BIN            ; O Y
        FileSource [dirsmppdisc]intfile0.bin ; O Y
        EndFileSource ; O -
        EndFile   ; O -
    EndFileInterleave ; O -
    FileInterleave 13                    ; O Y
        File     INTFILE1.BIN            ; O Y
        FileSource [dirsmppdisc]intfile1.bin ; O Y
        EndFileSource ; O -
        EndFile   ; O -
    EndFileInterleave ; O -
    FileInterleave 13                    ; O Y
        File     INTFILE2.BIN            ; O Y
        FileSource [dirsmppdisc]intfile2.bin ; O Y
        EndFileSource ; O -
        EndFile   ; O -
    EndFileInterleave ; O -
    FileInterleave 13                    ; O Y
        File     INTFILE3.BIN            ; O Y
        FileSource [dirsmppdisc]intfile3.bin ; O Y
        EndFileSource ; O -
        EndFile   ; O -
    EndFileInterleave ; O -
    EndExtent    ;R -
    PostGap       150                      ;R N
EndTrack        ;R -
;
Track          CDDA                      ;R N
    Pause        150                      ;R N
    FileSource    [dirsmppdisc]sound0.da   ;R Y
    EndFileSource ;R -
EndTrack        ;R -

```

```
;  
;      Track to EndTrack                ; O Y  
;  
LeadOut      CDDA                        ;R N  
Empty        500                          ;R N  
EndLeadOut   ;R N  
EndSession   ;R N  
;===== End of file =====
```

## **SEGA SATURN TECHNICAL BULLETIN #12**

**To: Sega and Third Party Developers**  
**From: Developer Technical Support**  
**Date: June 2, 1995**  
**Re: SCU DMA, Boot ROM, and Vblank Precautions**

---

### 1) Burst-Read from VRAM is prohibited

SCU's DMA read must not be performed against VRAM.

### 2) Limitation for horizontal direction resolution switch

Always use the BOOT ROM's internal service routine when switching the resolution in horizontal direction.

### 3) Limitation for valid period of V blank flag

VBLANK bit of the screen status register (TVSTAT: 180004H) becomes valid, only when DISP bit of TV screen mode register (TVMD: 180000H) is "1".

When DISP bit is "0", VBLANK bit will always be "1".

## SEGA SATURN TECHNICAL BULLETIN #13

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** June 2, 1995  
**Re:** VRAM Bank Splitting

---

The storage areas for pattern name data in the scroll screen are restricted as follows, regardless of whether the screen is a normal scroll screen or a rotation scroll screen:

- (1) If neither VRAM-A nor VRAM-B is split into two  
 Data can only be stored in one of the two VRAMs, either VRAM-A or VRAM-B.
- (2) If only VRAM-A is split into two
  - a) When data is stored in VRAM-B, data can also be stored in VRAM-A1.
  - b) When data is not stored in VRAM-B, data can be stored in either VRAM-A0 or VRAM-A1.
- (3) If only VRAM-B is split into two
  - a) When data is stored in VRAM-A, data can also be stored in VRAM-B1.
  - b) When data is not stored in VRAM-A, data can be stored in either VRAM-B0 or VRAM-B1.
- (4) If both VRAM-A and VRAM-B are split into two  
 Data can be stored in either VRAM-A0 or VRAM-B0, and in VRAM-A1 or VRAM-B1.

Table Restrictions on the storage locations for pattern name data

VRAM mode bit		VRAM-A		VRAM-B	
VRAMD	VRBMD	VRAM-A0	VRAM-A1	VRAM-B0	VRAM-B1
0	0	○		×	
		×		○	
1	0	×	○	○	
		○	○	×	
0	1	○		×	○
		×		○	○
1	1	○	○	×	×
		○	×	×	○
		×	○	○	×
		×	×	○	○

○: Data can be stored                      ×: Data cannot be stored

If data can be stored in several locations, not all locations need to be used.

## **SEGA SATURN TECHNICAL BULLETIN #14**

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** June 2, 1995  
**Re:** Use of VRAM for Bit Maps

---

Although the VDP2 must be used to display images with 16.77-million colors (VDP1 displays only up to 32,768 colors), the drawback of using VDP2 is that the VRAM addresses are not continuous when image data is transferred by the DMA.

This report explains in detail a technique for setting up continuous VRAM addresses for any bit map size when VDP2 is used.

[Overview of This Material]

1. Principles: Page 1
  - This section explains the principles used to implement a continuous address bit map of any size.
2. Application: Page 5
  - This section explains how the principles can be applied to move a bit map smaller than the television screen to any position on the television screen.
3. Summary: Page 9
  - Summary, notes, merits, supplement

## VDP2 Bit Map

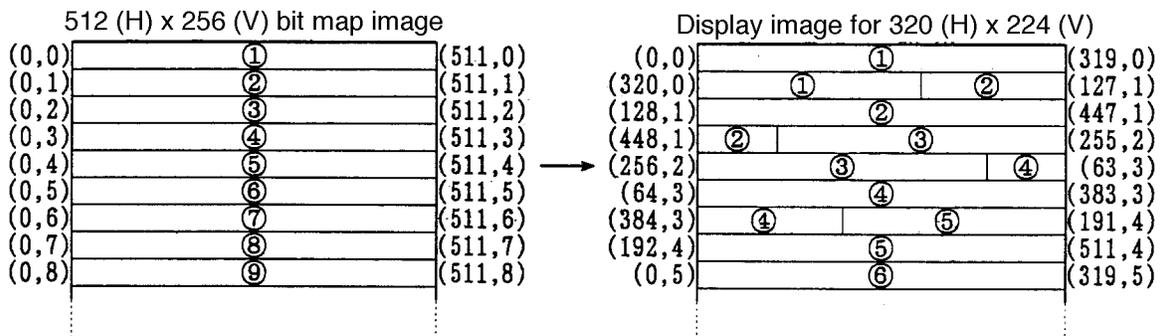
The minimum size of a VDP2 bit map is 512-dot (horizontal) × 256-dot (vertical). However, when VDP2 is used with a demo, the VRAM addresses are not continuous when the DMA transfers image data. Because of this drawback, many software applications use VDP1 (sprites). However, VDP1 can only display pictures that have up to 32,768 colors. VDP2 must be used to display pictures with 16.77 million colors.

This document explains how to use a VDP2 bit map and produce continuous VRAM addresses with any bit map size.

### 1. Principles

This section explains the principles used to implement continuous addresses bit maps of any size.

For example, suppose that the bit map size is set at "512-dot (horizontal) × 256-dot (vertical)," and the VRAM addresses continue from coordinates (0, 0) to (511, 0). The next address after (511, 0) is (0, 1). To arrange a "320-dot (horizontal) × 224-dot (vertical) bit map into continuous addresses, change the display coordinates for displaying the bit map on the screen as shown in the following figure.



To implement the display coordinates shown in this figure, use the line scroll function and the vertical cell scroll function. The explanations that follow assume the following: The size of the VDP2 bit map is set to 512-dot (horizontal) × 256-dot (vertical), the horizontal direction of the display bit map is a multiple of 8, the display start line is n=0, and the display start cell is w=0.

#### 1) Horizontal coordinates

For horizontal display coordinates that change for each line, use the line scroll function and set the horizontal display coordinates of the left end as the horizontal line scroll value.

The expression for calculating the horizontal line scroll value of line n is:

$$(\text{Horizontal line scroll value of line } n) = \{00010000H \times (\text{horizontal size}) \times n\} \& 01ff0000H$$

#### 2) Vertical coordinates

For vertical display coordinates that change for each line or in the middle of a line, combine the line scroll function and the vertical cell scroll function.

First, set the vertical cell scroll value so that the fraction portion of the display coordinate value calculated from the scroll value is discarded and the vertical display coordinate increases by 1 in the middle of the line. The expression for calculating the vertical cell scroll value of cell w is:

$$(\text{Vertical cell scroll value of cell } w) = 00000400H \times w$$



II Set the values calculated from the calculation expression into the vertical cell scroll table.

	+0	+4	+8	+C
25E70000H	00000000	00000400	00000800	00000c00
25E70010H	00001000	00001400	00001800	00001c00
25E70020H	00002000	00002400	00002800	00002c00
25E70030H	00003000	00003400	00003800	00003c00
25E70040H	00004000	00004400	00004800	00004c00
25E70050H	00005000	00005400	00005800	00005c00
25E70060H	00006000	00006400	00006800	00006c00
25E70070H	00007000	00007400	00007800	00007c00
25E70080H	00008000	00008400	00008800	00008c00
25E70090H	00009000	00009400	00009800	00009c00
25E700A0H	0000a000	0000a400	0000a800	0000ac00

← In this example, data for cells 41 and above are not used.

III Set the values calculated from the calculation format into the line scroll table.

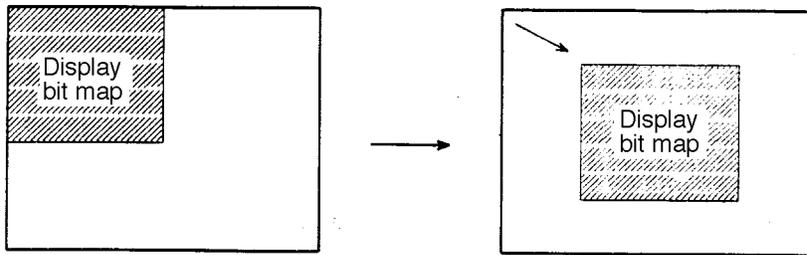
	+0	+4	+8	+C
25E60000H	00000000	00000000	01400000	0000a000
25E60010H	00800000	00010000	01c00000	0001e000
25E60020H	01000000	00028000	00400000	00030000
25E60030H	01800000	0003c000	00c00000	00040000
25E60040H	00000000	00050000	01400000	0005a000
25E60050H	00800000	00060000	01c00000	0006e000
25E60060H	01000000	00078000	00400000	00080000
25E60070H	01800000	0008c000	00c00000	00090000
25E60080H	00000000	000a0000	01400000	000aa000
25E60090H	00800000	000b0000	01c00000	000be000
25E600A0H	01000000	000c8000	00400000	000d0000
25E600B0H	01800000	000dc000	00c00000	000e0000
25E600C0H	00000000	000f0000	01400000	000fa000
25E600D0H	00800000	00100000	01c00000	0010e000
25E600E0H	01000000	00118000	00400000	00120000
25E600F0H	01800000	0012c000	00c00000	00130000
25E60100H	00000000	00140000	01400000	0014a000
25E60110H	00800000	00150000	01c00000	0015e000
25E60120H	01000000	00168000	00400000	00170000
25E60130H	01800000	0017c000	00c00000	00180000
25E60140H	00000000	00190000	01400000	0019a000
25E60150H	00800000	001a0000	01c00000	001ae000
25E60160H	01000000	001b8000	00400000	001c0000
25E60170H	01800000	001cc000	00c00000	001d0000
25E60180H	00000000	001e0000	01400000	001ea000
25E60190H	00800000	001f0000	01c00000	001fe000
25E601A0H	01000000	00208000	00400000	00210000
25E601B0H	01800000	0021c000	00c00000	00220000
25E601C0H	00000000	00230000	01400000	0023a000
25E601D0H	00800000	00240000	01c00000	0024e000
25E601E0H	01000000	00258000	00400000	00260000
25E601F0H	01800000	0026c000	00c00000	00270000
25E60200H	00000000	00280000	01400000	0028a000
25E60210H	00800000	00290000	01c00000	0029e000
25E60220H	01000000	002a8000	00400000	002b0000
25E60230H	01800000	002bc000	00c00000	002c0000
25E60240H	00000000	002d0000	01400000	002da000
25E60250H	00800000	002e0000	01c00000	002ee000
25E60260H	01000000	002f8000	00400000	00300000
25E60270H	01800000	0030c000	00c00000	00310000
25E60280H	00000000	00320000	01400000	0032a000
25E60290H	00800000	00330000	01c00000	0033e000
25E602A0H	01000000	00348000	00400000	00350000
25E602B0H	01800000	0035c000	00c00000	00360000
25E602C0H	00000000	00370000	01400000	0037a000
25E602D0H	00800000	00380000	01c00000	0038e000
25E602E0H	01000000	00398000	00400000	003a0000
25E602F0H	01800000	003ac000	00c00000	003b0000
25E60300H	00000000	003c0000	01400000	003ca000
25E60310H	00800000	003d0000	01c00000	003de000
25E60320H	01000000	003e8000	00400000	003f0000
25E60330H	01800000	003fc000	00c00000	00400000
25E60340H	00000000	00410000	01400000	0041a000
25E60350H	00800000	00420000	01c00000	0042e000
25E60360H	01000000	00438000	00400000	00440000
25E60370H	01800000	0044c000	00c00000	00450000

	+0	+4	+8	+C
25E60380H	00000000	00460000	01400000	0046a000
25E60390H	00800000	00470000	01c00000	0047e000
25E603A0H	01000000	00488000	00400000	00490000
25E603B0H	01800000	0049c000	00c00000	004a0000
25E603C0H	00000000	004b0000	01400000	004ba000
25E603D0H	00800000	004c0000	01c00000	004ce000
25E603E0H	01000000	004d8000	00400000	004e0000
25E603F0H	01800000	004ec000	00c00000	004f0000
25E60400H	00000000	00500000	01400000	0050a000
25E60410H	00800000	00510000	01c00000	0051e000
25E60420H	01000000	00528000	00400000	00530000
25E60430H	01800000	0053c000	00c00000	00540000
25E60440H	00000000	00550000	01400000	0055a000
25E60450H	00800000	00560000	01c00000	0056e000
25E60460H	01000000	00578000	00400000	00580000
25E60470H	01800000	0058c000	00c00000	00590000
25E60480H	00000000	005a0000	01400000	005aa000
25E60490H	00800000	005b0000	01c00000	005be000
25E604A0H	01000000	005c8000	00400000	005d0000
25E604B0H	01800000	005dc000	00c00000	005e0000
25E604C0H	00000000	005f0000	01400000	005fa000
25E604D0H	00800000	00600000	01c00000	0060e000
25E604E0H	01000000	00618000	00400000	00620000
25E604F0H	01800000	0062c000	00c00000	00630000
25E60500H	00000000	00640000	01400000	0064a000
25E60510H	00800000	00650000	01c00000	0065e000
25E60520H	01000000	00668000	00400000	00670000
25E60530H	01800000	0067c000	00c00000	00680000
25E60540H	00000000	00690000	01400000	0069a000
25E60550H	00800000	006a0000	01c00000	006ae000
25E60560H	01000000	006b8000	00400000	006c0000
25E60570H	01800000	006cc000	00c00000	006d0000
25E60580H	00000000	006e0000	01400000	006ea000
25E60590H	00800000	006f0000	01c00000	006fe000
25E605A0H	01000000	00708000	00400000	00710000
25E605B0H	01800000	0071c000	00c00000	00720000
25E605C0H	00000000	00730000	01400000	0073a000
25E605D0H	00800000	00740000	01c00000	0074e000
25E605E0H	01000000	00758000	00400000	00760000
25E605F0H	01800000	0076c000	00c00000	00770000
25E60600H	00000000	00780000	01400000	0078a000
25E60610H	00800000	00790000	01c00000	0079e000
25E60620H	01000000	007a8000	00400000	007b0000
25E60630H	01800000	007bc000	00c00000	007c0000
25E60640H	00000000	007d0000	01400000	007da000
25E60650H	00800000	007e0000	01c00000	007ee000
25E60660H	01000000	007f8000	00400000	00800000
25E60670H	01800000	0080c000	00c00000	00810000
25E60680H	00000000	00820000	01400000	0082a000
25E60690H	00800000	00830000	01c00000	0083e000
25E606A0H	01000000	00848000	00400000	00850000
25E606B0H	01800000	0085c000	00c00000	00860000
25E606C0H	00000000	00870000	01400000	0087a000
25E606D0H	00800000	00880000	01c00000	0088e000
25E606E0H	01000000	00898000	00400000	008a0000
25E606F0H	01800000	008ac000	00c00000	008b0000

This setup produces a continuous address bit map of 320-dot (horizontal)× 224-dot (vertical).

## 2. Application

This section explains how to use the principles described in the previous section to place a bit map smaller than the TV screen at any location on the TV screen.



The easiest way to place a bit map at any location on the TV screen is to use the screen scroll function. However, simply scrolling the screen does not produce good results because the following two problems occur:

- I The picture is repeated even in undesired areas.
- II The line scroll values change because the display start position is not at the top left of the TV screen.

These two problems can be corrected by using the window function and changing the calculation expression for line scroll values.

### 1) Window function

Problem I can be corrected easily with the window function. At the location where the bit map is to be displayed, set a transparent processing window of the same size as the bit map, and validate the outside of the window.

### 2) Line scroll values

Problem II can be corrected by calculating the line scroll values (see "Principles") according to the following procedure. However set the display start line of the bit map to  $n = 0$  and the display start coordinates of the bit map to  $(M_x, M_y)$ . Lines that do not display the bit map are unrelated, and the line scroll value for those lines should be set to  $n = 0$ .

Step i: Calculate the horizontal line scroll value for line  $M_y+n$ .

$$(\text{Horizontal line scroll value}) = \{00010000H \times (\text{horizontal size}) \times n\} \& 01ff0000H$$

Step ii: Calculate the integer portion  $I(n)$  of the vertical display coordinate value for line  $M_y+n$ .

$$I(n) = \{00000080H \times (\text{horizontal size}) \times n\} \& 01ff0000H$$

Step iii: For line  $n$  of the display bit map, calculate cell number  $m$  at which the vertical display coordinate value increases by 1.

$$A(n) = 64 \times \{(I(n)/00010000H) + 1\}$$

$$B(n) = \{(\text{horizontal size})/8\} \times (n + 1)$$

$$\text{If } A(n) \geq B(n): m = 64$$

$$\text{If } A(n) < B(n): m = A(n) - B(n-1) + (\text{rounded up value of } M_x/8)$$

Step iv: Calculate the vertical line scroll value for line  $M_y+n$ .

$$(\text{Vertical line scroll value}) = I(n) + \{00000400H \times (64 - m)\}$$

### 3) Setting example

This item explains in detail a setting example in which a 192-dot (horizontal)× 144-dot (vertical) bit map (NBG0, 16.77 million colors) is displayed in the center of the TV screen and the VRAM addresses become continuous.

- Bit map display start coordinates = (64, 40)
- Bit map leading address = 25E00000H
- Line scroll table address = 25E20000H
- Vertical cell scroll table address = 25E30000H
- Back screen table address = 25E7FFFEH

i Set the VDP2 registers as follows:

	+0	+2	+4	+6	+8	+A	+C	+E	
25F80000H	8000	0000	0000	0000	0000	0000	0000	0100	← Splits only one side into a double buffer because the bit map data fits into one bank.
25F80010H	4444	4444	cfff	ffff	ffff	ffff	ffff	ffff	← Sets the size to 512 (H) x 256 (V) dots in a 16.77M bit map.
25F80020H	0001	0000	0000	0000	0042	0000	0000	0000	
25F80030H	0000	0000	0000	0000	0000	0000	0000	0000	
25F80040H	0000	0000	0000	0000	0000	0000	0000	0000	
25F80050H	0000	0000	0000	0000	0000	0000	0000	0000	
25F80060H	0000	0000	0000	0000	0000	0000	0000	0000	
25F80070H	07c0	0000	0000	0000	0001	0000	0001	0000	← Sets the horizontal screen scroll value according to the bit map display start coordinates.
25F80080H	0000	0000	0000	0000	0000	0000	0000	0000	
25F80090H	0000	0000	0000	0000	0000	0007	0001	8000	← Enables line scrolling (horizontal and vertical scroll values) and vertical cell scrolling.
25F800A0H	0001	0000	0000	0000	0000	0000	0003	ffff	
25F800B0H	0000	0000	0000	0000	0000	0000	0000	0000	
25F800C0H	0080	0028	01fe	00b7	0000	0000	0000	0000	← Sets the window.
25F800D0H	0003	0000	0000	0000	0000	0000	0000	0000	
25F800E0H	0000	0000	0000	0000	0000	0000	0000	0000	
25F800F0H	0000	0000	0000	0000	0000	0007	0000	0000	← Displays only NBG0.
25F80100H	0000	0000	0000	0000	0000	0000	0000	0000	
25F80110H	0000	0000	0000	0000	0000	0000	0000	0000	

ii Set the values calculated from the calculation expression into the vertical cell scroll table.

	+0	+4	+8	+C	
25E30000H	00000000	00000400	00000800	00000c00	
25E30010H	00001000	00001400	00001800	00001c00	
25E30020H	00002000	00002400	00002800	00002c00	
25E30030H	00003000	00003400	00003800	00003c00	
25E30040H	00004000	00004400	00004800	00004c00	
25E30050H	00005000	00005400	00005800	00005c00	
25E30060H	00006000	00006400	00006800	00006c00	
25E30070H	00007000	00007400	00007800	00007c00	
25E30080H	00008000	00008400	00008800	00008c00	
25E30090H	00009000	00009400	00009800	00009c00	
25E300A0H	0000a000	0000a400	0000a800	0000ac00	← In this example, data for cells 41 and above is not used.

iii Set the values calculated from the calculation format into the line scroll table.

	+0	+4	+8	+C
25E20000H	00000000	00000000	00000000	00000000
25E20010H	00000000	00000000	00000000	00000000
25E20020H	00000000	00000000	00000000	00000000
25E20030H	00000000	00000000	00000000	00000000
25E20040H	00000000	00000000	00000000	00000000
25E20050H	00000000	00000000	00000000	00000000
25E20060H	00000000	00000000	00000000	00000000
25E20070H	00000000	00000000	00000000	00000000
25E20080H	00000000	00000000	00000000	00000000
25E20090H	00000000	00000000	00000000	00000000
25E200A0H	00000000	00000000	00000000	00000000
25E200B0H	00000000	00000000	00000000	00000000
25E200C0H	00000000	00000000	00000000	00000000
25E200D0H	00000000	00000000	00000000	00000000
25E200E0H	00000000	00000000	00000000	00000000
25E200F0H	00000000	00000000	00000000	00000000

	+0	+4	+8	+C
25E20100H	00000000	00000000	00000000	00000000
25E20110H	00000000	00000000	00000000	00000000
25E20120H	00000000	00000000	00000000	00000000
25E20130H	00000000	00000000	00000000	00000000
25E20140H	00000000	00000000	00c00000	00000000
25E20150H	01800000	0000a000	00400000	00010000
25E20160H	01000000	00010000	01c00000	0001c000
25E20170H	00800000	00020000	01400000	00020000
25E20180H	00000000	00030000	00c00000	00030000
25E20190H	01800000	0003a000	00400000	00040000
25E201A0H	01000000	00040000	01c00000	0004c000
25E201B0H	00800000	00050000	01400000	00050000
25E201C0H	00000000	00060000	00c00000	00060000
25E201D0H	01800000	0006a000	00400000	00070000
25E201E0H	01000000	00070000	01c00000	0007c000
25E201F0H	00800000	00080000	01400000	00080000
25E20200H	00000000	00090000	00c00000	00090000
25E20210H	01800000	0009a000	00400000	000a0000
25E20220H	01000000	000a0000	01c00000	000ac000
25E20230H	00800000	000b0000	01400000	000b0000
25E20240H	00000000	000c0000	00c00000	000c0000
25E20250H	01800000	000ca000	00400000	000d0000
25E20260H	01000000	000d0000	01c00000	000dc000
25E20270H	00800000	000e0000	01400000	000e0000
25E20280H	00000000	000f0000	00c00000	000f0000
25E20290H	01800000	000fa000	00400000	00100000
25E202A0H	01000000	00100000	01c00000	0010c000
25E202B0H	00800000	00110000	01400000	00110000
25E202C0H	00000000	00120000	00c00000	00120000
25E202D0H	01800000	0012a000	00400000	00130000
25E202E0H	01000000	00130000	01c00000	0013c000
25E202F0H	00800000	00140000	01400000	00140000
25E20300H	00000000	00150000	00c00000	00150000
25E20310H	01800000	0015a000	00400000	00160000
25E20320H	01000000	00160000	01c00000	0016c000
25E20330H	00800000	00170000	01400000	00170000
25E20340H	00000000	00180000	00c00000	00180000
25E20350H	01800000	0018a000	00400000	00190000
25E20360H	01000000	00190000	01c00000	0019c000
25E20370H	00800000	001a0000	01400000	001a0000
25E20380H	00000000	001b0000	00c00000	001b0000
25E20390H	01800000	001ba000	00400000	001c0000
25E203A0H	01000000	001c0000	01c00000	001cc000
25E203B0H	00800000	001d0000	01400000	001d0000
25E203C0H	00000000	001e0000	00c00000	001e0000
25E203D0H	01800000	001ea000	00400000	001f0000
25E203E0H	01000000	001f0000	01c00000	001fc000
25E203F0H	00800000	00200000	01400000	00200000
25E20400H	00000000	00210000	00c00000	00210000
25E20410H	01800000	0021a000	00400000	00220000
25E20420H	01000000	00220000	01c00000	0022c000
25E20430H	00800000	00230000	01400000	00230000
25E20440H	00000000	00240000	00c00000	00240000
25E20450H	01800000	0024a000	00400000	00250000
25E20460H	01000000	00250000	01c00000	0025c000
25E20470H	00800000	00260000	01400000	00260000

← Start line of bit map display

	+0	+4	+8	+C	
25E20480H	00000000	00270000	00c00000	00270000	
25E20490H	01800000	0027a000	00400000	00280000	
25E204A0H	01000000	00280000	01c00000	0028c000	
25E204B0H	00800000	00290000	01400000	00290000	
25E204C0H	00000000	002a0000	00c00000	002a0000	
25E204D0H	01800000	002aa000	00400000	002b0000	
25E204E0H	01000000	002b0000	01c00000	002bc000	
25E204F0H	00800000	002c0000	01400000	002c0000	
25E20500H	00000000	002d0000	00c00000	002d0000	
25E20510H	01800000	002da000	00400000	002e0000	
25E20520H	01000000	002e0000	01c00000	002ec000	
25E20530H	00800000	002f0000	01400000	002f0000	
25E20540H	00000000	00300000	00c00000	00300000	
25E20550H	01800000	0030a000	00400000	00310000	
25E20560H	01000000	00310000	01c00000	0031c000	
25E20570H	00800000	00320000	01400000	00320000	
25E20580H	00000000	00330000	00c00000	00330000	
25E20590H	01800000	0033a000	00400000	00340000	
25E205A0H	01000000	00340000	01c00000	0034c000	
25E205B0H	00800000	00350000	01400000	00350000	
25E205C0H	00000000	00000000	00000000	00000000	← End line of bit map display
25E205D0H	00000000	00000000	00000000	00000000	
25E205E0H	00000000	00000000	00000000	00000000	
25E205F0H	00000000	00000000	00000000	00000000	
25E20600H	00000000	00000000	00000000	00000000	
25E20610H	00000000	00000000	00000000	00000000	
25E20620H	00000000	00000000	00000000	00000000	
25E20630H	00000000	00000000	00000000	00000000	
25E20640H	00000000	00000000	00000000	00000000	
25E20650H	00000000	00000000	00000000	00000000	
25E20660H	00000000	00000000	00000000	00000000	
25E20670H	00000000	00000000	00000000	00000000	
25E20680H	00000000	00000000	00000000	00000000	
25E20690H	00000000	00000000	00000000	00000000	
25E206A0H	00000000	00000000	00000000	00000000	
25E206B0H	00000000	00000000	00000000	00000000	
25E206C0H	00000000	00000000	00000000	00000000	
25E206D0H	00000000	00000000	00000000	00000000	
25E206E0H	00000000	00000000	00000000	00000000	
25E206F0H	00000000	00000000	00000000	00000000	

iv Set the back screen table (25E7FFFEH) to black (0000H).

This setup produces a continuous address bit map of 192-dot (horizontal)× 144-dot (vertical). In this example, VRAM-A and VRAM-B can be configured as double buffers because the bit map data fits into one bank. However, in this case, the vertical cell scroll table must be set in both VRAM-A and VRAM-B because it must be set in the side that is not the display VRAM.

### 3. Summary

Described below is the procedure for displaying a continuous address bit map of a specific size at any location on a TV screen. However, the horizontal size of the display bit map must be a multiple of 8.

#### 1) Set the screen scroll value.

Set the horizontal screen scroll value. However, for the TV screen, set the horizontal display start position of the bit map to  $M_x$ .

$$(\text{Integer portion of the horizontal screen scroll value}) = (0800H - M_x) \& 07ffH$$

#### 2) Set the window.

Set a transparent processing window of the same size as the bit map to the TV screen display position of the bit map. Make the outside of the window effective.

#### 3) Set the vertical cell scroll table.

Set the vertical cell scroll table. Set the leftmost cell to  $w = 0$ .

$$(\text{Vertical cell scroll value of cell } w) = 00000400H \times w$$

#### 4) Set the line scroll table.

Set the line scroll table. However, for the TV screen, set the display start line of the bit map to  $n = 0$ . Also, for line that do not display the bit map, set the line scroll value to 0.

- Bit map size for VDP2 setup = 512-dot (horizontal)  $\times$  256-dot (vertical)
- Display bit map size =  $S_x$ -dot (horizontal)  $\times$   $S_y$ -dot (vertical)
- Display start coordinate of bit map on TV screen =  $(M_x, M_y)$
- $0 \leq n \leq S_y - 1$

$$(\text{Horizontal line scroll value for line } M_y+n) = \{00010000H \times S_x \times n\} \& 01ff0000H$$

$$(\text{Vertical line scroll value for line } M_y+n) = I(n) + \{00000400H \times (64 - m)\}$$

Where,  $I(n) = \{00000080H \times S_x \times n\} \& 01ff0000H$

$$A(n) = 64 \times \{(I(n)/00010000H + 1)\}$$

$$B(n) = (S_x/8) \times (n + 1)$$

$$\text{If } A(n) \geq B(n), \\ m = 64$$

$$\text{If } A(n) < B(n), \\ m = A(n) - B(n-1) + (\text{rounded up value of } M_x/8)$$

#### 5) Merits

- The amount of VRAM that must be allocated to bit map data can be kept to a minimum.
- The VRAM addresses become continuous, regardless of the specified number of bit map colors.
- For bit map data of 16.77-million colors that fits in one bank or bit map data of 32,768 colors, the VRAM can be configured as a double buffer, which allows pictures to be updated even when they are displayed.

6) Comments

- The window setup is not necessary for a full-screen display.
- If the horizontal size of the display bit map is 8-dot, 16-dot, 32-dot, 64-dot, 128-dot, or 256-dot, the vertical cell scroll is not necessary. Also, calculation of the vertical line scroll value is simplified.

## SEGA SATURN TECHNICAL BULLETIN #15

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** June 2, 1995  
**Re:** VDP1 User's Manual Correction

---

The following is a correction for page 79 of the VDP1 User's Manual Version 1(2/20/94):

**Error:** Position of "clipping mode bit" and "user clipping valid bit" is different in the drawing and the explanation.

bit        10        9

Pclp	Clip	Cmod	Mesh
------	------	------	------

•  
•

: clipping mode bit (Cmod), bit 10

•

: user clipping enable bit (Clip), bit 9

**Correct:** The drawing is correct.

bit        10        9

Pclp	Clip	Cmod	Mesh
------	------	------	------

•  
•

: clipping mode bit (Cmod), bit 9

•

: user clipping enable bit (Clip), bit 10

## SEGA SATURN TECHNICAL BULLETIN #16

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** June 2, 1995  
**Re:** SCU DSP Instruction Clarification

---

Additional information to be added to pg119 from SCU User's Manual version 2 (5/31/94).

MOV [ s ], [ d ]	transfer([source]->[destination]) •••
operation	
discription (function)	•••
instruction code	<div style="border: 1px solid black; width: 20px; height: 15px; display: inline-block;"></div>

The following table is in this table above.

bit Data				[s] select
bit 3	bit 2	bit 1	bit 0	
1	0	1	0	[ALU HIGH]

Addition: upper side 32 bit within

## SEGA SATURN TECHNICAL BULLETIN #17

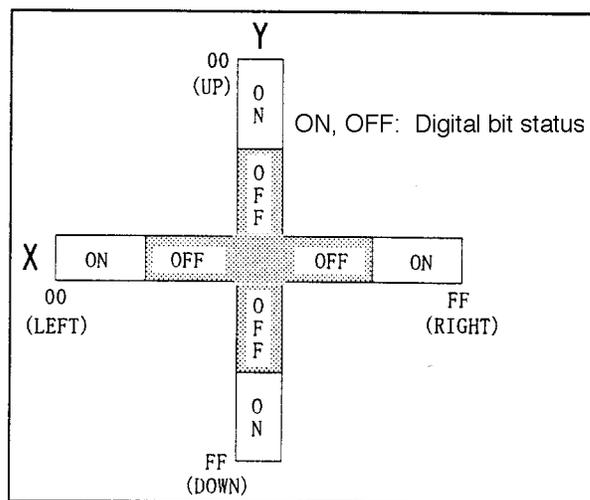
**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** June 2, 1995  
**Re:** Mission Stick Specifications

---

Note that some of the specifications for the mission stick differ from the specifications for the trail-version analog joy stick.

- 1. The digital RLDU stick was discontinued. The digital RLDU returns a value according to the analog stick (see figure below).
- 2. The mission stick features a center-adjust function. When the power is turned on, the stick position is automatically assumed to be the center (=128). Structurally, however, the center may shift after extended use. In addition, if the stick is intentionally tilted when the power is turned on, it will not operate properly because of this center-adjust function. This item will be added to the operating instructions as a note.
- 3. For X, Y, and Z of the mission stick, a minimum value of 0 and a maximum value of 255 are guaranteed. The minimum and maximum values are output before the mechanical movement limits.

Analog stick movement distance and digital bit changes



## SEGA SATURN TECHNICAL BULLETIN #18

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** June 2, 1995  
**Re:** Limitation of Default Interrupt Processing Routine

---

The following function is used to register a default interrupt processing routine that cancels the registration of a previously registered interrupt processing routine:

```
SYS_SETSINT(Num, 0);
```

If this function is used from the slave SH, the correct default is not written to the corresponding vector in the slave vector table of vector number Num.

When registering a default from the slave SH, do not register a default that specifies 0 as the address.

There are no problems operating a slave or master vector table from the master SH.

To return a slave vector to the default registration, use the following methods:

1. If the slave SH itself operates slave SH vectors

In cases where the slave SH program resides in the work RAM and the slave itself determines the interrupt processing based on existing conditions, first (when the default can be obtained) use the following function to save the processing to a function:

```
func_org = SYS_GETSINT(Num);
```

After registering and updating the target processing routine:

```
SYS_SETSINT(Num, func_1st);
```

```
:
```

```
SYS_SETSINT(Num, func_2nd);
```

```
:
```

register the first address to return to the default:

```
SYS_SETSINT(Num, func_org);
```

2. If the master SH operates slave SH vectors

In cases where a different slave SH program is read at each stage and the master turns the slave on and off in a complex manner, the slave vectors should be initialized either before the master turns the slave on or after the master turns the slave off. From the master SH, specify the following at one of the timings:

```
SYS_SETSINT(Num + 0 x 100, 0);
```

Adding "0 x 100" to the vector number allows slave vectors to be operated from the master SH, even in normal processing routine registration.

## SEGA SATURN TECHNICAL BULLETIN #19

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** June 2, 1995  
**Re:** GFS\_Init Settings

---

The file system initialization function (GFS\_Init) executes the CD block initialization function (CDC\_CdInit) to set the ECC and retry counts to the maximum values. The actual settings are as follows:

- Initialization flag: Default value
  - Standby time: Default value
  - ECC count: 5
  - Retry count: 15
- ```
CDC_CdInit(0, 0, 5, 0x0f);
```

To change these settings when using GFS, call GFS\_Init, then execute the CDC\_CdInit function. The program can be specified so that only the target parameters are changed while the other parameters remain the same.

- Program example

```
#include "sega_gfs.h"

#define STNBY 90 /* Standby time: 90 seconds */
#define NOCHG -1 /* No change specification */

sint32 sampleInit(void)
{
    sint32 ret;

    /* File system initialization */
    ret = GFS_Init(...);
    if (ret < 0) {
        return NG;
    }

    /* Standby time change (others are not changed)
*/
    ret = CDC_CdInit(NOCHG, STNBY, NOCHG, NOCHG);
    if (ret != CDC_ERR_OK) {
        return NG;
    }
}
```

```
    }  
    return OK;  
}
```

## SEGA SATURN TECHNICAL BULLETIN #20

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** June 2, 1995  
**Re:** Program Library User's Guide 1 Corrections

---

The following information lists corrections to the Saturn "Program Library User's Guide 1 (ST-136-R2-093094)".

### Corrections to the File System Library Manual Version 1.0

- Errata

| Page   | Location          | Error                          | Correction                 |
|--------|-------------------|--------------------------------|----------------------------|
| 11     | Example in 3.4    | OpenByName(Uint8 *fname)       | OpenByName(Sint8 *fname)   |
| 23, 27 | No. 2.6           | GFS_TRANS_...                  | GFS_TMODE_...              |
| 30     | No. 3.4           | GFS_DIR_FNAME(dir) Uint8[]     | GFS_DIR_FNAME(dir) Sint8[] |
| 34     | No. 1.4           | GFS_NameTold(Uint8 *fname)     | GFS_NameTold(Sint8 *fname) |
| 34     | No. 1.5           | const Uint8 *GFS_IdToName      | Sint8 *GFS_IdToName        |
| 35     | No. 2.3           | off                            | ofs                        |
| 36     | No. 2.7<br>Output | (does not include last sector) | (includes last sector)     |
| 37     | No. 3.1           | off                            | ofs                        |
| 39     | No. 4.2<br>Remark | GFS_NwIsCompleted function     | GFS_NwIsComplete function  |
| 40     | No. 4.6           | GFS_EXEC_...                   | GFS_SVR_...                |
| 49     | C.2 (3)           | GFS_ATR_FORM1 0 x 80           | GFS_ATR_FORM1 0 x 08       |

- Page 27, No. 2.6 (GFS\_TMODE\_)

| Constant name | Explanation                                                                                                                 |
|---------------|-----------------------------------------------------------------------------------------------------------------------------|
| GFS_TMODE_SCU | DMA transfer (level 0) by the SCU<br>When the transfer destination is WORK RAM-L, the transfer becomes a software transfer. |

- Page 29, No. 3.2 (GfsDirTbl)  
Item names for (1) to (3) will be added as follows:
  - (1) Directory information table type  
The directory information management structure ...
  - (2) Directory information management  
This data type is used to manage directory information.
  - (3) Setting method
    - (a) When directory information without file names is used
  
- Page 35, No. 2.3 (GFS\_Seek)  
The description for the function "the end of the file is exceeded ..." will be deleted and changed as follows:

A position outside the file range cannot be specified as the pointer.
  
- Page 36, No. 2.7 (GFS\_GetFileSize)  
The remark description will be deleted and changed as follows:

[Remark] In files containing both Form1 and Form2, both sctsize and lastsiz become 0.
  
- Page 38, No. 3.2 (GFS\_Fread), No. 3.3 (GFS\_NwFread)  
The remark description "The access pointer executes read processing ..." will be deleted.
  
- Page 44, A.3 (Notes)  
The description for "When a CD-ROM is Not Used" will be deleted.  
\* This deletion is due to the specification changes related to the file identifier in C.2 (8).

## SEGA SATURN TECHNICAL BULLETIN #21

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** June 2, 1995  
**Re:** GFS\_Init and GFS\_LoadDir Function Errors

---

If an error occurs with the GFS\_Init or GFS\_LoadDir function, perform the corrective action described below. A program sample is shown on the following page.

(1) GFS\_ERR\_CDRD or GFS\_ERR\_FATAL error  
GFS\_Init sets the ECC and read retry counts to the maximum values to provide maximum prevention from an <ERROR> status occurrence. If a <FATAL> status occurs, the GFS\_Init function issues the STOP command (home position seek) for error recovery.

To handle these errors, set up a recovery processing as shown in the program sample in the attachment. In the recovery processing, issue the PAUSE command, wait for the <PAUSE> status, and then reissue the function. Set the number of execution repetitions to at least 3.

If the error persists even after the repeated executions, there may be unrecoverable scratch on the disc. Display a message or switch to the multiplayer.

(2) GFS\_ERR\_CDNODISC or GFS\_ERR\_CDOPEN error  
Switch to the multiplayer

(3) Other errors  
Other errors should not occur. If any other error occurs, reexamine the program. The error may be due to a fault in the GFS library or the hardware. If you are unable to isolate the error, contact SEGA.

With the product version, the only corrective action is to switch to the multiplayer.

Sample of Error Recovery Processing for GFS\_Init and GFS\_LoadDir Functions

- Program Example

```
# include "sega_cdc.h"
```

```
Sint32 recovGfsInit(void);  
Sint32 waitStat(Sint32 sts);
```

```

/* Recovery processing for GFS_Init and GFS_LoadDir */
Sint32 recovGfsInit(void)
{
    Sint32    ret;
    CdcPos    pos;
    /* Issue PAUSE command */
    CDC_POS_PTYPE(&pos) = CDC_PTYPE_NOCHG;
    ret = CDC_CdSeek(&pos);
    if (ret != CDC_ERR_OK) {
        return NG;
    }
    /* Wait until <PAUSE> status */
    ret = waitStat(CDC_ST_PAUSE);

    return ret;
}

/* Wait until specified drive status */
Sint32 waitStat(Sint32 sts)
{
    Sint32    ret;
    Sint32    stwk;
    CdcStat    stat;
    while (TRUE) { /*Actually upper limit for loop
count is necessary */
        /* Get periodic response */
        ret = CDC_GetPeriStat(&stat);
        if (ret == CDC_ERR_PERI) {
            continue;
        }
        if (ret != CDC_ERR_OK) {
            return NG;
        }
        stwk = CDC_GET_STC(&stat);
        if (stwk == sts) {
            break;
        }
    }
    return OK;
}

```

## SEGA SATURN TECHNICAL BULLETIN #22

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** June 2, 1995  
**Re:** VDP1 and VDP2 Resolution Specification Changes

---

The following table shows the specifications of the horizontal resolution settings for VDP1 and VDP2.

| VDP2 setting (HRESO value)                        | VDP1 setting (TVM value) | Setting status |
|---------------------------------------------------|--------------------------|----------------|
| Normal mode<br>(000 or 001)                       | Normal (000)             | Enabled        |
|                                                   | High-resolution (001)    | Disabled       |
|                                                   | Rotation 16 (010)        | Enabled        |
|                                                   | Rotation 8 (011)         | Enabled        |
|                                                   | HDTV (100)               | Disabled       |
| High-resolution mode<br>(010 or 011)              | Normal (000)             | Enabled *      |
|                                                   | High-resolution (001)    | Enabled        |
|                                                   | Rotation 16 (010)        | Enabled *      |
|                                                   | Rotation 8 (011)         | Enabled *      |
|                                                   | HDTV (100)               | Disabled       |
| Dedicated monitor mode<br>(100, 101, 110, or 111) | Normal (000)             | Disabled       |
|                                                   | High-resolution (001)    | Disabled       |
|                                                   | Rotation 16 (010)        | Disabled       |
|                                                   | Rotation 8 (011)         | Disabled       |
|                                                   | HDTV (100)               | Enabled        |

Note: The asterisks in the table indicate combinations for which the specification has changed.

## SEGA SATURN TECHNICAL BULLETIN #23

**To:** Sega and Third Party Developers

**From:** Developer Technical Support

**Date:** June 2, 1995

**Re:** VDP Interlace Settings

---

The following graphics will be displayed by the interlace setting of VDP2 (LSMD bit) and VDP1 (DIE bit):

| LSMD value | DIE value | VDP2 display             | VDP1 display             |
|------------|-----------|--------------------------|--------------------------|
| 00         | 0         | non-interlace            | non-interlace            |
|            | 1         | non-interlace            | cannot display correctly |
| 10         | 0         | single-density interlace | single-density interlace |
|            | 1         | single-density interlace | double-density interlace |
| 11         | 0         | double-density interlace | single-density interlace |
|            | 1         | double-density interlace | double-density interlace |
|            |           |                          |                          |

## **SEGA SATURN TECHNICAL BULLETIN #24**

**To: Sega and Third Party Developers**  
**From: Developer Technical Support**  
**Date: June 2, 1995**  
**Re: Changing VDP2 Screen Resolution**

---

The following cautionary items are to be noted when changing from VDP2's TV screen mode to high-resolution mode:

- Normal scroll screen (NBG 0~3) is displayed as if a normal mode picture is reduced by half, in the horizontal direction.
- Rotational scroll (RBG 0, 1) can be displayed, however, the picture resolution will be the same as the normal mode's.
- VRAM cycle pattern register becomes valid only for T0~T3, and becomes invalid for T4~T7.
- Vertical cell scroll function is not available.
- There are some limitations for color operation function.  
--> Please refer to "VDP User's Manual pg. 236, table 12.1"
- Expanded color calculation function and blur (gradation) calculation function is not available.

## SEGA SATURN TECHNICAL BULLETIN #25

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** June 2, 1995  
**Re:** Palette Format Sprite Display

---

When palette-format sprites are used, the picture may not be displayed for certain palette codes and color bank values. The picture is not displayed because the dot data is processed as dot data (normal shadow data) for the VDP2 shadow function. The table on the next page shows the sprite data that is processed as normal shadow data for each sprite type set in VDP2.

For details on this topic, see Section 6.4, "CMDCOLR (Color Control Word)," in the VDP1 Hardware Manual (ST-013-R3-052794) and Section 14.1, "Shadow Processing," in the VDP2 Hardware Manual.

### Normal Shadow Data According to Sprite Type

| Sprite type  | Number of sprite colors | Palette code | Color bank       |
|--------------|-------------------------|--------------|------------------|
| Types 0-3, 5 | 16                      | 1110         | xxxxx1111110000  |
|              | 64                      | xx111110     | xxxxx1111xx0000  |
|              | 128                     | x1111110     | xxxxx111xxx0000  |
|              | 256                     | 11111110     | xxxxx111xxx0000  |
| Types 4, 6   | 16                      | 1110         | xxxxx1111110000  |
|              | 64                      | xx111110     | xxxxx1111xx0000  |
|              | 128                     | x1111110     | xxxxx111xxx0000  |
|              | 256                     | 11111110     | xxxxx11xxx0000   |
| Type 7       | 16                      | 1110         | xxxxxxx111110000 |
|              | 64                      | xx111110     | xxxxxxx111xx0000 |
|              | 128                     | x1111110     | xxxxxxx11xxx0000 |
|              | 256                     | 11111110     | xxxxxxx1xxx0000  |
| Types C-F    | 16                      | 1110         | xxxxxxxx11110000 |
|              | 64                      | xx111110     | xxxxxxxx11xx0000 |
|              | 128                     | x1111110     | xxxxxxxx1xxx0000 |
|              | 256                     | 11111110     | Not applicable   |
| Type 8       | 16                      | 1110         | xxxxxxxxx1110000 |
|              | 64                      | xx111110     | xxxxxxxxx1xx0000 |
|              | 128                     | x1111110     | Not applicable   |
|              | 256                     | 11111110     | Not applicable   |

|          |     |          |                  |
|----------|-----|----------|------------------|
| Type 9-B | 16  | 1110     | xxxxxxxxxx110000 |
|          | 64  | xx111110 | Not applicable   |
|          | 128 | x1111110 | Not applicable   |
|          | 256 | 11111110 | Not applicable   |

## SEGA SATURN TECHNICAL BULLETIN #26

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** June 2, 1995  
**Re:** Obtaining CD Directory Information

---

In order to get the directory information from the directory information table in the file system library, the following function is to be used. The following function is available and can be used from the ver1.10 (Disk ver 11/11/94) of the Software Library.

| Title                  | Function                  | Function Name  | No  |
|------------------------|---------------------------|----------------|-----|
| Function Specification | Get directory Information | GFS_GetDirInfo | 1.6 |

[ Format ] Sint 32 GFS\_GetDirInfo(Sint32 fid, GfsDirId \*dirrec)

[ Input ] fid : File identifier

[ Output ] dirrec: Directory Information

[ Function value ] Error code

[ Function ] Get directory information from file identifier.

## **SEGA SATURN TECHNICAL BULLETIN #27**

**To: Sega and Third Party Developers**  
**From: Developer Technical Support**  
**Date: June 2, 1995**  
**Re: Limitations in Monoral or Language Setting**

---

When in monoral or language setting, the following limitations have to be followed. As for the method and reference of the setting values, please refer to the "Programmer's Guide / System Library User's Guide / SMPC I/F User's Manual.

### 1. Setting Value Reference

The user setting contents which are set by the following multiplayers can be referenced from the application. In the application, this setting value must be used as the default value.

- (1) Tone Output (stereo/mono)
- (2) Language Setting
- (3) Date, Time Setting

### 2. Setting Value Change

The user setting contents which are set by the following multiplayers can be changed from the application. In the application, if they are changed by the users, the changed setting value must be set.

- (1) Tone Output (stereo/mono)
- (2) Language Setting

### 3. Important !

The user setting contents which are set by the following multiplayers must not be changed from within the application.

- (1) Date, Time Setting
- (2) Help Window (display / not to display)
- (3) Effect Sound (ON / OFF)
- (4) Reserve Area

**SEGA SATURN TECHNICAL BULLETIN #28**

**To: Sega and Third Party Developers**  
**From: Developer Technical Support**  
**Date: June 9, 1995**  
**RE: Using Dual CPU's on the SEGA SATURN**

---

Tech Bulletin #28 begins on next page.

## 1. Preface

This manual explains how to use two CPUs (SH2) in the SEGA SATURN.

When the SEGA SATURN is activated, it operates with only the main CPU. To activate the slave CPU, perform the procedures explained in this manual.

This manual is intended for readers who have a general knowledge of the SEGA SATURN hardware and software. When reading this manual, use the following manuals as references:

- "SH7095 Hardware Manual"
- "SCU User's Manual (Hardware Manual Vol. 1)"
- "System Program User's Manual (Programmer's Guide Vol. 1 System Library)"
- Software library document files  
(See **MANSYS.DOC** in /**SATURN/SEGALIB/MAN.**)
- "SEGA SATURN Target Box User's Manual" (shipped with the Target Box)

## 2. Overview of Dual CPU Operation in the SEGA SATURN

This section gives an overview of dual CPU operation in the SEGA SATURN.

### 2.1 Fully Shared Mode (Memory Sharing)

In the SEGA SATURN, the slave CPU shares all external devices with the master CPU. Programs that are executed by the slave CPU and the reset vector that is obtained at reset are exactly the same as those of the master CPU.

However, the master CPU and the slave CPU are identified in the boot ROM because each must be initialized independently.

If the slave CPU and master CPU conflict during external access, one of the CPU's must wait for access. Meanwhile, execution speed decreases.

### 2.2 Dual CPU Communications Using the Free Running Timer (FRT)

One of the ways the master and slave CPUs communicate in the SEGA SATURN is by using the input capture signal of the free running timer (FRT) in an internal SH2 on-chip module.

Specifically, the FRT input capture signal can be input to the slave CPU by writing any 16-bit value to address 21000000<sub>H</sub>. The FRT input capture signal can also be input to the master CPU by writing any 16-bit value to address 21800000<sub>H</sub>.

## 2.3 Slave CPU Interrupts

Unlike the master CPU, slave CPU interrupts are not set from the SCU. Instead, the slave CPU interrupts are connected from a peripheral module called DCC, which controls dual CPU operation. The slave CPU interrupts are described below.

(1) Interrupts used by the slave CPU.

The slave CPU can use the following three interrupts:

- ① Internal peripheral module interrupt of the slave CPU.  
The slave CPU can use interrupts generated by six internal peripheral modules, including the free running timer (FRT).
- ② H-blank-in interrupt  
The interrupt source is IRL2, and the vector number is 65 (41H).
- ③ V-blank-in interrupt  
The interrupt source is IRL6, and the vector number is 67 (43H).

Unlike the master CPU, the slave CPU does not have an SR mask restriction. To mask interrupts, use the SR mask.

(2) H-blank-in interrupts and V-blank-in interrupts

In the slave CPU, both the H-blank-in and V-blank-in interrupts are level signal interrupts that accept interrupts during the blank period. For example, when V-blank-in interrupt processing begins and ends, the interrupt is restarted as long as the V-blank period continues.

To call an interrupt function only once for an interrupt, use one of the following two methods to set up the necessary processing in the application.

- ① Waiting for blank termination in the interrupt function.  
The following are two ways of waiting for blank termination.
  - Monitor the blank flag in the VDP2 screen status register, and return control from the interrupt function when the blank period ends.
  - At the start of interrupt processing, set a timer to the length of the blank period, and then return control from the interrupt function after verifying that the set time has elapsed.

With the first method, the performance of the master CPU may drop because an external address (VDP2 address) is accessed.

- ② Using the interrupt mask when control is returned  
To prevent reception of the same interrupt, use the interrupt mask that was saved in the stack and do not return the interrupt mask during the blank period even after the interrupt function returns control.

Timer interrupts must be used to implement this method. However, when the H-blank-in and V-blank-in timer interrupts are used, the internal interrupt must be set to a higher level than the timer interrupts.



### 3. Setting Up a Development Environment for Dual CPU Operation

This section describes how to set up a development environment for dual CPU operation as well as debug methods.

#### 3.1 Dual CPU Software Development

To develop applications for dual CPU operation, connect a CPU board and either an E7000 emulator or an EVA board to both the master and slave sides.

#### 3.2 Setting Up the E7000 Emulator

When using an E7000 emulator as the slave CPU, use the emulator MODE command to set the slave CPU to slave mode.

---

[Slave set up]

```
: mode;c(RET)
E7000 MODE(MD5-0)=xx? 2E(RET)
MODE SET (C:CONFIGURATION/U:USER/M:MASTER-SLAVE)=X? C(RET)
CONFIGURATION WRITE OK?(Y/N)? Y(RET)
```

**Note:** For the master CPU, set E7000 MODE(MD5-0)=XX? 0E(RET).

---

#### 3.3 Setting Up the EVA Board

When using an EVA board as the slave CPU, set the following:

- (1) Reset clear  
Use the master CPU emulator to release the slave CPU reset.

---

[Release method]

```
: m 2010001f;b(RET)
2010001f xx ? 02(RET)
20100020 xx ? .(RET)
```

---

The above set up starts the EVA board connected to the slave CPU.

- (2) Confirm the following  
Check that the EVA board connected to the slave CPU is em ct=d.
- (3) Note  
When using an EVA board with the slave CPU, the EVA board cannot be operated until the slave CPU reset is cleared.

### 3.4 Debugging Environment

Depending on the environment used, possible configurations are as follows:

- (1) Development using a workstation.

When developing applications on a workstation (Sun SPARC series or HP9000/700 series), use an E7000 emulator for both the master CPU and the slave CPU. (The EVA board cannot be used with workstations.)

Any combination of GUIISH and LAN host system software can be used.

- (2) Development using a PC Compatible.

Applications can be developed using one or two PC-Compatibles. When two PCs are used, the master and slave CPUs can be operated simultaneously. Any combination of GUIISH or IPI software can be used.

However, when only one PC is used, the master and slave CPUs are operated separately via the switching of windows. (See "8. Debugging with One PC Compatible" in this manual for more information.)



## 4. Programming with a Slave CPU

### 4.1 Program Sharing

Because the slave and master CPUs share all external devices, either CPU can run an executable file at any location. (If the cache is used as internal RAM, any program placed in internal RAM is not shared.)

### 4.2 Stack Variables and Static/Global Variables

Separate stack areas are allocated for the slave CPU and the master CPU according to the boot ROM settings. Therefore, both CPUs can execute reentrant functions simultaneously. However, if both CPUs execute programs that overwrite static or global variables, be sure to note the execution sequence and concurrent executions in each CPU.

### 4.3 Initializing the Slave CPU

When the master CPU activates the slave CPU, it overwrites the execution entry read by the boot ROM after initialization (**SYS\_SETSINT** (0x94, **EntryFunc**)), then uses the slave SH2 ON function (**PER\_SMPC\_SSH\_ON**) of the SMPC interface library to release the slave reset.

**Note:** **EntryFunc** is a slave entry function.

### 4.4 Initialization by the Boot ROM (Vector and Stack)

(1) The boot ROM initializes the slave CPU as follows:

- Vector base register (VBR): Address 6000400H
- Stack pointer (SP): Address 6001000H
- Interrupt initialization: Enable FRT input capture interrupt (64H, level 15)

(2) The slave CPU vector table in work RAM is not modified when the slave SH2 is turned on or off.

### 4.5 Changing the Clock

When the clock is changed, SMPC switches the slave CPU to reset status. Therefore, always restart the slave CPU with either the SMPC command (**SSH\_ON** = 02H) or the slave SH2 ON function (**PER\_SMPC\_SSH\_ON**) of the SMPC interface library after changing the clock.

### 4.6 Notes on Slave CPU Usage

The following items cannot be executed from the slave CPU:

- SEGA SATURN Audio CD Control Screen call function
- Programs that assume the use of SCU Interrupts
- Processes related to peripheral acquisition of the SMPC interface library peripheral data acquisition processes.

## 5. Communication Between the Master and Slave CPUs

This section explains methods of communication between the master CPU and the slave CPU. (Refer to Chapter 11, "16-bit Free Running Timer," in the "SH7095 Hardware Manual" for more information.)

### 5.1 Communication from Master CPU to Slave CPU

A bi-directional communication method is necessary to coordinate operation between the master and slave CPUs. Communication from the master CPU to the slave CPU can be implemented using either of the following methods:

(1) FRT input capture interrupt

The slave CPU is set during boot ROM initialization with the FRT input capture interrupt. If an interrupt processing routine is registered to 64<sub>H</sub> of the slave CPU interrupt vector in the application initialization routine, processes that occur when an interrupt is triggered can be set from the master CPU. (When registered from the master CPU, the interrupt vector is 164<sub>H</sub>.) To trigger the FRT input capture interrupt from the master CPU, execute a 16-bit write to address 21000000<sub>H</sub> with any value. The slave CPU then starts the interrupt process that was previously registered.

(2) FRT input capture flag polling

When the SH2 CPU accepts the FRT input capture flag, it sets the flag in the FRT's internal register. This means that modification of the flag can be monitored during processing wait state (or synchronization wait state). When the frequency of synchronization or processing wait is large, this method becomes especially effective because the acceptance time is shorter than the interrupt processing time. When using this method, be sure to disable the FRT input capture interrupt in the application initialization routine. (Set byte value 01<sub>H</sub> to TIER address FFFFFE10<sub>H</sub>.)

### 5.2 Communication from Slave CPU to Master CPU

The SEGA SATURN system also provides methods for communication from the slave CPU to the master CPU. The same methods provided for communication from the master CPU to the slave CPU are available.

(1) FRT input capture interrupt

The master CPU is set during boot ROM initialization with the FRT input capture interrupt. If an interrupt processing routine is registered to 64<sub>H</sub> of the master CPU interrupt vector in the application initialization routine, processes that occur when an interrupt is triggered can be set from the slave CPU. To trigger the FRT input capture interrupt from the slave CPU, execute a 16-bit write to address 21800000<sub>H</sub>. The master CPU then starts the interrupt process that was previously registered.

(2) FRT input capture flag polling

Same as 5.1 (2).



## 6. Data Transfer Between the Master and Slave CPUs

The SH2 CPU cache unit does not have a snoop function. To transfer data between the master and slave CPUs, execute a cache-through read from the CPU that reads the data, or execute read after purging the cache of the target area. (For details on the cache, refer to chapter 8, "Cache," in the "SH7095 Hardware Manual.")

### 6.1 Cache-Through Read

Cache-through read is performed by reading from the address obtained after adding (logical OR) 20000000H to the target address. (For more details, refer to pages 4 to 6, "SCU Mapping," in the "SCU User's Manual.")

### 6.2 Cache Initialization (Purging)

The cache memory can be purged by two methods:

#### (1) Cache purge (full initialization)

At initialization, purge the cache memory by writing 1 to the CP bit (fourth bit) of the SH2's CCR (write byte value 10H to address FFFFFFFE92H). After executing full initialization, write values to the CCR and enable the cache.

|               |                                  |     |
|---------------|----------------------------------|-----|
| Write values: | when using 4 KB cache mode       | 01H |
|               | when using 2 KB cache + 2 KB RAM | 09H |

#### (2) Specific line purge

To purge a specific line, add 40000000H to the target address and write 0 by 16-bit access to the resulting address. This operation purges a 16-byte area that includes the target address.

## 7. Slave CPU Sample Program

This section shows a sample program that uses the slave CPU. The program demonstrates the use of the FRT input capture flag polling.

### 7.1 Initialization and Activation Functions for the Slave CPU

The following program uses functions that initialize and activate the slave CPU and is executed in the master CPU.

```
volatile Uint8 *SMPC_SF =(Uint8 *)0x20100063; /* SMPC status flag */
volatile Uint8 *SMPC_COM =(Uint8 *)0x2010001F; /* SMPC command register */
const Uint8 SMPC_SSHON = 0x02; /* SMPC slave SH on command */
const Uint8 SMPC_SSHOFF = 0x03; /* SMPC slave SH off command */
void InitSlaveCPU(void)
{
    volatile Uint16 i;
    /* Set Slave SH to reset state */
    while((*SMPC_SF & 0x01) == 0x01);
    *SMPC_SF = 1; /* - SMPC StatusFlag Set */
    *SMPC_COM = SMPC_SSHOFF; /* - Slave SH OFF SET */
    while((*SMPC_SF & 0x01) == 0x01);
    SYS_SETSINT(0x94, (void *)&SlaveCPUMain); /* Set Entry Function */
    /* Clear reset state of Slave SH */
    *SMPC_SF = 1; /* - SMPC StatusFlag Set */
    *SMPC_COM = SMPC_SSHON; /* - Slave SH ON SET */
    while((*SMPC_SF & 0x01) == 0x01);
}
}
```

### 7.2 Entry Functions from Master CPU to Slave CPU

The following program uses the FRT input capture flag polling method.

```
#define IPRA (Uint16 *)0xfffffee2
#define IPRB (Uint16 *)0xfffffe60
#define TIERS (Uint8 *)0xfffffe10
#define FTCSR (Uint8 *)0xfffffe11
void SlaveCPUMain(void)
{
    /* Wait until SlaveCommand is set */
    /* then call function for SlaveCommand */
    set_imask(0xf);
    *IPRA = 0x0000; /* IPRA interrupt disabled */
    *IPRB = 0x0000; /* IPRB interrupt disabled */
    *TIERS = 0x01; /* TIERS FRT Input Capture interrupt disabled */
    while(1){
        /* User "FRT InputCaptureFlag" polling for wait command from Master */
        if((*FTCSR & 0x80) == 0x80){
            *FTCSR = 0x00; /* FTCSR clear */
            /* Execute function requested from master CPU */
            (*(void (*)(void))(void **)((Uint32)&SlaveCommand+0x20000000))();
            SlaveCommand = (void *)0; /* RESET request code */
        }
    }
}
}
```



### 7.3 Function Execution Requests from Master CPU to Slave CPU

```
extern void SlaveFunction(void);

SlaveCommand = SlaveFunction;
*(UInt16 *)0x21000000 = 0xffff; /* FRT Input Capture for Slave */
```

## 8. Debugging with One PC Compatible

The following two methods can be used to debug dual CPU applications with one PC Compatible connected to an E7000 PC and an EVA board.

### 8.1 Set Up and Operation When Only IPI Is Used

Open two DOS prompts in MS-Windows, and run IPI in each window. The set up procedure is explained below. It is assumed that the E7000 is connected to the master side and the EVA board to the slave side.

- Set up example

|             | Tool used | Software used | PC interface board (Dip SW) |                       |
|-------------|-----------|---------------|-----------------------------|-----------------------|
|             |           |               | Address (1-5)               | Interrupt level (6-7) |
| Master side | E7000 PC  | IPI.EXE       | D000:0000 H                 | IRQ11                 |
| Slave side  | EVA board | IPI.EXE       | D400:0000 H                 | IRQ12                 |

(These settings must not interfere with the settings of other expansion boards.)

(1) Setting up the physical memory address of the PC interface board

The master CPU's PC interface board (master board) and the slave CPU's PC interface board (slave board) must have different physical address settings. In the set up example above, the address for the master board is set to D000:0000<sub>H</sub>. The address for the slave board is set to D400:0000<sub>H</sub>.

(2) Setting up **CONFIG.SYS**

If a virtual EMS memory driver is incorporated into **CONFIG.SYS**, the **CONFIG.SYS** settings must be changed. For set up instructions, refer to pages 6 and 7 in the "IBM PC Interface Software User's Manual." In the set up example above, the memory address ranges (D0000<sub>H</sub> to D3FFF<sub>H</sub> and D4000<sub>H</sub> to D7FFF<sub>H</sub>) of the master and slave boards are set outside the range of the virtual EMS driver. To set the base address of the EMS page frame to E0000<sub>H</sub>, specify the following line:

---

```
DEVICE=C:\WINDOWS\EMM386.EXE RAM /X=D000-D7FF FRAME=E000
```

---

(3) Setting up **SYSTEM.INI**

To set the memory address ranges (D0000<sub>H</sub> to D3FFF<sub>H</sub> and D4000<sub>H</sub> to D7FFF<sub>H</sub>) of the master and slave boards outside the memory range of MS-Windows, modify the **SYSTEM.INI** file. The setting for the set up example is as follows:

---

```
[386Enh]
EMMExclude=D000-D7FF
```

---

(4) Setting up environment variables

Set up the environment variables that are used by the master and slave boards. To facilitate processing, define these environment variables in the **AUTOEXEC.BAT** file. In the environment variables, specify the physical memory addresses of the master and slave boards. If the addresses are not set, both copies of IPI will use the master board concurrently.

The setting for the set up example is as follows:

---

|                               |                                                              |
|-------------------------------|--------------------------------------------------------------|
| <b>SET SYS1=C:\SYS1,1B,D0</b> | <b>Environment variable for master IPI</b>                   |
|                               | <b>(E7000 PC system program must be installed to \SYS1.)</b> |
| <b>SET SYS2=C:\SYS2,1B,D4</b> | <b>Environment variable for slave IPI</b>                    |

---

**Note:** If the E7000 PC is being used on the slave side, the E7000 PC system program must also be installed to \SYS2.

(5) Activating the master and slave boards from IPI

① Activating the master

Activate the DOS prompt of the main group in MS-Windows, then enter the following command to activate IPI and connect the E7000 PC:

---

```
C:\>IPI SYS1(RET)
```

---

At the E7000 monitor menu, enter "S" or "R" to load the E7000 PC system program. After the E7000 PC prompt ":" is displayed, activate the slave.

② Activating the slave

Again, activate the DOS prompt window from MS-Windows. Then enter the following command to activate IPI and connect the EVA board:

---

```
C:\>IPI SYS2(RET)
```

---

After the EVA board prompt ":" is displayed, activate the EVA board according to the procedure described in Section 3.3, "Setting Up the EVA Board."



## 8.2 Set Up and Operation When GUIISH Is Used

Two copies of GUIISH (GUI software for the E7000) cannot be run simultaneously. Operate GUIISH for one side and IPI for the other. The set up procedure for executing IPI and GUIISH simultaneously is explained below. It is assumed that E7000 PCs are connected to both the master side and the slave side.

- Connection example

|             | Tool used | Software used | PC interface board (Dip SW) |                       |
|-------------|-----------|---------------|-----------------------------|-----------------------|
|             |           |               | Address (1-5)               | Interrupt level (6-7) |
| Master side | E7000 PC  | GUIISH.EXE    | D000:0000 H                 | IRQ11                 |
| Slave side  | E7000 PC  | IPI.EXE       | D400:0000 H                 | IRQ12                 |

(These settings must not interfere with the settings of other expansion boards.)

- (1) Setting the physical memory address of the PC interface board

The memory address of the PC interface used by GUIISH must be higher than the memory address of the PC interface used by IPI.

In the set up example above, GUIISH is used on the master side. Therefore, the memory address for the master side is set to D000:0000<sub>H</sub>, which is higher than D400:0000<sub>H</sub>, the memory address for the slave side.

- (2) Setting up **CONFIG.SYS**

Execute the set up described in item (2) of Section 8.1.

- (3) Setting up **SYSTEM.INI**

Execute the set up described in item (3) of Section 8.1.

- (4) Setting up environment variables

Set up the environment variables to be used by GUIISH (master side) and IPI (slave side). To facilitate processing, define these environment variables in the **AUTOEXEC.BAT** file. In the environment variable used by IPI, specify the memory address of the slave board. If the address is not set, both GUIISH and IPI will use the master board simultaneously.

The settings for the set up example is as follows:

|                                   |                                        |
|-----------------------------------|----------------------------------------|
| <b>SET GUISPATH=C:\GUIISH</b>     | <b>Environment variable for GUIISH</b> |
| <b>SET E7000SYS=C:\SYS2,1B,D4</b> | <b>Environment variable for IPI</b>    |

(5) Activating the master and slave boards

① Activating the master (GUIISH)

Click the E7000 PC icon of the GUIISH group in MS-Windows. GUIISH is run and connects to the E7000 PC.

The E7000 monitor menu is displayed in the GUIISH command area. In the E7000 monitor menu, enter "S" or "R" to load the E7000 PC system program. After the E7000 PC prompt ":" is displayed, activate the slave.

② Activating the slave

Activate the DOS prompt window in MS-Windows, then enter the following command to activate IPI and establish a connection with the EVA board:

---

```
C:\>IPI(RET)
```

---

At the E7000 PC monitor menu, enter "S" or "R" to load the E7000 PC system program. After the E7000 PC prompt ":" is displayed, activate the slave.



## SEGA SATURN TECHNICAL BULLETIN #29

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** June 2, 1995  
**Re:** Setting CD-DA Volume in Applications

---

When setting the CD-DA volume in SEGASATURN applications, lower the CD-DA level by 6 dB. This change reduces the difference between the CD-DA volume and the sound CD play volume in the multi-player screen.

### **Instructions**

The following describes detailed setting instructions for:

1. Setting the hardware directly
2. Setting the CD-DA volume with the Saturn Sound Driver.
3. Setting the CD-DA volume with the sound interface library

### **Supplement**

To produce a special effect or to change the CD-DA level dramatically, use the sound CD level in the multi-player screen as a reference and match the sound levels as closely as possible.

#### **1. Setting the hardware directly**

For each slot, change the setting for the EFSDL[2:0] control register from 111B (-0 dB) to 110B (-6 dB). Details are described below.

The left and right slot numbers for CD-DA are 16 and 17.

Left channel: Write DFH to the slot 16 address 100200H + 17H.

Contents: EFSDL[2:0] = 110B (send level) and EFPAN[4:0] = 11111B (position data)

Right channel: Write CFH to the slot 17 address 100220H + 17H.

Contents: EFSDL[2:0] = 110B (send level) and EFPAN[4:0] = 01111B (position data)

When accessing the channels from the main CPU, use the following addresses:

Left channel = 25B00200H + 16H

Right channel = 25B00220H + 16H

Use word access when accessing the addresses from the main CPU.

For details, see Section 4.1, "Register Map," on page 24 of the "Hardware Manual Vol. 1/SCSP User's Manual /Rel. 2(ST-077-R2-052594)."

## **2. Setting the CD-DA volume with the Saturn Sound Driver.**

Use the CD-DA Level command (command number 80H) of the Saturn control commands, and change the data from E0H (-0 dB) to C0H (-6 dB). Specifically, write the following data to command block 1 (+00H) of the host interface work (700H):

Data = 80H, 00H, C0H, C0H

Meaning = command, dummy, left level, right level

For details, see "Sound Control Commands" on page 22 of the "Saturn Sound Driver System Interface /Ver. 3.01(ST-166-R4-012595)" in the "CD Tools and Software Library Supplementary Document."

## **3. Setting the CD-DA volume with the sound interface library**

Use the Function DC-DA Level setting. Change the setting values for both left and right from 7 (-0 dB) to 6 (-6 dB). The actual format is as follows:

SND\_SetCdDaLev(6, 6)

For details, see page 2 of the "Programmer's Guide Vol. 1/Program Library User's Guide/Sound Interface Library/Rel. 3(ST-135-R3-012395)."

## **SEGA SATURN TECHNICAL BULLETIN #30**

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** June 2, 1995  
**Re:** Temporary Files Created When Building Disc Image

---

When a disc image is built or preprocessed with the virtual CD, the following temporary files are created in addition to the generation files. Consider these files when allocating the necessary HDD capacity.

### **VCDBUILD**

The following files are created in addition to the "\*.dsk" and "\*.rti" files. These temporary files are deleted when processing of the corresponding ISO files ends.

- Temporary file when the MPEG ISO file is processed. The file size is:  
12 bytes x (number of sectors in ISO file)
- Temporary file when a channel interleaved ISO file is processed. The file size is:  
2 bytes x (number of sectors in ISO file)

### **VCDPRE**

The following files are created in addition to the "\*.pvd" and "\*.rti" files. These temporary files are deleted when processing of the corresponding ISO files ends.

- Temporary file when the MPEG ISO file is processed. The file size is:  
12 bytes x (number of sectors in ISO file)
- Temporary file when a channel interleaved ISO file is processed. The file size is:  
2 bytes x (number of sectors in ISO file)
- "\*.qsb" file for each source DOS file used for audio tracks. The file size is:  
98 bytes x (number of sectors)

## SEGA SATURN TECHNICAL BULLETIN #31

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** May 6, 1996  
**Re:** Changes in Area Symbols

---

The area symbols for Sega Saturn territory identifiers have changed as follows:

**Table of Area Symbols Symbol Changes**

|            | <b>Korea</b> | <b>Brazil</b> | <b>Asia PAL</b> | <b>Central and South America</b> |
|------------|--------------|---------------|-----------------|----------------------------------|
| <b>OLD</b> | 6H "K"       | 5H "B"        | AH "A"          | DH "L"                           |
| <b>NEW</b> | 2H "T"       | 4H "U"        | CH "E"          | CH "E"                           |

- The hex numbers denote the area symbols set in the Sega Saturn hardware.
- Although noted throughout in the manual as "area code", the terminology has now been changed to "area symbol".

### **Cautions**

- The area codes "K", "B", "A" and "L" are no longer used. Please note that the information regarding these areas contained in the explanation of the Boot System in *Sega Saturn Technical Bulletin #11* is no longer valid.
- The area symbols 5H, 6H, AH, and DH are now all SEGA RESERVED. Please replace pages 39 and 40 in the *SMPC User's Manual* with the following pages that reflect the changes.

## Result Parameters

|            |       |   |     |       |       |   |   |       |
|------------|-------|---|-----|-------|-------|---|---|-------|
|            | bit 7 |   |     | bit 4 | bit 3 |   |   | bit 0 |
| SR 201006H | 0     | 1 | PDE | RESB  | —     | — | — | —     |

- PDE 0: No peripheral data remains.  
1: Peripheral data remains.
- RESB 0: Reset button OFF  
1: Reset button ON

Can be read at any time regardless of the INTBACK command.

|                |       |      |   |   |   |   |   |       |
|----------------|-------|------|---|---|---|---|---|-------|
|                | bit 7 |      |   |   |   |   |   | bit 0 |
| OREG0-2010021H | STE   | RESD | — | — | — | — | — | —     |

- STE 0: SETTIME is not set after an SMPC cold reset.<sup>Note 1</sup>  
1: SETTIME is not set after an SMPC cold reset.<sup>Note 1</sup>
- RESD 0: Reset enable  
1: Reset disable (default)

- Note 1 An SMPC cold reset is generated under the following conditions:
1. When the SMPC reset switch is pressed inside the battery compartment at the rear of the Saturn.
  2. When the main power supply is turned on while the battery is not installed or dead.
  3. When a battery is installed with the power supply off.

|                |                                       |                                       |  |       |
|----------------|---------------------------------------|---------------------------------------|--|-------|
|                | bit 7                                 |                                       |  | bit 0 |
| OREG1 2010023H | "1000" place in Western calendar year | "100" place in Western calendar year  |  | (BCD) |
| OREG2 2010025H | "10" place in Western calendar year   | "1" place in Western calendar year    |  | (BCD) |
| OREG3 2010027H | Day of the week <sup>Note 2</sup>     | Month (hexadecimal) <sup>Note 3</sup> |  | (BCD) |

### Note 2

Day of the week: 0H: Sunday, 1H: Monday, 2H: Tuesday, 3H: Wednesday, 4H: Thursday, 5H: Friday, 6H: Saturday

### Note 3

Month: 1H: January, 2H: February, 3H: March, 4H: April, 5H: May, 6H: June, 7H: July, 8H: August, 9H: September, AH: October, BH: November, CH: December

|                |                      |                     |   |   |   |   |      |       |
|----------------|----------------------|---------------------|---|---|---|---|------|-------|
|                | bit 7                |                     |   |   |   |   |      | bit 0 |
| OREG4 2010029H | "10" place in date   | "1" place in date   |   |   |   |   |      | (BCD) |
| OREG5 201002BH | "10" place in hour   | "1" place in hour   |   |   |   |   |      | (BCD) |
| OREG6 201002DH | "10" place in minute | "1" place in minute |   |   |   |   |      | (BCD) |
| OREG7 201002FH | "10" place in second | "1" place in second |   |   |   |   |      | (BCD) |
| OREG8 2010031H | 0                    | 0                   | 0 | 0 | 0 | 0 | CTG1 | CTG0  |

CTG1: Cartridge code 1  
CTG0: Cartridge code 0

|                |                     |  |  |       |
|----------------|---------------------|--|--|-------|
|                | bit 7               |  |  | bit 0 |
| OREG9 2010033H | Area code (00H-0FH) |  |  |       |

## Area Symbols

| Area Symbol | Area                                   | Principal Countries                                                                |
|-------------|----------------------------------------|------------------------------------------------------------------------------------|
| 0H          | May not be used                        |                                                                                    |
| 1H          | Japan                                  | Japan                                                                              |
| 2H          | Asia NTSC                              | Taiwan, Philippines, Korea                                                         |
| 3H          | SEGA RESERVED                          |                                                                                    |
| 4H          | North America (Americas)               | United States, Canada, Mexico, Brazil                                              |
| 5H          | SEGA RESERVED                          |                                                                                    |
| 6H          | SEGA RESERVED                          |                                                                                    |
| 7H          | SEGA RESERVED                          |                                                                                    |
| 8H          | SEGA RESERVED                          |                                                                                    |
| 9H          | SEGA RESERVED                          |                                                                                    |
| AH          | SEGA RESERVED                          |                                                                                    |
| BH          | SEGA RESERVED                          |                                                                                    |
| CH          | European PAL, and other PAL countries. | Most of Europe as well as Australia, South Africa, Asia, Central and South America |
| DH          | SEGA RESERVED                          |                                                                                    |
| EH          | SEGA RESERVED                          |                                                                                    |
| FH          | May not be used                        |                                                                                    |

OREG10 2010035H bit 7  
bit 0  

System status 1

System Status 1 (Status of control signals output from SMPC, 0: OFF, 1: ON)

- b7 0B
- b4 1B
- b1 SYSRES signal
- b6 DOTSEL signal\*
- b3 MSHNMI signal
- b0 SNDRES signal
- b5 1B
- b2 1B

\* The DOTSEL signal indicates the current screen mode (horizontal resolution- 0: 320, 1: 352).

OREG11 2010037H bit 7  
bit 0  

System status 2

System Status 2 (Status of control signals output from SMPC, 0: OFF, 1: ON)

- b7 RESERVED
- b4 RESERVED
- b1 RESERVED
- b6 CDRES signal
- b3 RESERVED
- b0 RESERVED
- b5 RESERVED
- b2 RESERVED

## SEGA SATURN TECHNICAL BULLETIN #32

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** November 8, 1995  
**Re:** Differences in Sega Saturn Hardware and Peripheral Color/Form Factor

---

### **Differences in Sega Saturn Hardware and Peripheral Color/Form Factor**

The colors and shapes of the Sega Saturn and Sega Saturn peripherals differ for the US and the rest of the world. Please pay attention to the displayed images of the Saturn hardware and peripherals within the application if it is sold in other markets. Note, however, that the peripheral IDs and access methods are the same for all versions of the hardware.

#### **1. Changes in Colors and/or Form Factor**

|          | <b>Japan (Gray)</b>     | <b>US (Black)</b> | <b>Europe (Black)</b> |
|----------|-------------------------|-------------------|-----------------------|
| <b>1</b> | Sega Saturn Control Pad | Control Pad       | Control Pad           |
| <b>2</b> | Mission Stick           | Mission Stick     | Mission Stick         |

#### **2. Color Change Only**

|          | <b>Japan (Gray)</b> | <b>US (Black)</b> | <b>Europe (Black)</b> |
|----------|---------------------|-------------------|-----------------------|
| <b>3</b> | Sega Saturn         | Sega Saturn       | Sega Saturn           |
| <b>4</b> | Racing Controller   | Arcade Racer      | Arcade Racer          |
| <b>5</b> | Shuttle Mouse       | Sega Saturn Mouse | Mouse                 |
| <b>6</b> | Multi Terminal      | 6Player           | 6Player               |
| <b>7</b> | VirtuaStick         | VirtuaStick       | VirtuaStick           |

#### **3. Changes Between Versions for Japan and the Overseas**

- For **1**, the color is black and the shape differs greatly. The European and the US versions are the same.
- For **2**, the grip and buttons B and C are larger. The European and US versions are the same.
- For **4**, the START and butterfly-shaped shifter are gray in color. The European and US versions are the same.
- For **3**, **5**, **6**, and **7**, everything is black. The European and US versions are the same.

#### **4. Addenda**

For areas other than the US, Europe, and Japan, please contact Sega Technical Support.

## **SEGA SATURN TECHNICAL BULLETIN #33**

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** November 8, 1995  
**Re:** Additional VDP2 Restrictions

---

### **Additional VDP2 Restrictions**

This document adds an additional restriction item for the VDP 2. This information is an addition to the other VDP2 specification restrictions found in *Sega Saturn Technical Bulletin #12*. (Note that *Bulletin #12* has a different document title.)

#### **NEW RESTRICTION**

#### **4. Restriction on Horizontal Flip Function Bits**

The horizontal flip function bits of the cell-format normal scroll screen (NBG0 and NBG1) are only valid when the number of character colors is 16 or 256. Otherwise, do not set NBG0 or NBG1 to "1".

#### **References**

*VDP2 User Manual (Rel. 2)*, page 75, "Horizontal Flip Function Bits".

A list of the revised VDP2 limitations, including 4. above, is shown below:

### **VDP2 Specification Restrictions**

#### **1. Burst Reads from VRAM are Prohibited**

SCU DRAM reads may not be performed to VRAM.

#### **2. Restriction on Switching Horizontal Resolution**

Always use the boot ROM's internal service routines when switching the horizontal screen resolution.

#### **3. Valid V-Blank Flag Period Restriction**

The VBLANK bit (bit 3) of the screen status register (TVSTAT: 180004H) is valid only when the DISP bit of the TV screen mode register (TVMD: 180000H) is 1. When the DISP bit is 0, the VBLANK bit is always 1.

#### **4. Restriction on Horizontal Flip Function Bits (NEW)**

The horizontal flip function bits of the cell-format normal scroll screen (NBG0 and NBG1) are only valid when the number of character colors is 16 or 256. Otherwise, do not set NBG0 or NBG1 to "1".

## SEGA SATURN TECHNICAL BULLETIN #34

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** February 21, 1996  
**Re:** Sega Saturn Mission Stick Application Manual

---

### Sega Saturn Mission Stick Overview

- **Three-Axis Mode**

The Sega Saturn Mission Stick is composed of a base unit and a detachable stick unit. The base unit has two stick connector ports (Main Control and Sub Control) as well as A, B, C, X, Y, Z, L, R and START buttons. The connector on the base unit is plugged into a control port on the Sega Saturn. The stick unit is composed of a three-axis (AX, AY, AZ) joystick equipped with three trigger buttons A, B and C. It is connected to the Main Control port of the base unit. Digital data bits (Right, Left, Down, Up) are output for AX and AY.

**Note:** When there is only one stick available, it must always be connected to the Main Control port of the base unit.

- **Six-Axis Mode**

Connect the optional stick (sold separately) to the Sub Control port to enable the six-axis mode. Digital data bits (Right, Left, Down, Up) are output only from the stick connected to the Main Control port. Moreover, the A, B and C trigger buttons of the stick connected to the Main Control port are output to ATRG, BTRG and CTRG, while the A, B and C triggers of the stick connected to the Sub Control port are output to XTRG, YTRG and ZTRG.

### **Reference**

See pages 77, 83 and 97 of *Hardware Manual Vol. 1, Rel. 2, SMPC User Manual* for more information.

The following pages show the data formats for the Mission Stick's three-axis mode and six-axis modes.

# Sega Saturn Mission Stick Data Formats

## 1. Three-Axis Mode

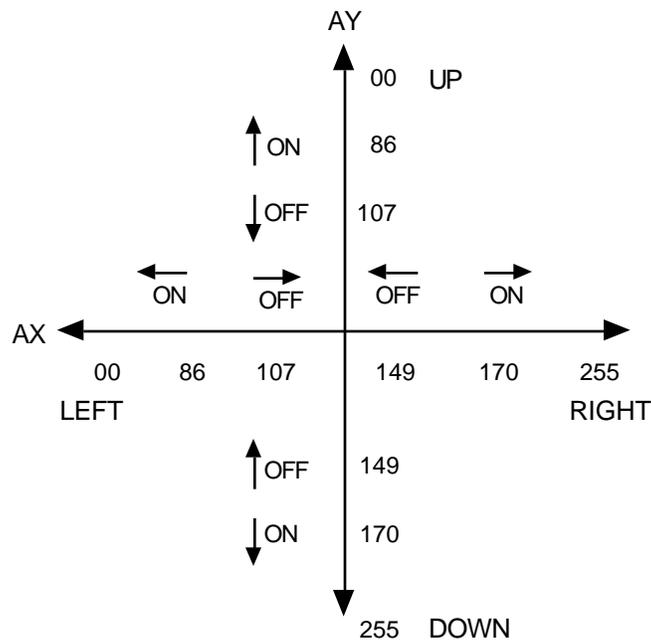
Saturn Peripheral ID  
 Saturn Peripheral Type: 1H (Analog device)  
 Data Size: 5H (5 bytes)

**Table 1.1 Three-Axis Mode Data Format**

|                             | bit7  | bit6 | bit5 | bit4 | bit3  | bit2 | bit1 | bit0 |
|-----------------------------|-------|------|------|------|-------|------|------|------|
| <b>SATURN Peripheral ID</b> | 0     | 0    | 0    | 1    | 0     | 1    | 0    | 1    |
| <b>1st Data</b>             | Right | Left | Down | Up   | Start | ATRG | CTRG | BTRG |
| <b>2nd Data</b>             | RTRG  | XTRG | YTRG | ZTRG | LTRG  | 1    | 1    | 1    |
| <b>3rd Data</b>             | AX7   | AX6  | AX5  | AX4  | AX3   | AX2  | AX1  | AX0  |
| <b>4th Data</b>             | AY7   | AY6  | AY5  | AY4  | AY3   | AY2  | AY1  | AY0  |
| <b>5th Data</b>             | AZ7   | AZ6  | AZ5  | AZ4  | AZ3   | AZ2  | AZ1  | AZ0  |

- Start, ATRG, CTRG, BTRG, RTRG, XTRG, YTRG, ZTRG and LTRG become 0 when the button is pressed.
- For AX7~AX0, AY7~AY0 and AZ7~AZ0, the absolute values of the unsigned A/D converter output is issued.
- For AX7~AX0 and AY7~AY0, the upper left is (0,0) and the lower right is (255,255).
- For AZ7~AZ0, down is 0 and up is 255.

The digital bits (Right, Left, Up, Down) that are used to enable the user to navigate around menu screens such as the Sega Saturn's CD control screen change according to the AX and AY threshold values shown below.



- Right becomes 0 (ON) when AX is 170 or higher and 1 (OFF) when AX is 147 or

lower.

- Left becomes 0 (ON) when AX is 86 or lower and 1 (OFF) when AX is 107 or higher.
- Down becomes 0 (ON) when AY is 170 or higher and 1 (OFF) when AY is 147 or lower.
- Up becomes 0 (ON) when AY is 86 or lower and 1 (OFF) when AY is 107 or higher.

## 2. Six-Axis Mode

Saturn Peripheral ID

Saturn Peripheral Type: 1H (Analog device)

Data Size: 9H (9 bytes)

**Table 2.1 Six-Axis Mode Data Format**

|                             | bit7  | bit6 | bit5 | bit4 | bit3           | bit2           | bit1 | bit0 |
|-----------------------------|-------|------|------|------|----------------|----------------|------|------|
| <b>SATURN Peripheral ID</b> | 0     | 0    | 0    | 1    | 1              | 0              | 0    | 1    |
| <b>1st Data</b>             | Right | Left | Down | Up   | Start          | ATRG           | CTRG | BTRG |
| <b>2nd Data</b>             | RTRG  | XTRG | YTRG | ZTRG | LTRG           | Expansion Data |      |      |
| <b>3rd Data</b>             | AX7   | AX6  | AX5  | AX4  | AX3            | AX2            | AX1  | AX0  |
| <b>4th Data</b>             | AY7   | AY6  | AY5  | AY4  | AY3            | AY2            | AY1  | AY0  |
| <b>5th Data</b>             | AZ7   | AZ6  | AZ5  | AZ4  | AZ3            | AZ2            | AZ1  | AZ0  |
| <b>6th Data</b>             | *     | *    | *    | *    | Expansion Data |                |      |      |
| <b>7th Data</b>             | BX7   | BX6  | BX5  | BX4  | BX3            | BX2            | BX1  | BX0  |
| <b>8th Data</b>             | BY7   | BY6  | BY5  | BY4  | BY3            | BY2            | BY1  | BY0  |
| <b>9th Data</b>             | BZ7   | BZ6  | BZ5  | BZ4  | BZ3            | BZ2            | BZ1  | BZ0  |

- The six-axis mode is based on the three-axis mode protocol.
- The 7th~9th data are used as the analog data of the second stick connected to the Sub Control port of the base unit.
- Data is undefined for the bits shown with asterisks in the table above. As a result, the digital bits (Right, Left, Up, Down) of the second stick cannot be used.

**Note:** Digital bits are valid only for the stick connected to the Main Control port of the base unit. They have the same threshold values as in the three-axis mode.

- Start, ATRG, BTRG, CTRG, RTRG, XTRG, YTRG, ZTRG and LTRG become 0 when the button is pressed.
- The Main Control stick data for triggers A, B and C are output as ATRG, BTRG and CTRG, respectively.
- The Sub Control stick data for triggers A, B and C are output as XTRG, YTRG and ZTRG, respectively.
- AX7~AX0, AY7~AY0, AZ7~AZ0, BX7~BX0, BY7~BY0 and BZ7~BZ0 are absolute values of the unsigned A/D converter output data.
- For AX7~AX0, AY7~AY0, BX7~BX0 and BY7~BY0, the upper left is (0,0) and lower right, (255,255).

- For AZ7~AZ0 and BZ7~BZ0, down is 0 and up, 255.

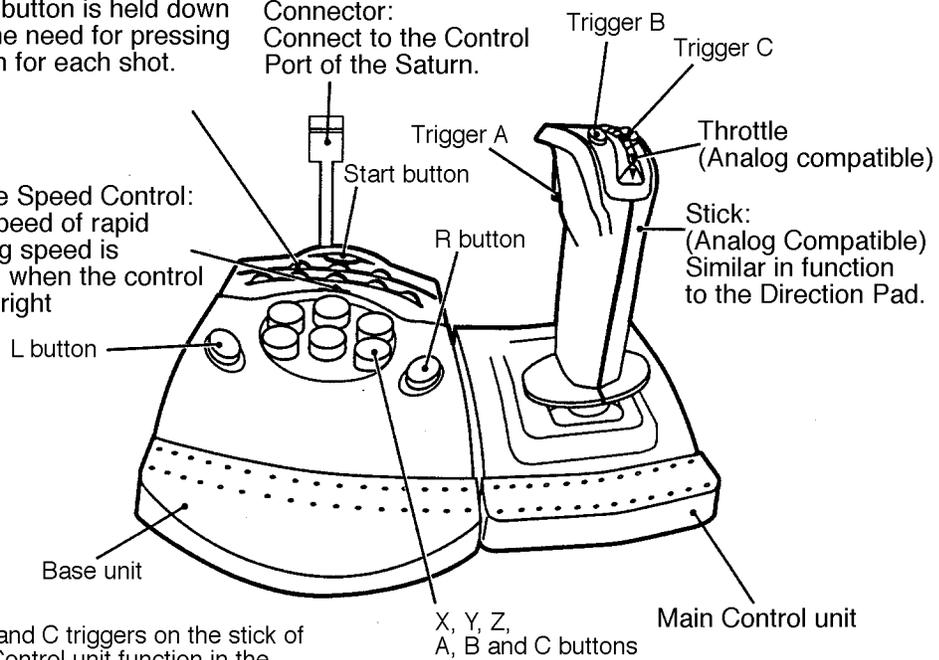
**Rapid Fire Switch:**

When ON, firing is automatic while the button is held down without the need for pressing the button for each shot.

**Rapid Fire Speed Control:**

Adjusts speed of rapid fire. Firing speed is increased when the control is moved right

**Connector:**  
Connect to the Control Port of the Saturn.



**Note:**

The A, B, and C triggers on the stick of the Main Control unit function in the same manner as the A, B, and C buttons on the Base unit, respectively.

**Figure 1 Explanation of the Sega Saturn Mission Stick Controls**

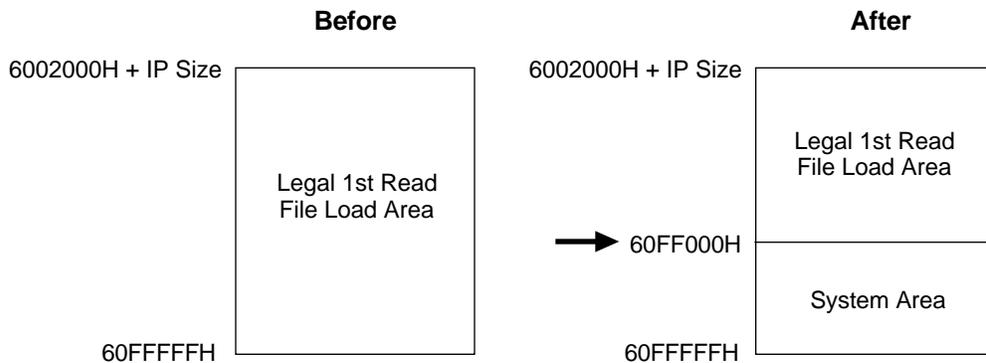
## SEGA SATURN TECHNICAL BULLETIN #35

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** November 8, 1995  
**Re:** Change in the 1st Read File Load Area Size

---

### Change in the 1st Read File Load Area Size

The legal memory area for loading the 1st read file has been changed as follows. This change is limited to the 1st read file- there are no other effects.



The 1st read file cannot be loaded into the memory area between 60FF000H to 60FFFFFFH since it is used by the system. After 1st read file is loaded, the area is released to the application.

- **System Work Areas and Areas Released to the Application**
- Addresses 6000000H to 6001FFFH are used by the system, so they cannot be used by the application. However, 6000E00H to 6001FFFH may be used for stacks.
- After the IP process finishes and the application is running, up to 6001000H can be used by the application if a stack is set up elsewhere. Similarly, up to 6000E00H can be used by the application if a stack is set up elsewhere.

### Example

|          |                               |
|----------|-------------------------------|
| 6000000H | Vectors,<br>Resident Routines |
| 6000E00H | Slave SH Stack                |
| 6001000H | Master SH Stack               |
| 6002000H |                               |

## SEGA SATURN TECHNICAL BULLETIN #36

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** May 6, 1996  
**Re:** Saturn Hardware Chip Initialization

---

### **Important:**

Always observe the guidelines found in the Saturn software/hardware development manuals regarding hardware restrictions and undefined operations. The effects of these restrictions and operations will differ between different revisions of the Saturn hardware.

Also, make sure to initialize each hardware chip device with your application. Since the default values set by the boot ROM in the VDP1, VDP2, and SCSP during the boot process remain in those devices after startup, never allow the application to use those values as default settings.

**Example 1:** Caution on bits `ECD` and `SPD` of the polygon draw command:

To use the polygon draw command, set the `ECD` and `SPD` bits (bits 7, 6) of the draw mode word (`CMDPMOD`) to the fixed value "1". The operation is not guaranteed when "0" is specified.

Refer to: **Section 7.7 Polygon Draw Command on page 126 of the Hardware Manual Vol. 2 /VDP1 User's Manual Rel. 2.**

**Example 2:** Caution on the `clip` bit in the draw mode word of each draw command:

When using user specified clipping, be sure to always issue the user clipping coordinate set command when the `clip` bit (bit 10) of the draw mode word (`CMDPMOD`) is set to "1". When coordinates are not specified, the value is not guaranteed.

Refer to: **Section 7.2 User Clipping Coordinate Set Command on page 112 of the Hardware Manual Vol. 2 /VDP1 User's Manual Rel. 2.**

## SEGA SATURN TECHNICAL BULLETIN #37

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** May 6, 1996  
**Re:** VDP2 Specification Changes

---

**1. Burst reads from VRAM are prohibited.**

SCU DMA reads may not be performed on VRAM.

**2. Restriction on switching horizontal screen resolution.**

The service routine provided by the boot ROM must always be used when switching horizontal screen resolution.

**3. Restriction on valid period for the V-Blank flag.**

The VBLANK bit of the screen status register (TVSTAT:180004H) is only valid when the DISP bit of the TV screen mode register (TVMD:180000H) is 1. When the DISP bit is 0, the VBLANK bit is always 1.

*Refer to:* **Hardware Manual Vol. 2: VDP2 User's Manual (Rel.2) :**  
Page 16, *TV Screen Mode Register*  
Page 21, *Screen Status Register*

**4. Restriction on the left-right flip function bit.**

The left-right flip function bit of the cell-format normal scroll screen (NBG0, 1) is only valid when the number of character colors is 16 or 256. Do not set this bit to 1 when the number of character colors is other than 16 or 256.

*Refer to:* **Hardware Manual Vol. 2: VDP2 User's Manual (Rel.2)**  
Page 75, *Flip Function Bit*

**5. Restriction on the vertical end coordinate window position.**

When using normal windows in interlaced high resolution video mode, do not set the vertical end coordinate window position value registers (WPEY0:1800C6H, WPEY:1800CEH) between 1FCH to 1FFH. If these values are input, the window becomes invalid.

*Refer to:* **Hardware Manual Vol. 2: VDP2 User's Manual (Rel.2)**  
Page 181, *Window Position Register*

## 6. Correction on the V-Counter register bit description.

The V-Counter register (VCNT:18000AH) bits in normal and non-interlaced high resolution modes is corrected below in Table 2.4.

Refer to: **Hardware Manual Vol. 2: VDP2 User's Manual (Rel.2)**  
*Page 24, V-Counter Register*

### Incorrect

**Table 2.4 V-Counter register bits**

| TV Screen Mode                           | VCT9 | VCT8 | VCT7 | VCT6 | VCT5 | VCT4 | VCT3 | VCT2 | VCT1 | VCT0    |
|------------------------------------------|------|------|------|------|------|------|------|------|------|---------|
| Normal, High Resolution (Non-Interlaced) | V8   | V7   | V6   | V5   | V4   | V3   | V2   | V1   | V0   | Invalid |

### Correct

**Table 2.4 V-Counter register bits**

| TV Screen Mode                           | VCT9 | VCT8 | VCT7 | VCT6 | VCT5 | VCT4 | VCT3 | VCT2 | VCT1 | VCT0 |
|------------------------------------------|------|------|------|------|------|------|------|------|------|------|
| Normal, High Resolution (Non-Interlaced) | V9   | V8   | V7   | V6   | V5   | V4   | V3   | V2   | V1   | V0   |

## 7. Correction on the VRAM cycle pattern register settings.

To display a normal scroll screen with a character size of 2 horizontal cells by 2 vertical cells in high resolution mode, the VRAM cycle pattern register is set with the following character pattern data read access restrictions.

### Incorrect

**Table 3.4 Character pattern data read access restrictions**

| TV Screen Mode  | Pattern Name Table Data Access Timing |       |            |            |    |    |    |    |
|-----------------|---------------------------------------|-------|------------|------------|----|----|----|----|
|                 | T0                                    | T1    | T2         | T3         | T4 | T5 | T6 | T7 |
| High Resolution | T0~T2                                 | T1~T3 | T0, T2, T3 | T0, T1, T3 | —  | —  | —  | —  |

### Correct

**Table 3.4 Character pattern data read access restrictions**

| TV Screen Mode  | Pattern Name Table Data Access Timing |       |        |    |    |    |    |    |
|-----------------|---------------------------------------|-------|--------|----|----|----|----|----|
|                 | T0                                    | T1    | T2     | T3 | T4 | T5 | T6 | T7 |
| High Resolution | T0~T2                                 | T1~T3 | T2, T3 | T3 | —  | —  | —  | —  |

Refer to: **Hardware Manual Vol. 2: VDP2 User's Manual (Rel.2)**  
*Page 32, 34, Image Data Access.*

## SEGA SATURN TECHNICAL BULLETIN #38

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** May 6, 1996  
**Re:** Arcade Racer Application Manual

---

### Arcade Racer Overview

The Arcade Racer is a single-axis analog peripheral used mainly for driving games.

The handle of the Arcade Racer is equipped with X, Y, Z, START, A, B, and C buttons and a butterfly shifter unit. Digital data bits (right, left, down, up) are output by the following actions:

- **Left** and **right** by turning the handle left and right, respectively.
- **Up** by pressing the left side of the butterfly shifter.
- **Down** by pressing the right side of the butterfly shifter.

**Important Note:** The Arcade Racer is not equipped with **L** and **R** buttons.

*Refer to:* Hardware Manual Vol. 1, SMPC User's Manual (Rel.2)  
page 77, 83, 97: SATURN Analog Devices.

### Arcade Racer Output Data Format

#### 1. Data Format

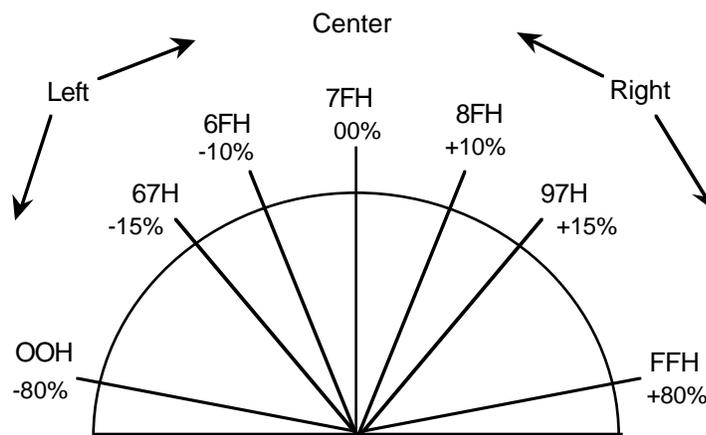
SATURN Peripheral ID  
SATURN Peripheral Type: 1H (analog device)  
Data Size: 3H (3 bytes)

**Table 1 Data Format**

|                             | bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 | bit 0 |
|-----------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>Saturn Peripheral ID</b> | 0     | 0     | 0     | 1     | 0     | 0     | 1     | 1     |
| <b>1st Data</b>             | Right | Left  | Down  | Up    | Start | ATRG  | CTRG  | BTRG  |
| <b>2nd Data</b>             | 1     | XTRG  | YTRG  | ZTRG  | 1     | 1     | 1     | 1     |
| <b>3rd Data</b>             | AX7   | AX6   | AX5   | AX4   | AX3   | AX2   | AX1   | AX0   |

- Start, ATRG, CTRG, BTRG, XTRG, YTRG and ZTRG all go to "0" (ON state) when pressed.
- "0" (ON state) is output by pulling the butterfly shifter mechanism towards the player.
- AX7~AX0 output the absolute value of the unsigned A/D converter output.
- For AX7~AX0, left is 0, right is 255, and center is 127. See Figure 1 below.

The digital data bit (right, left) changes according to the AX threshold value to enable the user to navigate menu screens such as the Sega Saturn CD control screen. See Figure 1 below.



**Figure 1 Digital Data Bit Threshold Values**

- Right is "0"(ON) when AX is greater than 97H (+15°), and is "1" (OFF) when less than 8FH (+10°).
- Left is "0" (ON) when AX is less than 67H(-15°), and is "1" (OFF) when greater than 6FH (-10°).
- Down is "0" (ON) when the right side of the butterfly shifter is pulled toward the player, and "1" (OFF) when released.
- Up is "0" (ON) when the left side of the butterfly shifter is pulled toward the player, and "1" (OFF) when released.

## SEGA SATURN TECHNICAL BULLETIN #39

**To:** Sega and Third Party Developers

**From:** Developer Technical Support

**Date:** May 6, 1996

**Re:** Supplemental Information on the SCU-DMA Transfer Byte Count

---

When the SCU-DMA transfer byte count is set to 0, the transfer count is set to the maximum value for each setting.

**Figure 1 Transfer Byte Count**

| DMA Transfer Level | Direct Mode            |                     | Indirect Mode                     |                     |
|--------------------|------------------------|---------------------|-----------------------------------|---------------------|
|                    | Register Setting Value | Transfer Byte Count | Transfer Byte Count Setting Value | Transfer Byte Count |
| <b>Level 0</b>     | 00000H                 | 100000H bytes       | 00000H                            | 100000H bytes       |
|                    | 00001H                 | 000001H bytes       | 00001H                            | 000001H bytes       |
|                    | 00002H                 | 000002H bytes       | 00002H                            | 000002H bytes       |
|                    | ⋮                      | ⋮                   | ⋮                                 | ⋮                   |
|                    | FFFFFFH                | 0FFFFFFH bytes      | FFFFFFH                           | 0FFFFFFH bytes      |
| <b>Level 1</b>     | 000H                   | 1000H bytes         | 00000H                            | 100000H bytes       |
|                    | 001H                   | 0001H bytes         | 00001H                            | 000001H bytes       |
|                    | 002H                   | 0002H bytes         | 00002H                            | 000002H bytes       |
|                    | ⋮                      | ⋮                   | ⋮                                 | ⋮                   |
|                    | FFFH                   | 0FFFH bytes         | FFFFFFH                           | 0FFFFFFH bytes      |
| <b>Level 2</b>     | 000H                   | 1000H bytes         | 00000H                            | 100000H bytes       |
|                    | 001H                   | 0001H bytes         | 00001H                            | 000001H bytes       |
|                    | 002H                   | 0002H bytes         | 00002H                            | 000002H bytes       |
|                    | ⋮                      | ⋮                   | ⋮                                 | ⋮                   |
|                    | FFFH                   | 0FFFH bytes         | FFFFFFH                           | 0FFFFFFH bytes      |
| <b>DSP</b>         | 00H                    | 100H words          |                                   |                     |
|                    | 01H                    | 001H words          |                                   |                     |
|                    | 02H                    | 002H words          |                                   |                     |
|                    | ⋮                      | ⋮                   |                                   |                     |
|                    | FFH                    | 0FFH words          |                                   |                     |

**Note:** DMA transfer for the DSP is done in word units (4 bytes).

A maximum of 100000H bytes can be DMA transferred by Levels 0, 1, and 2 of the Indirect mode.

When DSP-DMA is set to 0, the transfer count is set to the maximum value. However, if a value larger than 40H word is specified for an internal RAM DMA, data is overwritten continuously at the same address. This is because each RAM page holds only 40H words. (Access does not move to another address during a DSP DMA. In comparison, access will move to another RAM page during CPU read/writes.)

### Example:

When DMA settings are:

Transfer source address= 6001000H  
Transfer destination address= 00H of RAM0  
Transfer byte count= 00H

|          |   |                                                     |
|----------|---|-----------------------------------------------------|
| 6001000H | → | 00H of RAM0 (1st word of data)                      |
| 6001004H | → | 01H of RAM0 (2nd word)                              |
| 6001008H | → | 02H of RAM0 (3rd word)                              |
|          | : | :                                                   |
| 60010FCH | → | 3FH of RAM0 (64th word)                             |
| 6001100H | → | 00H of RAM0 (65th word) the 1st word is overwritten |
| 6001104H | → | 01H of RAM0 (66th word)                             |
|          | : | :                                                   |
| 60013FAH | → | 3EH of RAM0 (255th word)                            |
| 60013FCH | → | 3FH of RAM0 (256th word) maximum transfer amount    |

### References:

- **CPU-DMA Direct Mode:**  
Page 42, *Transfer Byte Number, SCU User's Manual, Third Version* (ST-97-R5-072694).
- **CPU-DMA Indirect Mode:**  
Page 10, *Specification No. 25 SCU Specification Changes, in Sega Saturn Technical Bulletin #10* (ST-TECH-10).
- **DSP-DMA.**  
Page 87, *DMA Command Execution, SCU User's Manual, Third Version* (ST-97-R5-072694).

## SEGA SATURN TECHNICAL BULLETIN #40

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** May 6, 1996  
**Re:** Additional Sega Saturn Compatible Peripheral ID Character Codes

---

New peripheral ID character codes for Saturn compatible peripherals have been added. These character codes are located in the System Area of the CD-ROM. The new peripheral ID character codes are listed in **boldface** below.

### **Peripheral ID Character Code List for Compatible Peripherals**

| <b>Compatible Peripherals</b>     | <b>Character Code</b> |
|-----------------------------------|-----------------------|
| Control Pad                       | J                     |
| Analog Controller (Mission Stick) | A                     |
| Mouse                             | M                     |
| Keyboard                          | K                     |
| Steering Wheel (Arcade Racer)     | S                     |
| Multitap (6Player)                | T                     |
| <b>Gun (Virtua Gun/Stunner)</b>   | <b>G</b>              |
| <b>Saturn-to-Saturn cable</b>     | <b>C</b>              |
| <b>MPEG</b>                       | <b>P</b>              |
| <b>FDD</b>                        | <b>F</b>              |
| <b>Modem</b>                      | <b>D</b>              |
| <b>XBAND</b>                      | <b>X</b>              |

- **Reference on System ID, Compatible Peripherals:**  
See Page 28, section 4. *Boot System: Compatible Peripherals* in *Disc Format Standards Specification Sheet (ST-040-R4-051795)* in *Programmer's Guide Vol. 1*.

## SEGA SATURN TECHNICAL BULLETIN #41

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** March 26, 1996  
**Re:** Saturn Stunner/Virtua Gun User's Manual Version 1.00

---

### 1. Overview

The Stunner is a shooting game-specific gun peripheral that is connected to the control port of the SEGA SATURN. The Stunner has a Trigger and a Start Button.

#### • **Basic Specifications**

- Recommended screen size: 14 inches or larger.
- Shooting distance: Approximately 5 meters (16.4 feet) from the screen.
- Shooting angle: 30° vertically and horizontally from the center of the screen.

**Note:** The above applies for a 14 inch monitor in a normally lit room. The specifications may vary for different screen sizes and brightness of the room.

### 2. Incompatible Video Monitors

The Stunner detects the scan lines of a picture tube and compares it to its display timing. It then determines the coordinate position and returns that value to the application.

Some video monitors cannot support or cannot fully support the Stunner due to this operating system.

#### • **Incompatible Monitor Types or Scan Methods**

- Liquid crystal displays and projectors do not use conventional picture tubes and are therefore incompatible.
- High Definition TeleVisions (HDTV) are incompatible since the screen display method is different than a conventional television.
- Double scanning televisions (EDTV2, Clear Vision) cannot be used because the scan line speed is incompatible.

- **Incompatible Display Modes**

- Special display modes such as dual screen and picture-in-picture cannot be used. These modes save the video image data to a frame buffer before it is displayed and therefore causes the timing to be off.

**Solution:** Set the television to normal display mode.

- Some wide-aspect ratio televisions cannot support the Stunner when in 4:3 display mode.

**Solution:** Set to wide display mode.

- **Other**

- When the television screen is dirty or the screen brightness is too low.

**Solution:** Clean the screen or adjust the brightness.

- The scan line is difficult to detect when the screen size is too small.

**Solution:** Use a 14 inch or larger screen or add a collision detection adjustment mode. For further details, see *Collision Detection Adjustment Mode* discussed below.

### 3. Peripheral Specifications

- **SMPC Mode**

It is necessary to switch the SMPC to SH2 Direct mode since the Stunner uses the HV counter to detect the position on the screen.

- **Initialization (SMPC Control Mode to SH2 Direct Mode)**

1) Set the external latch enable bit (EXTLEN: bit 9) of the VDP2 external signal enable register (EXTEN: 180002H offset) to 1.

2) Set SMPC to SH2 direct mode.

Set the IOSEL bit of the parallel I/O register (2010007DH) to 1.

Control Port 1: IOSEL1 (bit 0)

Control Port 2: IOSEL2 (bit 1)

**Note:** Both ports are byte accessed from the SH2.

3) Set the I/O port setting to "Input"

Set all of the parallel I/O register DDR bits (bit 0 ~ bit 6) to 0.

Control Port 1: Set all DDR1 (20100079H) bits (bit 6 ~ bit 0) to 0.

Control Port 2: Set all DDR2 (2010007BH) bits (bit 6 ~ bit 0) to 0.

**Note:** Both ports are byte accessed from the SH2.

Set all input selected PDR bits to 1.

Control Port 1: Set all PDR1 (20100075H) bits (bit 6 ~ bit 0) to 1.

Control Port 2: Set all PDR2 (20100077H) bits (bit 6 ~ bit 0) to 1.

**Note:** Both ports are byte accessed from the SH2.

- 4) Use bit 6 of the port as the external latch input for VDP2.  
Set EXLE bit of address 2010007FH to 1. (Normally 0)  
Control Port 1: Set EXLE1 bit (2010007FH: bit 0) to 1.  
Control Port 2: Set EXLE2 bit (2010007FH: bit 1) to 1.

**Note:** Both ports are byte accessed from the SH2.

**Refer to:** Page 7, *Parallel I/O Registers* in the *SMPC User's Manual* (ST-169-R1-072694)  
Page 19, *External Signal Enable Register* in the *VDP2 User's Manual* (ST-58-R2-060194)

- **Reading Coordinates**

- 1) The external latch flag (EXLTFG: bit 9) of the VDP2 screen status register (TVSTAT: 180004H offset) is read. If the bit is 1, the HV counter is read. The targeted position and the HV counter position will be off in reality. Therefore, adjust for the difference with the application. Refer to *Calibration Mode* described later.
- 2) The screen status register (TVSTAT) is cleared to 0 when the read is done. Therefore, it can be read only once during a V-blank.

**Note:** When the HV counter is read, the screen cannot be read if it is too dark (EXLTFG will not go to 1). Therefore, the screen must be white (bright) for 1/60th of a second after the Stunner trigger is pulled and the value read at that time is used to determine the position.

**Example 1:**

Color sample RGB format / sprite pixel color data white =FFFFH (32768 colors)  
/ scroll pixel color data =7FFFH (32768 colors)  
/ =00FFFFFFH(16,770,000 colors)

**Refer to:** Page 218, *10.2 RGB Format Pixels* in the *VDP2 User's Manual* (ST-58-R2-060194)

**Refer to:** Page 23, *H-Counter Register* in the *VDP2 User's Manual* (ST-58-R2-060194)

- **Reading Buttons (SH2 Direct Mode)**

There are two buttons: The Trigger and the Start Button. The parallel I/O register PDR is read to determine their states.

Control Port 1: PDR1 (20100075H)

Control Port 2: PDR2 (20100077H)

**Note:** Both ports are byte accessed from the SH2.

| PDR n=1,2     | bit 7 | bit 6          | bit 5        | bit 4   | bit 3 | bit 2 | bit 1 | bit 0 |
|---------------|-------|----------------|--------------|---------|-------|-------|-------|-------|
| n=port number | *     | External Latch | Start Button | Trigger | *     | *     | *     | *     |

\* **Undefined: DO NOT USE.**

- External latch, bit 6: Used as the VDP2 external latch input when the EXLE bit is 1.
- Start Button, bit 5: The signal differs from that of the control pad start button.
- Trigger, bit 4: Stunner trigger switch

- **Reading the Stunner ID in SMPC Control Mode**

The Stunner returns an "UNKNOWN" Genesis peripheral device ID [A0H] instead of a SATURN peripheral ID to the port status 6Player ID as an "UNKNOWN" device. This is because the Stunner uses the SMPC direct mode. The upper 4 bits of the port status byte are the 6Player ID [AH], the lower 4 bits are the number of connectors 0. Therefore, the port status is [A0H].

**Refer to:** Pages 61, 62, *INTBACK Command Result Parameter During Peripheral Data Acquisition* in the *SMPC User's Manual* (ST-169-R1-072694)

- **Reading the Stunner ID in SH2 Direct Mode**

Once the SMPC is set to the direct mode, the peripheral ID cannot be accessed by the INTBACK command. Follow the directions below to read the ID while in direct mode.

**Refer to:** Page 86, 3.4 *Support Peripheral Data Format in SH2 Direct Mode* in the *SMPC User's Manual* (ST-169-R1-072694)

- 1) Execute the ID check during a V-blank.
- 2) Set the port I/O settings to [bit 6=output], [bit 5~0=input].  
Control Port 1 I/O setting register (20100079H)=[40H] (set bit 6 for output)  
Control Port 2 I/O setting register (2010007BH)=[40H] (set bit 6 for output)
- 3) Calculating the peripheral ID using the SH2 direct mode  
Determine the ID from the 4 bit (ID3~ID0) port data using the following equation.  
Port 1 port address (20100075H)  
Port 2 port address (20100077H)  
ID3=(BIT3 or BIT2) and (BIT6=1); equation for ID3 through ID0  
ID2=(BIT1 or BIT0) and (BIT6=1)  
ID1=(BIT3 or BIT2) and (BIT6=0)  
ID0=(BIT1 or BIT0) and (BIT6=1)  
Check that the Stunner is connected when the peripheral ID=AH.
- 4) Change the port I/O settings back to original settings.  
Set the input settings for all parallel I/O register bits (bit 6~bit 0) to 0.  
Reset the register so that the Stunner may be used.

#### **4. Notes for Application Development**

- **Peripheral Character Codes for Compatible Peripherals**

The character code for the Stunner is "G".  
Enter "G" as a compatible peripheral character code in the System ID (start address: 50H).

**Refer to:** Page 24, *Boot System* in the *Disc Format Standards Specification Sheet Ver. 1.0* (ST-040-R4-051795)

- **Calibration Mode**

A calibration mode allows the user to make adjustments for the differences between the location targeted on-screen and the actual screen coordinates. These errors may be caused by the type of television used, the distance between the screen and the Stunner, or ambient lighting effects.

- **Sample Implementation of a Calibration Mode (Recommended):**

- 1) Display a target (cross-shaped) in the middle of the television screen.
- 2) Prompt the player to aim the gun at the target from the play position and pull the trigger.
- 3) If the player does not aim the gun accurately at the target, or if the aim is not properly adjusted, display a bullet hole away from the target center.
- 4) Prompt the player to press the Start button to clear any previous adjustment values.
- 5) Prompt the player to aim the gun at the target center and to pull the trigger. Set the adjustment value as the difference between the HCNT, VCNT values and the target's center coordinate.
- 6) Display a message notifying the player that the adjustment has been made.

- **The Start Button**

Although this manual refers to this button as the "Start Button", note that the switch signal differs than the Start Button on the standard SEGA SATURN control pads.

**Note:** The Start Button cannot be used for the boot ROMs Multiplayer (Audio CD Player) interface.

- **Enemies (Targets) on the Edge of the Screen**

Do not place targets 16 pixels from the edge of the screen since some television screens do not display the entire screen.

- **2 Player Mode**

When two players use the Stunner simultaneously, the main processing is done in 2 frames (1/30 sec). Odd and even frames are read separately.

- **Collision Detection Adjustment Mode (Recommended)**

SEGA recommends that the collision detection settings be adjustable in the application. When the screen size is small, the on-screen targets become proportionately smaller. As a result, even the smallest hand movement can throw the aim off. This problem will unintentionally increase the difficulty of the game.

- **Connecting to the 6Player**

The Stunner is not supported by the 6Player. Do not connect the Stunner to the 6Player.

- **Displaying the Stunner On-Screen**

The Stunner comes in three different colors. The color for each sales territory was chosen with consideration to existing toy gun regulations for that area. However, there are no regulations for the color of the Stunner when it is displayed on the game screens during the game, such as in the options screen.

**Table 1 Stunner/Virtua Gun Colors According to Sales Area**

| <b>Sales Area</b>     | <b>Gun Color</b> | <b>Trigger/Start Button</b> | <b>Name</b> |
|-----------------------|------------------|-----------------------------|-------------|
| Japan, Southeast Asia | Black            | Black                       | Virtua Gun  |
| America, Canada       | Orange           | Black                       | Stunner     |
| Europe                | Blue             | Black                       | Virtua Gun  |

## **SEGA SATURN TECHNICAL BULLETIN #SOA-1**

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** May 23, 1995  
**Re:** GFS Library Usage

---

### **Overview**

The purpose of this document is to shed a little light on how directories and subdirectories work on the Saturn CD and how to properly initialize the GFS system.

### **Directory Structure:**

The Saturn CD contains an ISO9660 track that consists of a root directory, subdirectories and the files that belong to them. The files conform to the DOS file naming convention of an eight letter prefix and a three letter extension. The files are placed on the disc in the order that they are specified in the script file, but the directories are sorted alphabetically. This means that a sequential search of a directory will not necessarily follow the order that the files are laid out on the disc.

While you can use the mechanism of finding files by name, this requires the extra overhead of a search by name through the directory table (It actually uses a strcmp() on each entry until it finds a match!). If you have a lot of files in a directory this can add up. It also requires 12 extra bytes per directory entry in the table. We suggest that you do your initial development by file name and convert your application to access by file ids later. The file id (fid) is simply the index into the directory table.

The initial program loader (ip.bin) will load the first file it finds in the directory. This means that you must name the file so that it is the first file alphabetically. We strongly suggest naming your kernel program 0. The first actual file in a directory will have a fid of 2. File ids of 0 and 1 are used for the directory tree system; Fid 0 contains info about the directory itself (self) and fid 1 contains info about the parent directory, if the current directory is a subdirectory. Refer to page nine of the Program Library - User Guide 1, CD-Library (ST-136-R1) for a diagram of the directory structure. Info about subdirectories are stored in the parent directory in the same manner as if they were a file entry.

### **Initializing and Using the GFS:**

In order to correctly initialize the file system it is important to make sure you know in advance the maximum number of entries that will be in each directory. The function GFS\_Init will, upon initializing, fill in a directory table with the contents of the root directory on the disc. It will only fill it up to the number that you pass it so you need to do some calculations.

In calculating how many files are in a directory add in the following:

- 2 for the directory overhead.
- 1 for each file in the current directory.
- 1 for each subdirectory that is in the current directory.
- 1 for the dummy file entry that is used to signify the end of the table in the searches.

With the appropriate file count in hand we can now initialize the GFS.

Here is a snippet of sample code:

```
#define OPEN_MAX 5 /* number of files open at one time */
#define MAX_DIR 300 /* number of files in the directory */

/* library working area */
Uint32 work[GFS_WORK_SIZE(OPEN_MAX) / sizeof(Uint32)];

/* directory table structure */
GfsDirTbl dirtbl;

/* directory w/names added for named file search */
GfsDirName dirname[MAX_DIR];

extern void *buff;

Uint32 Main(void)
{
    char fname[13];
    GfsHn gfs;
    Sint32 fid;
    Sint32 ret;
    Sint32 fsize,sctsize,nsct,lastsize;

    /* tell gfs that the directory table uses names */
    GFS_DIRTBL_TYPE(&dirtbl) = GFS_DIR_NAME;

    /* tell gfs how many entries can be in the directory */
    GFS_DIRTBL_NDIR(&dirtbl) = MAX_DIR;

    /* tell gfs where the directory table is */
    GFS_DIRTBL_DIRNAME(&dirtbl) = dirname;

    /* initialize the gfs */
    /* gfs will load the root directory into the table */
    ret = GFS_Init(OPEN_MAX,work,&dirtbl);
    if (ret <= 2) {
        return 1;
    }

    /* find the file id for "FILE1.BIN" */
```

```

fid = GFS_NameToId("FILE1.BIN");

/* open the file */
gfs = GFS_Open(fid);

/* if we found the file then */
if (gfs != NULL) {
    /* calculate the file size and number of sectors in the file */
    GFS_GetFileSize(gfs,&sctsize,&nsct,&lastsize);
    fsize = sctsize * (nsct-1) + lastsize;

    /* and read it into buff (sure hope buff is big enough !)*
    GFS_Fread(gfs, nsct, buff, fsize);

    /* close the file */
    GFS_Close(gfs);
}
else return 2; /* errored out */

return 0;
}

```

### Accessing Subdirectories

If you have an application that uses subdirectories you can share a common directory table among them. that will be loaded by the GFS\_LoadDir command. After loading it you can make it the current directory by calling GFS\_SetDir and passing it the address of the table. Note: only one directory can be current at one time. If you wish to have open files from several directories you must first set the current directory to the one you want, open the file, set the other directory to be current and open the file, etc.

Here is an example of accessing the root and a subdirectory:

```

#define OPEN_MAX 5
#define MAX_DIR1 54 /* 2 overhead, 50 files, 1 sub-dir, 1 dummy */
#define MAX_DIR2 303 /* 2 overhead, 300 files, 1 dummy */
#define SECT_SIZE 2048; /* size of one sector */

char buff[2048];

Uint32 main()
{
    char fname[13];
    Uint32 ret,i;
    GfsHn gfs;
    Sint32 fid;

    /* set up the parameters for the root directory */
    GFS_DIRTBL_TYPE(&dirb1) = GFS_DIR_NAME;
    GFS_DIRTBL_NDIR(&dirb1) = MAX_DIR1;
    GFS_DIRTBL_DIRNAME(&dirb1) = dirname1;

    /* and set up the parameters for subdirectory */
    GFS_DIRTBL_TYPE(&dirb2) = GFS_DIR_NAME;
    GFS_DIRTBL_NDIR(&dirb2) = MAX_DIR2;

```

```

GFS_DIRTBL_DIRNAME(&dirtbl2) = dirname2;

/* init the GFS and load in the root information */
ret = GFS_Init(OPEN_MAX,work,&dirtbl1);
if (ret <= 2) {
    return 1;
}
/*
    assume there are 50 files in the root named A1.BIN thru A50.BIN
    and each file is 2048 bytes in length
*/
for (i = 0; i < 50; i++) {
    sprintf(fname, "A%d.BIN", i+1);
    /* get the file id for fname */
    fid = GFS_NameToId(fname);
    /* open it */
    gfs = GFS_Open(fid);
    if (gfs == NULL) {
        return 2; /* error out */
    }
    else {
        GFS_Fread(gfs, 1, buff, 2048); /* read in the data */
        GFS_Close(gfs);
    }
}

/* now lets switch to a directory named DIREC1 */

/* same as accessing a file */
fid = GFS_NameToId("DIREC1");

/* load in the directory info */
GFS_LoadDir(fid,&dirtbl2);

/* make it the current directory */
GFS_SetDir(&dirtbl2);

/*
    assume there are 300 files in the subdirectory named
    B1.BIN thru B300.BIN and each file is 2048 bytes in length
*/
for (i = 0; i < 300; i++) {
    sprintf(fname, "A%d.BIN", i+1);
    /* get the file id for fname */
    fid = GFS_NameToId(fname);
    /* open it */
    gfs = GFS_Open(fid);
    if (gfs == NULL) {
        return 2; /* error out */
    }
    else {
        /* read in the data */
        GFS_Fread(gfs, 1, buff, 2048);
        GFS_Close(gfs);
    }
}

```

```

    }
}
return 0;
}

```

Here is the sample script for the subdirectory code example above:

```

Disc          sample.dsk
Session       CDROM
LeadIn MODE1
EndLeadIn

SystemArea   ip.bin

Track        MODE1
  Volume      ISO9660 "sample.pvd"
  PrimaryVolume 00:02:16
  SystemIdentifier "SEGA SEGASATURN"
  VolumeIdentifier "SAMPLE_GAME_TITLE"
  VolumeSetIdentifier "SAMPLE_GAME_TITLE"
  PublisherIdentifier "SEGA ENTERPRISES,LTD."
  DataPreparerIdentifier "SEGA ENTERPRISES,LTD."
  VolumeCreationDate 11/11/1994 00:00:00:00:36
  EndPrimaryVolume
  EndVolume

File          0.BIN ; this file name keeps it the first alphabetically
  FileSource   "kernel.bin" ;the executable binary
  EndFileSource
EndFile

File          A1.BIN
  FileSource   "a1.dat"
  EndFileSource
EndFile
; .
; . A2 thru A49 go here
; .
File          A50.BIN
  FileSource   "a50.dat"
  EndFileSource
EndFile

Directory     DIREC1 ; the subdirectory
  File         B1.BIN
    FileSource "b1.dat"
    EndFileSource
  EndFile

```

```
      ; .  
      ; . B2 thru B299 go here  
      ; .  
      File          B300.BIN  
          FileSource "b300.dat"  
          EndFileSource  
      EndFile  
EndDirectory
```

EndTrack

```
LeadOut          MODE1  
  Empty          500  
EndLeadOut  
EndSession  
EndDisc
```

## **SEGA SATURN TECHNICAL BULLETIN #SOA-2**

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** May 23, 1995  
**Re:** Casting VDP1 Shadows on VDP2 Backgrounds

---

### **Using VDP1 Sprites to Cast Shadows on VDP2 Backgrounds**

The Saturn graphics hardware makes it possible for a sprite to cast a shadow onto a background. When a sprite is casting a shadow, the sprite graphic is not displayed. Instead, the pixels underneath the sprite, i.e. the pixels that the sprite would have obscured, are displayed at a reduced luminance, creating a shadowy effect.

There are two ways to cause a sprite to cast a shadow onto a VDP2 background, each with its own set of advantages and disadvantages. The VDP2 manual refers to these two methods as the “normal shadow” and the “MSB shadow,” and, for the sake of consistency, this note will adopt that terminology.

Both kinds of shadow are created by instructing the VDP1 to write special pixel values to its frame buffer. These special pixel values are then interpreted by the VDP2 as it reads the frame buffer, subject to the states of several of the VDP2’s innumerable mode flags, which will be described below.

In order to use either kind of shadow, you must enable shadow processing for the background(s) onto which shadows are to be cast by setting the appropriate bit(s) of the VDP2 shadow control register (0x25f800e2; refer to page 259 of the VDP2 manual).

#### **The MSB Shadow**

MSB shadows are created by setting the MSBON bit in the draw-mode word of the VDP1 command table, which, in turn, sets the most-significant bit of the appropriate pixels in the VDP1 frame buffer. Since the most-significant bit of a pixel in the frame buffer can perform three different functions, depending on how the VDP2 is configured, you need to be sure that the VDP2 is in the correct mode. To do this, you must clear bits 4 and 5 of the sprite control register (0x25f800e0; refer to pages 188 and 207 of the VDP2 manual). Clearing bit 5 disables RGB sprites, so that the VDP2 will not use the most-significant bit to distinguish between paletted pixels and RGB pixels. Note that this means that you cannot create an MSB shadow sprite unless you completely give up the right to display RGB sprites. Clearing bit 4 informs the VDP2 that you want the most-significant bit to be used for enabling the MSB shadow instead of the VDP2’s sprite window feature.

Use of the MSB shadow feature is further restricted by the fact that it only works for sprite types 2 through 7 (refer to page 201 of the VDP2 manual). Since these sprite types all use 16-bit pixels, it follows that the MSB shadow feature may not be used when the VDP1 is in one of its high-resolution modes.

Once you've got the VDP2 in the correct mode and using an appropriate sprite type, you can contemplate actually drawing an MSB shadow sprite. To do this, set the most-significant bit (the MSBON bit) of the draw-mode word (the third word) in the sprite's command table. When this bit is set, the VDP1 does not actually draw the sprite into the frame buffer. Instead, it sets the most-significant bit of every pixel in the buffer where the sprite would otherwise have been drawn, leaving the remaining bits untouched. This means that the MSB shadow feature can be used to cast shadows onto other sprites, as well as onto backgrounds (but see below).

When the VDP2 encounters a VDP1 pixel with its most-significant bit set (assuming the VDP2 is in the appropriate mode), it responds in one of two ways. If all other bits are zero, i.e. the value of the pixel is 0x8000, then the pixel is taken to be transparent, and the background pixel that is immediately beneath the sprite pixel is displayed at a reduced luminance. If more than one background is being displayed, then the question of which backgrounds get dimmed hinges on the priority of the sprite pixel, and the priority of transparent shadow pixels is always taken from sprite priority register zero. Note that this means that all transparent MSB shadow pixels displayed at any given time will have the same priority. Note also that all of this happens only if you set bit 8 of the VDP2 shadow control register (0x25f800e2), which enables transparent shadow pixels. If this bit is clear (which is the default), then transparent shadow pixels are not displayed, which means that an MSB shadow sprite would still cast a shadow onto other sprites, but not onto any of the backgrounds.

If the unsigned value of a sprite pixel is greater than 0x8000 (i.e. the most-significant bit is set, and the remaining bits are not all zero), then the VDP2 interprets the pixel as being opaque, and the pixel is displayed according to the color bank, priority, and other information found in the remaining 15 bits, but with its luminance reduced.

### **The Normal Shadow**

Normal shadows are created by drawing a reserved paletted pixel value to the VDP1 frame buffer. What the value actually is depends on the sprite type, but, in general, the value is derived by setting all of the dot color bits except the least-significant bit to 1. Depending on the sprite type, this value may be 0x3e, 0x7e, 0xfe, 0x1fe, 0x3fe, or 0x7fe (see page 201 of the VDP2 manual). The values of the remaining bits in the pixel are not significant. When the VDP2 encounters such a pixel, the effect is the same as when it encounters a transparent MSB shadow pixel: the background pixel immediately underneath the sprite pixel is displayed at a reduced luminance.

Normal shadows are displayed regardless of the setting of the transparent shadow enable bit (bit 8) in the shadow control register (0x25f800e2).

Normal shadows have several advantages over MSB shadows. They can be used in high-resolution modes; they can be mixed freely with RGB sprites, and, since the priority bits are still available, they need not all have the same priority. The major disadvantage of the normal shadow is that the pixels of any sprite that happens to be underneath the normal shadow sprite will be obliterated when the normal shadow sprite is drawn, which means that it is not possible to cast a normal shadow onto a sprite.

Be advised that the paletted pixel value reserved for normal shadow pixels is reserved whether shadow processing is enabled or not. If shadow processing is not enabled, then normal shadow pixels are simply not displayed. This means that, depending on the sprite type being used, one or

more entries in color RAM cannot be used by any sprite. For more details, see SEGA Saturn Technical Bulletin #25.

Both kinds of shadow can be used simultaneously. If a single pixel satisfies the qualifications for both kinds of shadow, it is interpreted as a normal shadow pixel.

The following table summarizes the differences between the MSB shadow and the normal shadow.

|                                                  | MSB Shadow | Normal Shadow |
|--------------------------------------------------|------------|---------------|
| Can cast shadows on other sprites?               | Yes        | No            |
| Can be mixed with RGB sprites?                   | No         | Yes           |
| Can different shadows have different priorities? | No         | Yes           |
| Valid sprite types                               | 2-7        | All           |

## SEGA SATURN TECHNICAL BULLETIN #SOA-3

**To:** SEGA and Third Party Developers  
**From:** Developer Technical Support  
**Date:** May 25, 1995  
**Re:** SEGA Saturn CD Door-Open Standard

---

In order for your program to conform to the **Sega Saturn Software Development Standards** document (ST-151-R3-SB) which states "If the Sega Saturn's CD Door OPEN button is pressed during a game and the door opens, then the boot ROM's Audio CD Control Screen must be displayed in the same manner as a reset is implemented in the Title Loop sequence."

The purpose of this document is to show how to check for and respond to the CD door-open condition.

If you are using the SBL - (Sega Basic Library; older SOJ Libraries) place this code in your vertical blank routine:

```
/* Detect CD Disk Change and if so, jump to the Saturn Audio CD Control
Screen (gui) */
if( CDC_GetHirqReq() & CDC_HIRQ_DCHG )
    SYS_EXECDMP();
```

If you are using the SGL - (Sega 3D Game Library) make the following call in your initialization code:

```
/* cause s1Synch to jump to the Saturn Audio Control Screen if the CD
door is opened */
s1SetTrayCheck(TRUE);
```

In addition, if you are using the GFS, STM or the Cinepak (CPK) system you should use the appropriate routine below as well:

Note: These procedures are the same for both the SBL, and the SGL.

```
GFS_SetErrFunc();
STM_SetErrFunc();
CPK_SetErrFunc();
```

The above routines will allow you to specify a function that will be called when a file-based error occurs (such as opening the disk drive while being accessed). The error function should check the error type and respond accordingly. If the error is **ERR\_CDOPE**n then you should call the **sys\_EXECDMP** routine. Please see the appropriate library documentation for the correct usage of the error routines.

The above routines and masks are defined in:

- SEGA\_CDC.H**
- SEGA\_SYS.H**
- SEGA\_GFS.H**
- SEGA\_STM.H**
- SEGA\_CPK.H**

## **SEGA SATURN TECHNICAL BULLETIN #SOA-4**

**To:** SEGA and Third Party Developers  
**From:** Developer Technical Support  
**Date:** May 25, 1995  
**Re:** Saturn System Disks

---

Caution for 3rd party developers using a development system that requires a Saturn system disk.

The following notice needs to be followed in the case of a production unit Saturn being used for development. The black 3rd party system disk is different from the Sega brand developer system disk, hence the IP.BIN file must be modified before preprocessing using VCDPRE.EXE. The change is as follows:

Line 10H reads:  
"SEGA ENTERPRISES" (16 characters)

The correct 3rd party format is:  
"SEGA TP T-000 " (16 characters)  
where 000 represents the company ID number. (available from Sega's 3rd party department)

Failure to follow will result in an "unsuitable disk" error from the Saturn.

Developers can find this information in the "Disk Format Standards Format Manual (ST-040-R3-011895)" or the "Boot ROM System User's Manual (ST-220-120994)". Also, be aware that there is an older version of the manual ST-040-R2-062294 which is incorrect, but has been changed in the new revision.

## **SEGA SATURN TECHNICAL BULLETIN #SOA-5**

**To:** SEGA and Third Party Developers  
**From:** Developer Technical Support  
**Date:** May 25, 1995  
**Re:** VCD I/F Board Installation

---

Setting the jumpers:

1. ISA-IRQ(J3)
2. ISA-DMA(J4)
3. I/O Address(J5)

Default settings:

1. IRQ=10(02)
2. DMA=DREQ5(00)
3. I/O=340H(00)

\*The numbers in parentheses are used by the environment variable set in the autoexec.bat file.

The following environment variable must be placed in the autoexec in order for VCD to operate correctly.

SET VCDIO=020000 (default setting IRQ10, DREQ5, 340H)

The six digits are represented as follows:

|     |     |             |
|-----|-----|-------------|
| 02  | 00  | 00          |
| IRQ | DMA | I/O address |

The value of the environment variable varies when a value other than the default is set as the jumper setting. Refer to the next page for the proper values.

## **SEGA SATURN TECHNICAL BULLETIN #SOA-6**

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** August 16, 1995  
**Re:** VDP2 Cycle Pattern Registers

---

### **Disclaimer**

The information in this document is based on our interpretation of the *VDP2 User's Manual* and on experimental evidence. It is not possible for us to test every conceivable permutation of values that the cycle pattern registers might hold. Your mileage may vary.

### **What Do They Do?**

The cycle pattern registers control the manner in which the VDP2 accesses VRAM while the display is being drawn. Depending on how the display is configured, the VDP2 may need to access VRAM quite a few times in order to draw a single pixel. It may need to read pattern name data (i.e. character codes) and character pattern data (i.e. the characters themselves) for several different backgrounds. It may also need to read vertical cell scroll data. In addition, you may wish to access VRAM from the CPU during the display. The VDP2 is not smart enough to direct all of this VRAM traffic automatically; you must do it yourself. The cycle pattern registers allow you to do this by specifying which parts of the VDP2 are allowed to access which parts of VRAM how often and at what time(s). The cycle pattern registers also control how much access the CPU has to VDP2 VRAM while the screen is being displayed (the CPU may access VRAM freely during the vertical blanking interval).

The figure below illustrates how VDP2 VRAM is accessed for each pixel. There are eight memory cycles per pixel (four in hi-res mode), and VDP2 VRAM can be divided into up to four banks, all of which can be accessed during each cycle, which means that the VDP2 can perform up to 32 VRAM accesses per pixel. In the figure below, the cycles (or "timings," as they are sometimes called in the *VDP2 User's Manual*) are labeled T0 through T7, and the VRAM banks are labeled A0, A1, B0, and B1. You must specify who gets to have access to each bank of VRAM during each of the eight cycles, and you must do it so as to ensure that the VDP2 will be able to load all of the data that it needs to load in order to display the number and type of backgrounds that you told it to (except where otherwise noted, this document will assume that VRAM is partitioned into four banks).

|        | T0 | T1 | T2 | T3 | T4 | T5 | T6 | T7 |
|--------|----|----|----|----|----|----|----|----|
| A<br>0 |    |    |    |    |    |    |    |    |
| A<br>1 |    |    |    |    |    |    |    |    |
| B<br>0 |    |    |    |    |    |    |    |    |
| B<br>1 |    |    |    |    |    |    |    |    |

### What Do They Look Like?

The cycle pattern registers are a set of eight 16-bit registers: two for each of the four banks of VDP2 VRAM. Each pair of registers contains one four-bit field for each of the eight cycles that elapses during the display of a single pixel, for a total of 32 bits. Between them, these registers allow (or, if you prefer, require) you to specify who gets to access which bank of VRAM during which cycles. If VDP2 VRAM is configured as two larger banks instead of four smaller ones, then the cycle pattern registers for banks A1 and B1 are ignored.

Each of the 32 four-bit fields can assume one of the following values, corresponding to the different types of VRAM access that the cycle pattern registers control.

Value    Type of data that may be accessed

---

|    |                                                                         |
|----|-------------------------------------------------------------------------|
| 0  | NBG0 pattern name data                                                  |
| 1  | NBG1 pattern name data                                                  |
| 2  | NBG2 pattern name data                                                  |
| 3  | NBG3 pattern name data                                                  |
| 4  | NBG0 character pattern data or bit mapped data                          |
| 5  | NBG1 character pattern data or bit mapped data                          |
| 6  | NBG2 character pattern data (NBG2 does not support bit mapped displays) |
| 7  | NBG3 character pattern data (NBG3 does not support bit mapped displays) |
| 8  | This value is illegal                                                   |
| 9  | This value is illegal                                                   |
| 10 | This value is illegal                                                   |
| 11 | This value is illegal                                                   |
| 12 | NBG0 vertical cell scroll table data                                    |
| 13 | NBG1 vertical cell scroll table data                                    |
| 14 | CPU data (i.e., the CPU may either read from or write to VRAM)          |
| 15 | Nobody can access VRAM                                                  |

The cycle pattern registers are laid out so that if you display their values in a debugger (which you can't do, since they're write-only registers, but you could display shadows of them), the access codes will read naturally from left to right, with T0 at the left and T7 at the right. For a diagram of the cycle pattern registers, see p. 39 of the *VDP2 User's Manual*.

## How Many Accesses Are Required for What?

Here is a table which gives the number of VRAM accesses that must be allocated for each of the various types of VDP2 data.

| Type of Data                                    | Number of Accesses Required Per Background |
|-------------------------------------------------|--------------------------------------------|
| Pattern name data (1-word or 2-word)            | 1                                          |
| 16-color character pattern or bit mapped data   | 1                                          |
| 256-color character pattern or bit mapped data  | 2                                          |
| 2048-color character pattern or bit mapped data | 4                                          |
| 32K-color character pattern or bit mapped data  | 4                                          |
| 16M-color character pattern or bit mapped data  | 8                                          |
| Vertical cell scroll table data                 | 1                                          |

If you are using the VDP2 zooming hardware to reduce your screen (this is only supported for NBG0 and NBG1; see pp. 126-130 of the *VDP2 User's Manual*), then the VDP2 has to perform additional accesses, since each pixel on the screen can correspond to multiple pixels in VRAM. If you're reducing the screen by a factor of more than one but not more than two, then the number of pattern name data and character pattern data accesses must both be doubled. If you're reducing the screen by as much as a factor of four (the maximum reduction possible), then they must be quadrupled. This naturally creates restrictions on the color depth of the screens that are going to be reduced.

## What Timings Can I Use?

There are a number of restrictions on which types of VRAM access can be performed during which cycles and in what combinations, and here they are.

There can be a maximum of two pattern name data accesses during any given cycle, and one of them must access either bank A0 or bank B0, while the other must access either bank A1 or bank B1. If bank A is partitioned, but bank B is not, then bank A1 may be accessed simultaneously with bank B, but bank A0 may not be. Similarly, if bank B is partitioned, but bank A is not, then bank B1 may be accessed simultaneously with bank A, but bank B0 may not be. If neither bank A nor bank B is partitioned, then only one pattern name data access per cycle may be performed.

The cycles during which character pattern data may be read depend on the cycle(s) during which the corresponding pattern name data was read. Here are the restrictions.

| If the Pattern Name Data Is Read During This Cycle... | ...Then the Character Pattern Data Can Only Be Read During These Cycle... | ... Or, If You're In Hi-res Mode, During These Cycles |
|-------------------------------------------------------|---------------------------------------------------------------------------|-------------------------------------------------------|
| T0                                                    | T0, T1, T2, T4, T5, T6, T7                                                | T0, T1, T2                                            |
| T1                                                    | T0, T1, T2, T3, T5, T6, T7                                                | T1, T2, T3                                            |
| T2                                                    | T0, T1, T2, T3, T6, T7                                                    | T0, T2, T3                                            |
| T3                                                    | T0, T1, T2, T3, T7                                                        | T0, T1, T3                                            |
| T4                                                    | T0, T1, T2, T3                                                            | -                                                     |
| T5                                                    | T1, T2, T3                                                                | -                                                     |
| T6                                                    | T2, T3                                                                    | -                                                     |
| T7                                                    | T3                                                                        | -                                                     |

Vertical cell scroll table data may only be accessed during T0 and T1 for NBG0, and during T0, T1, and T2 for NBG1. If vertical cell scroll table data is being accessed for both NBG0 and NBG1, then the access for NBG0 must come first.

CPU access for bank A0 should match the CPU access for bank A1, and CPU access for bank B0 should match the access for bank B1. Cycles which are available for CPU access in, say, bank A0 but not in bank A1 should be programmed with access code 0xf (no access). If all of bank A (both bank A0 and bank A1) or all of bank B is unused, set its cycle pattern registers to 0xfeeeeeee, i.e., no access in T0 and CPU access during all other cycles. Note that if the CPU tries to read VRAM during a cycle which does not allow CPU access, the CPU will be held until VRAM becomes available. The CPU can write up to two long words to VRAM without having to wait.

### What About the Rotating Backgrounds?

The rotating backgrounds do not use the cycle pattern registers. Data that will be used by a rotating background may not share a VRAM bank with data that will be used by a normal background.

### Examples

To display these four screens,

| Screen | Color Depth | Display Mode | Bank Containing Pattern Name Data | Bank Containing Character Pattern or Bit Map Data |
|--------|-------------|--------------|-----------------------------------|---------------------------------------------------|
| NBG0   | 16          | Character    | A0                                | A0                                                |
| NBG1   | 16          | Bit Map      | -                                 | A1                                                |
| NBG2   | 16          | Character    | B0                                | B0                                                |
| NBG3   | 256         | Character    | B1                                | B1                                                |

Set the cycle pattern registers like so:

A0: 0x04eeeeee  
A1: 0x5feeeeeee  
B0: 0xf26eeeeee  
B1: 0x377eeeeee

If, for whatever reason, we wanted to reshuffle the various display components like so,

| Screen | Color Depth | Display Mode | Bank Containing<br>Pattern Name Data | Bank Containing<br>Character Pattern or Bit Map Data |
|--------|-------------|--------------|--------------------------------------|------------------------------------------------------|
| NBG0   | 16          | Character    | A1                                   | A0                                                   |
| NBG1   | 16          | Bit Map      | –                                    | A1                                                   |
| NBG2   | 16          | Character    | B1                                   | B0                                                   |
| NBG3   | 256         | Character    | B1                                   | B0                                                   |

We could set the cycle pattern registers like this:

A0: 0x4feeeeeee  
A1: 0x05eeeeee  
B0: 0x677eeeeee  
B1: 0xf23eeeeee

Now let's say we wanted to put everything that used to be in bank A1 into bank A0, and everything that used to be in bank B1 into bank B0, giving us this:

| Screen | Color Depth | Display Mode | Bank Containing<br>Pattern Name Data | Bank Containing<br>Character Pattern or Bit Map Data |
|--------|-------------|--------------|--------------------------------------|------------------------------------------------------|
| NBG0   | 16          | Character    | A0                                   | A0                                                   |
| NBG1   | 16          | Bit Map      | –                                    | A0                                                   |
| NBG2   | 16          | Character    | B0                                   | B0                                                   |
| NBG3   | 256         | Character    | B0                                   | B0                                                   |

We could set the cycle pattern registers like this:

A0: 0x504eeeeee  
A1: 0xfffeeeee  
B0: 0x2637ee7e  
B1: 0xffffeeefe

If, in addition, we wanted to be able to reduce NBG0 by up to one half, we could alter the settings for banks A0 and A1 as follows:

A0: 0x5040eee4  
A1: 0xffffeeef

## **SEGA SATURN TECHNICAL BULLETIN #SOA-7**

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** August 16, 1995  
**Re:** Sprite Transparency

---

### **MAKING VDP1 SPRITES PARTIALLY TRANSPARENT WITH RESPECT TO VDP2 BACKGROUNDS**

It is possible to instruct the VDP2 to display selected sprites so that they are partially transparent with respect to the VDP2's backgrounds, i.e., the RGB values of the sprite's pixels and those of the background's pixels are combined in a weighted average. This can be done with either paletted sprites or RGB sprites, but it's more useful with paletted sprites, since each paletted sprite gets to decide individually whether it will be partially transparent or not, whereas, with RGB sprites, either all of them are partially transparent, or none of them are, as we shall see. Note also that, while any sprite may be made partially transparent with respect to the backgrounds, the only way in which sprites may be made partially transparent with respect to each other is to use the VDP1's half-transparency effect, which only works if all sprites involved are RGB sprites.

There are several things that you must do in order to make a sprite partially transparent with respect to backgrounds.

First, you must tell the VDP2 to enable color calculations (that's Sega-speak for partial transparency and other effects in which the RGB values of individual pixels are manipulated) for the sprites by setting bit 6 of the color calculation control register (see p. 240 of the *VDP2 User's Manual*).

Next, decide how transparent you want the sprite to be by specifying one or more "color calculation ratios," or degrees of transparency, between the sprite and whatever backgrounds are behind it. Each color calculation ratio is represented by a number from 0 to 31, where 0 means "opaque," and 31 means "completely transparent." Up to eight of these ratios may be stored in the sprite color calculation ratio registers (see p. 210 of the *VDP2 User's Manual*). Paletted sprites select one of these ratios using the color calculation bits in the sprite's pixel data as defined by the sprite type being used (see pp. 201-202 of the *VDP2 User's Manual*). Note that not all sprite types allow access to all eight of the available color calculation ratios, and most of the hi-res sprite types (the 8-bit types) do not support color calculation at all. RGB sprites always use color calculation ratio zero (i.e., the ratio stored in bits 0 through 4 of the first sprite color calculation ratio register).

Since you will probably not want all of your sprites to be partially transparent, there needs to be some way to determine which sprites will be subjected to color calculations and which ones will not. The question of whether or not the VDP2 will perform color calculations on a given pixel in the VDP1 frame buffer is resolved by subjecting the pixel to one of four tests:

1. Perform color calculations if the pixel's priority is less than or equal to a specified value.
2. Perform color calculations if the pixel's priority is equal to a specified value.
3. Perform color calculations if the pixel's priority is greater than or equal to a specified value.
4. Perform color calculations if the most-significant bit of the pixel's *color* is set.

You determine which test is used by writing to bits 12 and 13 of the sprite control register (see p. 207 of the *VDP2 User's Manual*). The same test will be used for every pixel in the VDP1 frame buffer. The "specified value" alluded to in the first three tests is set by writing to bits 8, 9, and 10 of the sprite control register. The priority of an RGB pixel is always taken from sprite priority register zero (see p. 209 of the *VDP2 User's Manual*). This means that all RGB pixels have the same priority, which means that, when using one of the first three tests, either all of the RGB sprites are subjected to color calculations, or none of them are.

If you choose the fourth test, then all RGB sprites will be subjected to color calculations. If you use the fourth test with paletted sprites, then only pixels whose palette entries have their most-significant bits set will be subjected to color calculations. This feature makes it possible to turn potentially large areas of the screen partially transparent simply by rewriting a palette entry or two. In both of these cases, the color calculation ratio is taken from bits 0 through 4 of the first sprite color calculation ratio register (see p. 210 of the *VDP2 User's Manual*).

For more on color calculations in general, see chapter 12 of the *VDP2 User's Manual*.

## **SEGA SATURN TECHNICAL BULLETIN #SOA-8**

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** August 16, 1995  
**Re:** Saturn SCU DSP Tutorial

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### **1. Overview**

#### **1.1 Introduction**

This document provides a programmer's introduction to and overview of the DSP which is part of the Saturn System Control Unit, including the architecture of the DSP and the various programming considerations that architecture implies.

#### **1.2 Advantages of Using the DSP**

The DSP is a highly specialized processor intended to efficiently calculate sums of products, as when performing matrix and vector calculations such as 3D point transformations or lighting calculations. When performing the sorts of tasks for which it was designed, the DSP can be faster than the SH2, because it can load operands for one calculation, perform a second calculation, and store the results of a third calculation in parallel. It can also perform a 32x32 multiply, yielding a 48-bit result, in a single cycle.

The DSP gains an additional advantage when performing fixed-point calculations, since, when it stores its results to its data RAM, it can store either the lower or the upper 32 bits of its 48-bit accumulator, whereas the SH2 must take time to explicitly reformat the results of fixed-point calculations by using the "xtret" instruction.

#### **1.3 Disadvantages of Using the DSP**

The DSP runs at half the clock speed of the SH2, so, while the DSP can multiply in a single cycle, that cycle is twice as long as one of the SH2's cycles.

The DSP's doesn't have much memory, and the memory it does have is not mapped onto the system bus, which means that the DSP must continually take time to copy its data between its own data RAM and the SH2's work RAM.

The DSP is difficult to program. A routine that could be coded in SH2 assembly language in half an hour might take half a day to write, debug, and fully optimize on the DSP.

## **1.4 Organization of the DSP's Memory**

The DSP's RAM is organized in 32-bit words, and it is not addressable in smaller units. Program memory and data memory are separate; there are 256 words of program RAM and 256 words of data RAM, the latter being organized in 4 banks of 64 words each. Each bank of data RAM has its own address and data ports, so that multiple banks can be accessed in parallel during a single machine cycle.

## **1.5 Organization of the CPU**

The DSP's CPU contains an ALU and a multiplier which function in parallel. There is no divider. There are also several buses which connect the DSP's data RAM to its various registers, and these buses can also operate in parallel. This parallelism allows the DSP to load a pair of inputs for the multiplier, retrieve the results of a previous multiplication, add the results of a still earlier multiplication to a running total, and store that total to data RAM, all during a single cycle.

## **2. Registers**

Each of the DSP's registers is intended for a specific purpose. There are no general purpose registers, and there is no stack pointer. The width of each register, as well as the presence or absence of data paths leading to or from it, depend on the purpose for which it was intended.

### **2.1 The Accumulator**

The accumulator is a 48-bit register that holds the results of ALU operations. In particular, it is used to add up the 48-bit products generated by the multiplier. The ALU also takes one of its inputs from the accumulator. Most DSP data is 32 bits wide or less, so sign extension is performed when loading a less-than-48-bit number into the accumulator. When storing the contents of the accumulator to the DSP's data RAM, either the lower or the upper 32 bits may be written.

### **2.2 The P register**

The P register is the only DSP register besides the accumulator that is 48 bits wide. It has two functions: it receives the 48-bit products that the multiplier puts out, and it holds the second ALU input for operations that require a second input.

### **2.3 RX and RY**

The RX and RY registers hold the inputs to the DSP's multiplier. They are 32 bits wide. The multiplier multiplies the contents of RX and the contents of RY every cycle, and the results can be accessed on the following cycle by using the MOV MUL,P instruction.

### **2.4 The Index Registers: CT0 Through CT3**

The registers CT0 through CT3 are 6-bit registers that each address one of the DSP's four 64-word banks of data RAM. These are the data RAM address ports or index registers, and all data that is read from or written to the DSP's data RAM is routed by these registers.

## 2.5 The Program Counter

The PC (program counter) register is 8 bits wide and holds the address in program RAM of the next instruction to be executed.

## 2.6 LOP and TOP

The LOP and TOP registers are used to control looping and subroutine logic. LOP is a dedicated loop counter and is 12 bits wide. TOP is 8 bits wide and is used to hold the address in program RAM of the top of a loop or the return address of a subroutine. The BTM (loop bottom) instruction examines the contents of LOP, falling through if LOP is zero, and decrementing LOP and branching back to TOP otherwise. See section 7.1 for a discussion of how LOP and TOP can be used to create a crude subroutine-calling mechanism.

## 2.7 RA0 and WA0

The RA0 and WA0 are used to control DMA transfers. RA0 holds the address (divided by four) in external RAM from which data will be read into the DSP's program or data RAM. WA0 holds the address (divided by four) in external RAM to which data will be written from the DSP's data RAM. It is not possible to transfer the DSP's program RAM to external RAM.

## 3. Processor Control and Status Bits

These bits are all mapped onto the SCU's DSP control port, found at address 0x25fe0080. Individual bit mappings are given in the table below. Some of these bits are used to control the DSP's conditional branching instructions (see section 5.7). For further information on using the SCU registers to control the DSP, see the *SCU User's Manual* and the file DSP\_CTRL.C, which is part of the Sega standard software library for Saturn.

| Flag | R/W | Bit | Description                                                                                                                                                                                                                                                                                                                  |
|------|-----|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PR   | W   | 26  | Pause Reset bit. Writing a 1 to this bit unpauses a program that has been paused by writing a 1 to the Execute Pause bit (see below).                                                                                                                                                                                        |
| EP   | W   | 25  | Execute Pause bit. Writing a 1 to this bit pauses a program that is running (EX = 1).                                                                                                                                                                                                                                        |
| T0   | R   | 23  | When this flag is 1, DMA is occurring on the D0 bus.                                                                                                                                                                                                                                                                         |
| S    | R   | 22  | Sign bit. This bit is set to 1 when the result of an ALU operation is negative. In other words, the S bit is set to the value of the most-significant bit of the ALU result. For most ALU instructions, the most-significant bit is bit 31, but for the 48-bit addition instruction AD2, the most-significant bit is bit 47. |
| Z    | R   | 21  | Zero bit. This bit is set to 1 when the result of an ALU operation is zero.                                                                                                                                                                                                                                                  |
| C    | R   | 20  | Carry bit. This bit is set to 1 when an unsigned arithmetic overflow occurs; it is also set by the various shift and rotate instructions.                                                                                                                                                                                    |

|    |     |    |                                                                                                                                                                                                                                                                                                                               |
|----|-----|----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| V  | R   | 19 | Overflow bit. This bit is set to 1 when a signed arithmetic overflow occurs. Note that at least some versions of the DSP simulator do not implement this bit correctly. See the DSP Simulator manual for details.                                                                                                             |
| E  | R   | 18 | Program End Interrupt flag. When this bit is set, the DSP program has halted and requested an interrupt. Reading the DSP control port resets this flag.                                                                                                                                                                       |
| ES | W   | 17 | Execute Step bit. Writing a 1 to this bit while the program is halted (EX = 0) triggers the execution of the next single step in the program.                                                                                                                                                                                 |
| EX | R/W | 16 | Execution Control Flag. Writing a 1 to this bit begins program execution; writing a zero halts the program. Reading this register tells whether the DSP is running or not, however the DSP control port may not be read while a DSP program is running if the DSP program expects to request an interrupt when it terminates. |
| LE | W   | 15 | Program Counter Load Enable bit. If this bit is 1 when writing to the DSP control port, then bits 0-7 of the 32-bit value being written will be loaded into the DSP's program counter. Otherwise, these bits are ignored. The DSP's program counter may only be loaded when the DSP is halted (EX = 0).                       |

## 4. Buses

### 4.1 The D0 Bus

The D0 bus connects the DSP to the outside world and is used during DMA transfers. Since this bus is used only for DMA, the DSP can continue to execute instructions and access memory while DMA is occurring, as long as it doesn't touch the bank of data RAM that is involved in the DMA transfer. The D0 bus operates at the full clock rate of the SH2 (28 MHz), unlike the other buses, which operate at half that rate.

### 4.2 The D1 Bus

The D1 bus is used for most data movement operations. It connects the DSP's data RAM to most of the registers and is also used for loading 8-bit immediate data into the DSP's registers. See section 5.4 or the "Saturn SCU DSP Programmer's Reference" sheet for details of which data movement operations are performed on the D1 bus.

### 4.3 The X Bus

The X bus connects the DSP's data RAM to the RX and P registers. The X bus allows the RX register or the P register to be loaded at the same time that other data movement operations are occurring on the D1 bus and the Y bus.

### 4.4 The Y Bus

The Y bus connects the DSP's data RAM to the RY and A registers. The Y bus allows the RY register or the accumulator to be loaded at the same time that other data movement operations are occurring on the D1 bus and the X bus.

For additional information about the architecture of the DSP's buses, refer to the DSP block diagram in section 4.1 of the *SCU User's Manual*.

## 5. Instruction Set

### 5.1 ALU Instructions

These instructions take their input from the accumulator and the P register. The output is available on the same cycle. In order for the ALU output to be stored in the accumulator, the MOV ALU,A instruction must be used in parallel with the ALU instruction.

However, even if you don't use MOV ALU,A, you can still store the ALU result in memory, and the condition codes will still be set. You can also say CLR A in parallel with an ALU instruction. The accumulator will be cleared, but the condition codes will still be set according to the ALU result, and the ALU result can still be stored to memory. Note that the ALU result must be stored in the accumulator or in data RAM on the same cycle in which it is computed, or it will be lost. ALU instructions may be used in parallel with X-bus, Y-bus, and D1-bus instructions

| Mnemonic | Description                                        | S Z C V E x |
|----------|----------------------------------------------------|-------------|
| AD2      | Add ALH and ALL to PH and PL                       | S Z C V - - |
| ADD      | Add ALL and PL                                     | S Z C V - - |
| AND      | And ALL with PL                                    | S Z 0 - - - |
| NOP      | Do nothing                                         | - - - - -   |
| OR       | Or ALL with PL                                     | S Z 0 - - - |
| RL       | Rotate ALL left once; d31 moves to d0 and to C     | S Z C - - - |
| RL8      | Rotate ALL left 8 times; d24 moves to d0 and to C  | S Z C - - - |
| RR       | Rotate ALL right once; d0 moves to d31 and to C    | S Z C - - - |
| SL       | Shift ALL left once; d31 moves to C                | S Z C - - - |
| SR       | Shift ALL right once arithmetically; d0 moves to C | S Z C - - - |
| SUB      | Subtract PL from ALL                               | S Z C V - - |
| XOR      | Exclusive-or ALL with PL                           | S Z 0 - - - |

### 5.2 X-Bus Instructions

These instructions allow the RX and P registers to be loaded from data RAM, and they also allow multiplier's output to be loaded into the P register. The instructions that load the RX register may be used in parallel with the MOV MUL,P instruction. X-bus instructions may be used in parallel with ALU, Y-bus, and D1-bus instructions. None of these instructions affect the processor status flags.

| Mnemonic  | Description                                                                |
|-----------|----------------------------------------------------------------------------|
| MOV Mn,X  | Move the word pointed at by the CTn register ( $n = 0-3$ ) into RX         |
| MOV MCn,X | Move the word pointed at by CTn into RX and increment CTn                  |
| MOV MUL,P | Move 48-bit multiplier result into PH and PL                               |
| MOV Mn,P  | Move the word pointed at by CTn ( $n = 0-3$ ) into PL; sign extend into PH |
| MOV MCn,P | Move the word pointed at by CTn into PL, sign extend, and increment CTn    |

### 5.3 Y-Bus Instructions

These instructions allow the RY register and the accumulator to be loaded from data RAM, and they also allow ALU output to be loaded into the accumulator. The instructions that load the RY register may be used in parallel with the MOV ALU,A instruction or the CLR A instruction. Y-bus instructions may be used in parallel with ALU, X-bus, and D1-bus instructions. None of these instructions affect the processor status flags.

| Mnemonic         | Description                                                                   |
|------------------|-------------------------------------------------------------------------------|
| MOV <i>Mn,Y</i>  | Move the word pointed at by the CT $n$ register ( $n = 0-3$ ) into RY         |
| MOV <i>MCn,Y</i> | Move the word pointed at by CT $n$ ( $n = 0-3$ ) into RY and increment CT $n$ |
| CLR A            | Set accumulator to 0                                                          |
| MOV ALU,A        | Gate results of ALU operation into accumulator                                |
| MOV <i>Mn,A</i>  | Move word pointed at by CT $n$ ( $n = 0-3$ ) into ALL; sign extend into ALH   |
| MOV <i>MCn,A</i> | Move word pointed at by CT $n$ into ALL, sign extend, and increment CT $n$    |

### 5.4 D1-Bus Instructions

These instructions perform the bulk of the data movement chores. D1-bus instructions may be used in parallel with ALU, X-bus, and Y-bus instructions. None of these instructions affect the processor status flags.

| Mnemonic            | Description                                                                      |
|---------------------|----------------------------------------------------------------------------------|
| MOV <i>imm8,MCn</i> | Move 8-bit immediate data to location pointed at by CT $n$ ; increment CT $n$    |
| MOV <i>imm8,reg</i> | Move 8-bit immediate data to RX, PL, RA0, WA0, LOP, TOP, or CT0-3                |
| MOV <i>ALH,MCn</i>  | Move upper 32 bits of 48-bit accumulator to data RAM; increment CT $n$           |
| MOV <i>ALH,reg</i>  | Move upper 32 bits of accum. to RX, PL, RA0, WA0, LOP, TOP, or CT0-3             |
| MOV <i>ALL,MCn</i>  | Move lower 32 bits of 48-bit accumulator to data RAM; increment CT $n$           |
| MOV <i>ALL,reg</i>  | Move lower 32 bits of accum. to RX, PL, RA0, WA0, LOP, TOP, or CT0-3             |
| MOV <i>Mn,MCm</i>   | Move word pointed at by CT $n$ to word pointed at by CT $m$ ; increment CT $m$   |
| MOV <i>MCn,MCm</i>  | Move word pointed at by CT $n$ to word at CT $m$ ; increment CT $n$ and CT $m$ . |

### 5.5 Move Immediate Instructions

These instructions are used to load immediate values that are too large for the D1-bus instructions, or to load an immediate value into the program counter, which the D1-bus instructions won't do. MVI instructions may not be used in parallel with other instructions. None of these instructions affect the processor status flags.

| Mnemonic                  | Description                                                                            |
|---------------------------|----------------------------------------------------------------------------------------|
| MVI <i>imm25,MCn</i>      | Move 25-bit immediate data to location pointed at by <i>Ctn</i> ; increment <i>CTn</i> |
| MVI <i>imm25,reg</i>      | Move 25-bit immediate data to RX, PL, RA0, WA0, LOP, or PC                             |
| MVI <i>imm19,MCn,cond</i> | Move 19-bit immediate data to data RAM conditionally; increment <i>CTn</i>             |
| MVI <i>imm19,reg,cond</i> | Move 19-bit imm. data to RX, PL, RA0, WA0, LOP, or PC conditionally                    |

For the *cond* parameter, substitute one of the following: Z, NZ, S, NS, C, NC, T0, NT0, ZS, or NZS. For example, the instruction MVI 1,RX,Z moves a 1 into the RX register if and only if the Z flag is set. MVI 1,RX,NZ performs the move if and only if the Z flag is clear. MVI 1,RX,ZS performs the move if either Z or S is set, and MVI 1,RX,NZS performs the move if both Z and S are clear. By conditionally moving a value into the program counter, you can create a conditional subroutine call (see section 7.1 for more about how to create subroutine calls on the DSP).

## 5.6 DMA Instructions

These instructions initiate DMA transfers between the DSP's memory and external memory. Before the transfer is started, the source or destination address in external RAM must be stored in register RA0 (when reading data from external memory into the DSP's memory) or WA0 (when writing data to external memory from the DSP's memory). The addresses stored in RA0 and WA0 are multiplied by four before being used to address external RAM, so the actual source or destination addresses must be divided by four before being stored to RA0 or WA0.

The DSP can continue processing while the DMA transfer takes place. If a program depends on data from a DMA transfer being available, it must poll the T0 flag to make sure that the DMA transfer has been completed. DMA instructions may not be used in parallel with other instructions. Apart from the T0 flag, DMA does not affect the processor status flags.

| Mnemonic          | Description                                                                       |
|-------------------|-----------------------------------------------------------------------------------|
| DMA D0,Mn,imm8    | Transfer <i>imm8</i> 32-bit words from work RAM to data RAM indexed by <i>CTn</i> |
| DMA D0,PRG,imm8   | Transfer <i>imm8</i> 32-bit words from work RAM to program RAM location 0         |
| DMA Mn,D0,imm8    | Transfer <i>imm8</i> 32-bit words from data RAM indexed by <i>CTn</i> to work RAM |
| DMA D0,Mn,count   | Transfer from work RAM to data RAM indexed by <i>CTn</i>                          |
| DMA D0,PRG,count  | Transfer from work RAM to program RAM location 0                                  |
| DMA Mn,D0,count   | Transfer from data RAM indexed by <i>CTn</i> to work RAM                          |
| DMAH D0,Mn,imm8   | Transfer <i>imm8</i> 32-bit words from work RAM to data RAM indexed by <i>CTn</i> |
| DMAH D0,PRG,imm8  | Transfer <i>imm8</i> 32-bit words from work RAM to program RAM location 0         |
| DMAH Mn,D0,imm8   | Transfer <i>imm8</i> 32-bit words from data RAM indexed by <i>CTn</i> to work RAM |
| DMAH D0,Mn,count  | Transfer from work RAM to data RAM indexed by <i>CTn</i>                          |
| DMAH D0,PRG,count | Transfer from work RAM to program RAM location 0                                  |
| DMAH Mn,D0,count  | Transfer from data RAM indexed by <i>CTn</i> to work RAM                          |

For the *count* parameter, substitute either  $Mn$  or  $MCn$  ( $n = 0-3$ ). The number of words to be transferred is read from the specified location in data RAM  $n$ . If  $MCn$  is specified, then register  $CTn$  is incremented after the transfer count is read.

The difference between the DMA instructions and the DMAH instructions is that the DMAH instructions reset the  $RA0$  or  $WA0$  registers to their starting values after the transfer is complete, allowing the same transfer to be performed repeatedly without the need to reinitialize the registers. The DMA instructions leave  $RA0$  and  $WA0$  pointing to the long-word immediately following the last long-word read or written.

## 5.7 Jump Instructions

These instructions jump to a given location in program RAM. Note that, since the DSP prefetches one instruction ahead, the instruction immediately following a jump instruction will be executed whether the jump is taken or not. Jump instructions may not be used in parallel with other instructions. None of these instructions affect the processor status flags.

| Mnemonic             | Description        |
|----------------------|--------------------|
| JMP <i>imm8</i>      | Unconditional jump |
| JMP <i>cond,imm8</i> | Conditional jump   |

For the *cond* parameter, substitute one of the following: Z, NZ, S, NS, C, NC, T0, NT0, ZS, or NZS. For example, the instruction JMP FOO,Z jumps to the label FOO if and only if the Z flag is set. JMP FOO,NZ jumps if and only if the Z flag is clear. JMP FOO,ZS jumps if either Z or S is set, and JMP FOO,NZS jumps if both Z and S are clear.

## 5.8 Looping Instructions

These instructions control iterative processing. The BTM, or loop-bottom, instruction first examines the contents of the loop-counter register (LOP). If LOP is zero, BTM does nothing. Otherwise, BTM decrements LOP and then branches back to the address found in TOP. Note that the instruction immediately following the BTM is executed whether BTM branches or not. Refer to section 7.1 for a description of how BTM can be used to return from a subroutine. The LPS instruction allows repeated execution of a single instruction, using LOP as a counter. Looping instructions may not be used in parallel with other instructions. These instructions do not affect the processor status flags.

| Mnemonic | Description                                                    |
|----------|----------------------------------------------------------------|
| BTM      | If LOP=0, do nothing, else decrement LOP and set the PC to TOP |
| LPS      | Repeat the next instruction LOP+1 times                        |

## 5.9 Halt Instructions

These instructions halt the DSP with or without an interrupt. They may not be used in parallel with other instructions.

| Mnemonic | Description            | S Z C V E x   |
|----------|------------------------|---------------|
| END      | Halt without interrupt | - - - - - 0   |
| ENDI     | Halt with interrupt    | - - - - - 1 0 |

## 6. Parallelism

The DSP's two main functional units (the ALU and the multiplier) can operate in parallel, as can its four buses and its four banks of data RAM. As a result, the DSP can execute up to six instructions in a single cycle, including any or all of the following: one ALU instruction, an instruction to load the RX or P register, the MOV MUL, P instruction, an instruction to load the RY register or the accumulator, either the MOV ALU, A instruction or the CLR A instruction, and a D1-bus instruction. These are the only instructions that can be used in parallel with each other; other instructions require a cycle of their very own.

## 7. Programming Techniques

### 7.1 Subroutines

When the MVI (move immediate) instruction is used to alter the contents of the program counter, the previous value of the program counter (which points at the instruction immediately following the MVI) is saved in the TOP register, yielding a crude jump-to-subroutine mechanism. To jump to a subroutine, issue an instruction of the form MVI SUB,PC. Assuming that the LOP register has been initialized to something other than zero, the BTM instruction can then be used to return from the subroutine.

### 7.2 Organizing Data

Because each of the DSP's four index registers is dedicated to a single bank of the DSP's data RAM, data structures that need to be accessed simultaneously should reside in different data RAM banks. If, for example, you want to multiply a matrix by a series of vectors, then the matrix should be in one bank, the input vectors in a second bank, and the output vectors in a third. Otherwise, time will be wasted in unnecessarily loading and reloading index registers.

The DSP is much more efficient when it can read and write data sequentially, so it pays to structure your data accordingly. It may even pay to have the DSP reformat some of its data before it starts crunching on it, although the DSP is not terribly efficient at general-purpose data processing. For an example of this, see the matrix multiplication program in section 8.2.

### 7.3 Maximizing Parallelism

The DSP's advantage over the SH2 lies almost entirely in its ability to perform multiple operations in parallel, and optimizing this parallelism is crucial to using the DSP effectively. Strive to keep the multiplier fed. Don't use an MVI instruction, which monopolizes an entire cycle, when you can use a MOV instruction, which can be executed in parallel with other instructions. You can only load one index register per

cycle, so make sure that at least most of your data is stored in the order in which your program will need it. Remember that the accumulator can be cleared (using CLR A) for a new sum of products in the same cycle that the previous sum of products is computed and stored.

## 8. Examples

The formatting conventions used in these examples are consistent with those supported by the DSP assembler. It may be helpful to step through these examples using the DSP simulator. Further examples may be found in the DSP Assembler manual. See also the Saturn SCU DSP demonstration program.

### 8.1 Dot Product

This example computes the dot product of two 3-element vectors. Recall that the dot product of the vectors  $(x_1, y_1, z_1)$  and  $(x_2, y_2, z_2)$  is defined as  $x_1*x_2 + y_1*y_2 + z_1*z_2$ . We assume that the two vectors are already loaded into the DSP's data RAM: the first at locations 0 through 2 of data RAM 0, and the second at the same locations in data RAM 1. The elements of the vectors are presumed to be 16.16 fixed point numbers. The result is stored in location 0 of data RAM 2.

```

mov 0,ct0      ; Point CT0 at the first input vector.
mov 0,ct1      ; Point CT1 at the second input vector.
;
; Now that the index registers are initialized, we can start loading
; the vector elements. The first instruction loads the first elements
; of the two vectors into RX and RY, clears the accumulator, and
; initializes the index register that will be used to store the
; results. The second instruction loads the second vector elements and
; moves the product of the first two elements into the P register. The
; third instruction loads the third vector elements, moves the product
; of the second elements into the P register, and adds the product of
; the first vector elements to the accumulator, and so on. Finally, we
; store the upper 32 bits of the accumulator to data RAM 2.
;
                mov mc0,x          mov mc1,y  clr a      mov 0,ct2
                mov mc0,x  mov mul,p  mov mc1,y
ad2  mov mc0,x  mov mul,p  mov mc1,y  mov alu,a
ad2                mov mul,p                mov alu,a
ad2                mov alu,a  mov alh,mc2
endi

```

### 8.2 Matrix Multiplication

This example multiplies two 3x3 matrices together. The entries in the matrices are presumed to be 16.16 fixed-point numbers. The matrices are initially in work RAM, so the DSP must transfer them into its data RAM before multiplying them together. When the product has been computed, it will be transferred to work RAM.

```

Mat1Addr  = $6020000    ; Work RAM address of first input matrix.
Mat2Addr  = $6020100    ; Work RAM address of second input matrix.
MatOutAddr = $6020200    ; Work RAM destination for product matrix.
Mat1      = 0           ; Address of first matrix in data RAM 0.

```

```

Mat2      = 0           ; Address of second matrix in data RAM 1.
M2Tmp     = 0           ; Temp. address of 2nd matrix in data RAM 3.
MProd     = 0           ; Address of product matrix in data RAM 2.

        org 0

;
; Load the second matrix first, because we're going to transpose it
; while the first matrix is loading. Note that the work RAM address
; of the matrix is divided by four before being loaded into RA0.
;
        mov  M2Tmp,ct3   ; Load second matrix into data RAM 3.
        mvi  Mat2Addr>>2,ra0
        dma  d0,m3,9     ; Transfer the 9 words of the second matrix.
DMAWtM2:  jmp  t0,DMAWtM2 ; Wait for DMA to be done.
        mov  Mat1,ct0    ; Prefetched: happens each time jump does.
;
; Now load the first matrix into data RAM 0.
;
        mvi  Mat1Addr>>2,ra0
        dma  d0,m0,9     ; Transfer the 9 words of the first matrix.
;
; While the first matrix is loading, copy the second matrix from data
; RAM 3 to data RAM 1, transposing it as we go. We want the second
; matrix to be transposed in order to index the elements of the matrix
; more efficiently during the actual matrix multiplication.
;
        mov  M2Tmp,ct3
        mov  Mat2,ct1    ; Copy the first row of the original matrix
        mov  mc3,mc1     ; to the first column of the transposed
        mov  Mat2+3,ct1 ; matrix.
        mov  mc3,mc1
        mov  Mat2+6,ct1
        mov  mc3,mc1

        mov  Mat2+1,ct1 ; Copy the second row of the original matrix
        mov  mc3,mc1     ; to the second column of the transposed
        mov  Mat2+4,ct1 ; matrix.
        mov  mc3,mc1
        mov  Mat2+7,ct1
        mov  mc3,mc1

        mov  Mat2+2,ct1 ; Copy the third row of the original matrix
        mov  mc3,mc1     ; to the third column of the transposed
        mov  Mat2+5,ct1 ; matrix.
        mov  mc3,mc1
        mov  Mat2+8,ct1
        mov  mc3,mc1

DMAWtM1:  jmp  t0,DMAWtM1 ; Make sure DMA is done.
        mov  Mat2,ct1    ; Point at second matrix (prefetched).
        mov  Mat1,ct0    ; Point at first matrix.
;
; Now that the matrices are in place and in an advantageous format, we
; can multiply them together efficiently.

```

;

```
        mov mc0,x          mov mc1,y
        mov mc0,x mov mul,p mov mc1,y clr a
ad2 mov mc0,x mov mul,p mov mc1,y mov alu,a mov Mat2,ct1
ad2 mov mc0,x mov mul,p mov mc1,y mov alu,a mov MProd,ct2
ad2 mov mc0,x mov mul,p mov mc1,y clr a      mov alh,mc2
ad2 mov mc0,x mov mul,p mov mc1,y mov alu,a mov Mat2,ct1
ad2 mov mc0,x mov mul,p mov mc1,y mov alu,a mov MProd+3,ct2
ad2 mov mc0,x mov mul,p mov mc1,y clr a      mov alh,mc2
ad2 mov mc0,x mov mul,p mov mc1,y mov alu,a mov Mat1,ct0
ad2          mov mul,p          mov alu,a mov Mat2+3,ct1
ad2 mov mc0,x          mov mc1,y mov alu,a mov MProd+6,ct2
        mov mc0,x mov mul,p mov mc1,y clr a      mov alh,mc2
ad2 mov mc0,x mov mul,p mov mc1,y mov alu,a mov Mat2+3,ct1
ad2 mov mc0,x mov mul,p mov mc1,y mov alu,a mov MProd+1,ct2
ad2 mov mc0,x mov mul,p mov mc1,y clr a      mov alh,mc2
ad2 mov mc0,x mov mul,p mov mc1,y mov alu,a mov Mat2+3,ct1
ad2 mov mc0,x mov mul,p mov mc1,y mov alu,a mov MProd+4,ct2
ad2 mov mc0,x mov mul,p mov mc1,y clr a      mov alh,mc2
ad2 mov mc0,x mov mul,p mov mc1,y mov alu,a mov Mat1,ct0
ad2          mov mul,p          mov alu,a mov Mat2+6,ct1
ad2 mov mc0,x          mov mc1,y mov alu,a mov MProd+7,ct2
        mov mc0,x mov mul,p mov mc1,y clr a      mov alh,mc2
ad2 mov mc0,x mov mul,p mov mc1,y mov alu,a mov Mat2+6,ct1
ad2 mov mc0,x mov mul,p mov mc1,y mov alu,a mov MProd+2,ct2
ad2 mov mc0,x mov mul,p mov mc1,y clr a      mov alh,mc2
ad2 mov mc0,x mov mul,p mov mc1,y mov alu,a mov Mat2+6,ct1
ad2 mov mc0,x mov mul,p mov mc1,y mov alu,a mov MProd+5,ct2
ad2 mov mc0,x mov mul,p mov mc1,y clr a      mov alh,mc2
ad2 mov mc0,x mov mul,p mov mc1,y mov alu,a
ad2          mov mul,p          mov alu,a mov MProd+8,ct2
ad2          clr a      mov alh,mc2
```

;

; The product has now been computed, so send it to work RAM and halt.

;

```
        mvi MatOutAddr>>2,wa0
        mov MProd,ct2
        dma m2,d0,9
DMAWtP: jmp t0,DMAWtP ; Wait for DMA to be done.
        nop      ; Prefetched.
        endi
```

**SEGA SATURN TECHNICAL BULLETIN #SOA-9**

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** August 16, 1995  
**Re:** Saturn SCU DSP Programmer's Reference

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The following page contains a quick reference table for SCU DSP programming. \_

## Saturn SCU DSP Programmer's Reference

| Instruction                                                                                                                                                                                                     | Description                                        | T S Z C V E x                                                                                                                             | ALU Instructions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|-------------------------------|-----------------------|-----|-----|-----|-----|-----|
| AD2                                                                                                                                                                                                             | Add ACH and ACL to PH and PL                       | - S Z C V - -                                                                                                                             | ALU results will not be stored in the accumulator unless MOV ALU, A is used. ALU results may be stored in memory, and condition codes will be set correctly, even if MOV ALU, A is not used. If CLR A is used, condition codes are still set based on the ALU result, and the ALU result may still be stored to memory. The ALU result must be retrieved or stored in the same cycle in which it is computed, or it will be lost.                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| ADD                                                                                                                                                                                                             | Add ACL and PL                                     | - S Z C V - -                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| AND                                                                                                                                                                                                             | And ACL with PL                                    | - S Z 0 - - -                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| <b>A</b> NOP                                                                                                                                                                                                    | Do nothing                                         | - - - - - -                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| OR                                                                                                                                                                                                              | Or ACL with PL                                     | - S Z 0 - - -                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| <b>L</b> RL                                                                                                                                                                                                     | Rotate ACL left once; d31 moves to d0 and to C     | - S Z C - - -                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| RL8                                                                                                                                                                                                             | Rotate ACL left 8 times; d24 moves to d0 and to C  | - S Z C - - -                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| <b>U</b> RR                                                                                                                                                                                                     | Rotate ACL right once; d0 moves to d31 and to C    | - S Z C - - -                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| SL                                                                                                                                                                                                              | Shift ACL left once; d31 moves to C                | - S Z C - - -                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| SR                                                                                                                                                                                                              | Shift ACL right once arithmetically; d0 moves to C | - S Z C - - -                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| SUB                                                                                                                                                                                                             | Subtract PL from ACL                               | - S Z C V - -                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| XOR                                                                                                                                                                                                             | Exclusive-or ACL with PL                           | - S Z 0 - - -                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| <b>Multiplication</b>                                                                                                                                                                                           |                                                    |                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| <b>X</b> MOV dram+,X                                                                                                                                                                                            | Move data RAM to RX                                | - - - - - -                                                                                                                               | The product of the RX and RY registers can be read by using MOV MUL, P one cycle after the values of RX and/or RY are set. The product remains available until RX or RY is altered.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| MOV MUL,P                                                                                                                                                                                                       | Move 48-bit multiplier result into PH and PL       | - - - - - -                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| MOV dram+,P                                                                                                                                                                                                     | Move data RAM to PL and sign extend into PH        | - - - - - -                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| <b>Y</b> MOV dram+,Y                                                                                                                                                                                            | Move data RAM to RY                                | - - - - - -                                                                                                                               | <b>Immediate Data</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| CLR A                                                                                                                                                                                                           | Set accumulator to 0                               | - - - - - -                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| MOV ALU,A                                                                                                                                                                                                       | Gate results of ALU operation into accumulator     | - - - - - -                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| MOV dram+,A                                                                                                                                                                                                     | Move data RAM to ACL and sign extend into ACH      | - - - - - -                                                                                                                               | Immediate data is signed; sign extension is performed when moving immediate data into a register or into memory.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| <b>D</b> MOV imm8,dest1                                                                                                                                                                                         | Move short immediate data to data RAM or register  | - - - - - -                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| <b>I</b> MOV ALH,dest1                                                                                                                                                                                          | Move upper 32 bits of 48-bit accumulator           | - - - - - -                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| MOV ALL,dest1                                                                                                                                                                                                   | Move lower 32 bits of 48-bit accumulator           | - - - - - -                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| MOV dram+,dest1                                                                                                                                                                                                 | Move data RAM to data RAM or register              | - - - - - -                                                                                                                               | <b>DMA</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| MVI imm25,dest2                                                                                                                                                                                                 | Move immediate data to data RAM or register        | - - - - - -                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Addresses stored in RA0 or WA0 are multiplied by four before being used to address external memory. When DMAH is used, RA0 or WA0 is reset to its starting value after the transfer is complete, allowing the same transfer to be performed repeatedly without reinitializing RA0 or WA0. |    |                               |                       |     |     |     |     |     |
| MVI imm19,dest2,cond                                                                                                                                                                                            | Move immediate data conditionally                  | - - - - - -                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| DMA D0,dpram,imm8                                                                                                                                                                                               | Transfer from external RAM to data/program RAM     | 1 - - - - - -                                                                                                                             | <b>Jump Instructions</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| DMA dram,D0,imm8                                                                                                                                                                                                | Transfer from data RAM to external RAM             | 1 - - - - - -                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| DMA D0,dpram,ctr                                                                                                                                                                                                | Transfer from external RAM to data/program RAM     | 1 - - - - - -                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| DMA dram,D0,ctr                                                                                                                                                                                                 | Transfer from data RAM to external RAM             | 1 - - - - - -                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| DMAH D0,dpram,imm8                                                                                                                                                                                              | Transfer from external RAM to data/program RAM     | 1 - - - - - -                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| DMAH dram,D0,imm8                                                                                                                                                                                               | Transfer from data RAM to external RAM             | 1 - - - - - -                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| DMAH D0,dpram,ctr                                                                                                                                                                                               | Transfer from external RAM to data/program RAM     | 1 - - - - - -                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| DMAH dram,D0,ctr                                                                                                                                                                                                | Transfer from data RAM to external RAM             | 1 - - - - - -                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| JMP imm8                                                                                                                                                                                                        | Unconditional jump                                 | - - - - - -                                                                                                                               | JMP Z,imm8 jumps if the Z flag is set<br>JMP NZ,imm8 jumps if Z is clear.<br>JMP ZS,imm8 jumps if either Z or S is set.<br>JMP NZS,imm8 jumps if Z and S are both clear.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| JMP cond,imm8                                                                                                                                                                                                   | Conditional jump                                   | - - - - - -                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| BTM                                                                                                                                                                                                             | If LOP=0, do nothing, else decrement LOP; PC=TOP   | - - - - - -                                                                                                                               | The instruction after a JMP or BTM instruction is always executed, whether the jump is taken or not.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| LPS                                                                                                                                                                                                             | Repeat the next instruction LOP+1 times            | - - - - - -                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| END                                                                                                                                                                                                             | Halt without interrupt                             | - - - - - 0                                                                                                                               | <b>Subroutines</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| ENDI                                                                                                                                                                                                            | Halt with interrupt                                | - - - - - 1 0                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| cond = Z, NZ, S, NS, C, NC, T0, NT0, ZS, NZS<br>ctr = M0-M3, MC0-MC3<br>dest1 = MC0-MC3, RX, PL, RA0, WA0, LOP, TOP, CT0-CT3<br>dest2 = MC0-MC3, RX, PL, RA0, WA0, LOP, PC<br>dpram = M0-M3 or PRG              |                                                    | dram = M0-M3<br>dram+ = M0-M3 or MC0-MC3<br>imm8 = 8-bit immediate data<br>imm19 = 19-bit immediate data<br>imm25 = 25-bit immediate data | Subroutines can be created by taking advantage of the fact that when loading an immediate value into the PC using the MVI instruction, the previous value of the PC is copied to the TOP register. The value that gets copied to the TOP register is the address in program RAM of the instruction immediately following the MVI instruction. If the LOP register is initialized to 1, then the BTM instruction can be used to return from the subroutine, as follows:<br><br><pre> mov 1,lop ; D1 bus. mvi Sub,pc ; Go to subroutine. nop ; Gets prefetched. . . Sub: mov ... ; Whatever. . . btm ; Return to nop. </pre> Note that the NOP gets executed twice: once when the subroutine call is made, and once after the subroutine returns. |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| <b>Data Movement Table</b>                                                                                                                                                                                      |                                                    |                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| The following table shows which source/destination combinations are supported by the DSP's various move instructions and whether the data movement is performed by the X bus, the Y bus, the D1 bus, or by MVI. |                                                    |                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| Destinations                                                                                                                                                                                                    |                                                    |                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
| Sources                                                                                                                                                                                                         | A                                                  | P                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | RX                                                                                                                                                                                                                                                                                        | RY | RA0                           | WA0                   | LOP | TOP | PC  | CTn | mem |
| ALH                                                                                                                                                                                                             | -                                                  | D1                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | D1                                                                                                                                                                                                                                                                                        | -  | D1                            | D1                    | D1  | D1  | -   | D1  | D1  |
| ALL                                                                                                                                                                                                             | -                                                  | D1                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | D1                                                                                                                                                                                                                                                                                        | -  | D1                            | D1                    | D1  | D1  | -   | D1  | D1  |
| mem                                                                                                                                                                                                             | Y                                                  | X                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | X                                                                                                                                                                                                                                                                                         | Y  | D1                            | D1                    | D1  | D1  | -   | D1  | D1  |
| imm8                                                                                                                                                                                                            | -                                                  | D1                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | D1                                                                                                                                                                                                                                                                                        | -  | D1                            | D1                    | D1  | D1  | -   | D1  | D1  |
| imm25                                                                                                                                                                                                           | -                                                  | MVI                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | MVI                                                                                                                                                                                                                                                                                       | -  | MVI                           | MVI                   | MVI | -   | MVI | -   | -   |
| <b>DSP Registers</b>                                                                                                                                                                                            |                                                    |                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    | <b>Processor Status Flags</b> |                       |     |     |     |     |     |
| Name                                                                                                                                                                                                            | Size                                               | Description                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    | Name                          | Definition            |     |     |     |     |     |
| A (ALH/ALL)                                                                                                                                                                                                     | 48                                                 | Receives results of ALU operations                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    | PR                            | Pause reset           |     |     |     |     |     |
| P (PH/PL)                                                                                                                                                                                                       | 48                                                 | Receives results from multiplier                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    | EP                            | Execute pause         |     |     |     |     |     |
| RX                                                                                                                                                                                                              | 32                                                 | Multiplier input register                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    | T0                            | Transfer 0 (DMA flag) |     |     |     |     |     |
| RY                                                                                                                                                                                                              | 32                                                 | Multiplier input register                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    | S                             | Sign                  |     |     |     |     |     |
| CT0-CT3                                                                                                                                                                                                         | 6                                                  | Data RAM index registers                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    | Z                             | Zero                  |     |     |     |     |     |
| LOP                                                                                                                                                                                                             | 12                                                 | Loop counter                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    | C                             | Carry                 |     |     |     |     |     |
| TOP                                                                                                                                                                                                             | 8                                                  | Holds loop-start or subroutine return address                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    | V                             | Overflow/underflow    |     |     |     |     |     |
| PC                                                                                                                                                                                                              | 8                                                  | Program counter                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    | E                             | End interrupt         |     |     |     |     |     |
| RA0                                                                                                                                                                                                             | 32                                                 | DMA address for reading from external RAM                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    | ES                            | Execute single step   |     |     |     |     |     |
| WA0                                                                                                                                                                                                             | 32                                                 | DMA address for writing to external RAM                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    | EX                            | Execution control     |     |     |     |     |     |
|                                                                                                                                                                                                                 |                                                    |                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    | LE                            | PC load enable        |     |     |     |     |     |
| <b>SCU Registers Relating to the DSP</b>                                                                                                                                                                        |                                                    |                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    |                               |                       |     |     |     |     |     |
|                                                                                                                                                                                                                 |                                                    | 0x25fe0080                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    | Program control port          |                       |     |     |     |     |     |
|                                                                                                                                                                                                                 |                                                    | 0x25fe0084                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    | Program RAM data port         |                       |     |     |     |     |     |
|                                                                                                                                                                                                                 |                                                    | 0x25fe0088                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    | Data RAM address port         |                       |     |     |     |     |     |
|                                                                                                                                                                                                                 |                                                    | 0x25fe008c                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                           |    | Data RAM data port            |                       |     |     |     |     |     |

## **SEGA SATURN TECHNICAL BULLETIN #SOA-10**

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** August 16, 1995  
**Re:** Saturn SCU DSP Demonstration Program

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### **Introduction**

The Saturn SCU DSP Demonstration program provides sample code which runs on the DSP, along with a shell program written in Gnu C which loads the program into the DSP and executes it. The shell program uses the DSP support functions found in the DSP module of the Sega Standard Saturn Library for loading, starting, and halting the DSP. The demonstration program itself is available on Sega's BBS in the Saturn conference as the file DSP\_DEMO.ZIP.

### **List of Files**

The source and executable files are all in the directory "code". Here's a brief description of each file.

main.c Shell program source file.  
main.o Shell program object file.  
makefile Compiles, assembles, links, and rebuilds the ".lnk" file.  
pttrans.d DSP object code in C-compilable format.  
pttrans.dsp DSP source code.  
pttrans.s DSP object code in S-record format.  
sl.lnk Linker script file (built by the makefile).  
sl.map Map file.  
sl.sre Executable file in S-record format.

### **What the Program Does**

The DSP sample program performs 3D point transformation, i.e. it multiplies a 4x3 homogeneous matrix by an arbitrary list of 3-element vectors (the fourth element of each vector is presumed to be 1). The program attempts to take full advantage of the parallelism built into the DSP, and the transformation matrix, the input points, and the output points are transferred using the SCU's DMA capability. The sample code performs point transformations roughly a third faster than the equivalent code written in SH2 assembly language, even allowing for the time spent transferring data into and out of the DSP's memory. It is hoped that this program is general and useful enough to be used in an actual development environment.

The program accepts parameters in the form of a parameter block having the following format:

|                        |                                                                           |
|------------------------|---------------------------------------------------------------------------|
| Parameter Block + 0x0: | Address (divided by 4) of the transformation matrix in work RAM.          |
| Parameter Block + 0x4: | The number of points to be transformed.                                   |
| Parameter Block + 0x8: | Address (divided by 4) of the first input point.                          |
| Parameter Block + 0xc: | Address (divided by 4) of a buffer that will hold the transformed points. |

If you specify more points than the DSP can hold in its memory at one time, the program will load and transform the points in batches that will fit into the DSP's data RAM.

The addresses are divided by four because the contents of the DSP's DMA read and write registers get multiplied by four before they are used, and the SH2 is better suited to performing clerical work such as adjusting parameter formats than the DSP is.

### **Building and Running the Program**

The program was built using Gnu C version 95q1 and version 2.00 of the SCU DSP assembler. The makefile provided will rebuild the executable file if you make any changes. The makefile is configured to produce an executable file in S-record format. See the next section for instructions on how to alter the makefile so that it produces output in COFF format. Once the program has been downloaded, execute it starting at address 0x6004000. You won't see anything on the screen; the shell program just loads and runs the DSP program and then drops into an infinite loop. In order to check the results of the DSP program, you must break out of the shell program and examine the array OutputPts.

### **Getting Output in COFF Format**

You can get an executable file in COFF format by modifying the makefile as follows: first, for formality's sake, change all of the ".sre" file extensions to ".cof". Then find the OUPUT\_FORMAT instruction in the portion of the makefile that builds the linker script, and change "srec" to "coff-sh". That's it.

## SEGA SATURN TECHNICAL BULLETIN #SOA-11

**To:** Sega and Third Party Developers  
**From:** Developer Technical Support  
**Date:** August 16, 1995  
**Re:** VDP2 Rotating Backgrounds

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### Introduction

The Saturn's rotating background hardware allows you to rotate a character or bit mapped image in several different ways. Scaling and translation are also supported. This document provides an overview of the capabilities and limitations of this hardware. It is not intended to fully document every feature of the hardware, but to clarify the concepts underlying its operation. We presume that you have an understanding of basic 3D graphics concepts such as rotation matrices.

### What Does It Do?

The Saturn Basic Library displays rotated backgrounds in a right-handed coordinate system (see Fig. 1). The positive Z direction points into the screen, and positive rotations are clockwise as you look toward the origin from the positive end of each primary axis, as shown in the figure.

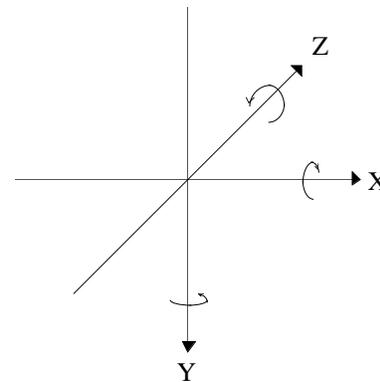


Figure 1

The coordinate system in which the rotating backgrounds are displayed.

Before a background is rotated, it exists in the XY plane, with its upper-left-hand corner at the origin. When the VDP2 rotates and otherwise transforms such a background, it performs a number of operations in a fixed sequence (note that this description, while conceptually accurate, does not necessarily reflect the manner in which these operations are implemented in the hardware):

Step 1. The background is translated in X and Y.

Step 2. The translated background is rotated twice around a center of rotation that you specify. First, the background is rotated around an axis that passes through the center

point and is parallel to the Z axis, i.e. the background rotates in the XY plane. Then the background is rotated around an axis that passes through the center point and is parallel to either the horizontal axis (the X axis) or the vertical axis (the Y axis). Rotation around a horizontal axis and rotation around a vertical axis are mutually exclusive. In practice, these two rotations are accomplished using a single rotation matrix in the rotation parameter table, but it may be helpful to think of them as being separate.

Step 3. The twice-rotated background is now projected onto the screen by scaling each line or column of the display to simulate perspective: lines or columns that are far away are scaled down; lines or columns that are close are scaled up. If you rotated around a horizontal axis in step 3, then the transformed background is scaled line-by-line. If you rotated around a vertical axis, then it is scaled column-by-column.

Step 4. The transformed and projected background is rotated one last time around the Z axis. This is equivalent to what you would expect to see while banking in a flight simulator. Note that this last rotation can be applied to the VDP1 frame buffer as well, allowing the sprites and the background to rotate together. To do this, set the TVM field of the VDP1's TV mode register to either 2 (Rotation 16 mode) or 3 (Rotation 8 mode). For further details, see pp. 15 and 36-37 of the *VDP1 User's Manual*.

Figure 2 (next page) illustrates this sequence of events. Of course, not all of these transformations need be performed, and any or all of them can be disabled by specifying a rotation or translation of zero.

### How Do You Control It?

The various rotation, translation, and scaling operations are controlled by the rotation parameter table (pp. 153-156 of the *VDP2 User's Manual*) and the coefficient table (ibid., pp. 163-165). In general, the rotation parameter table controls 3D transformation, while the coefficient table controls 2D perspective projection, though the coefficient table can be used to perform scaling as well. Here's how each step of the above sequence of transformations is controlled.

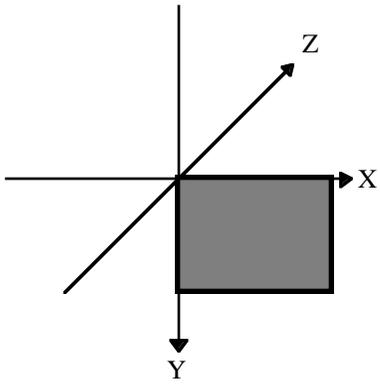
Step 1. The initial translation in X and Y is controlled by the 24-bit signed fixed-point values Mx and My, found at offsets 0x44 and 0x48 in the rotation parameter table. Positive values cause the background to move up and to the left on the screen.

Step 2. These rotations are controlled by a rotation matrix stored in the rotation parameter table. Each entry in the matrix is a 14-bit signed fixed point value. The hardware performs these two initial rotations according to the following formula:

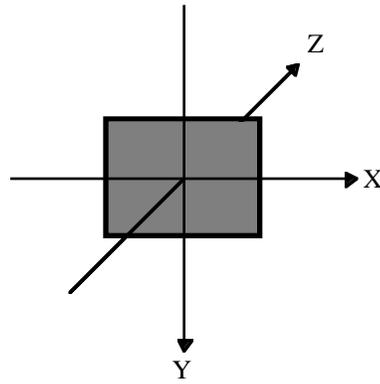
$$(X \ Y \ Z) * \begin{vmatrix} A & B & C \\ D & E & F \\ G & H & I \end{vmatrix} = (X_T \ Y_T \ Z_T)$$

Where (X Y Z) is an initial point and (X<sub>T</sub> Y<sub>T</sub> Z<sub>T</sub>) is the corresponding rotated point. A rotation of 90 degrees about the Z axis, for example, would be represented by the matrix

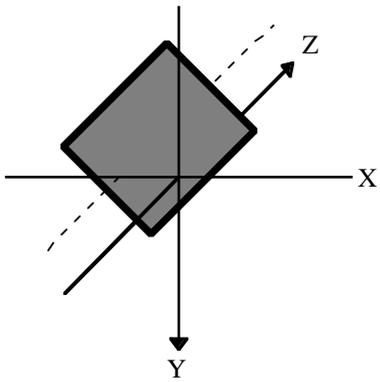
$$\begin{vmatrix} 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{vmatrix}$$



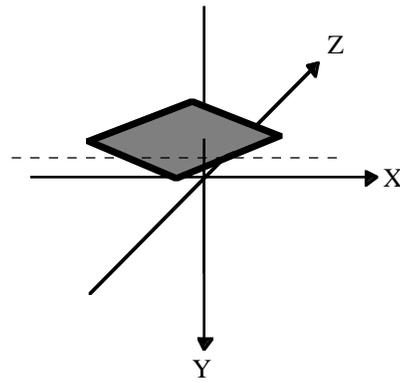
**Figure 2a**  
Initial orientation of the background.



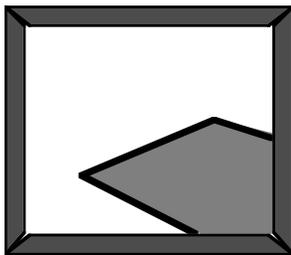
**Figure 2b**  
Translation in the XY plane.



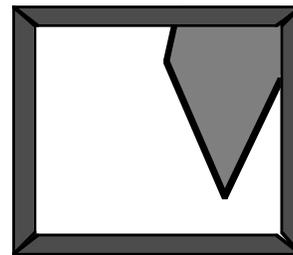
**Figure 2c**  
Rotation around an arbitrary perpendicular axis.



**Figure 2d**  
Rotation around an arbitrary horizontal axis.



**Figure 2f**  
2D projection.



**Figure 2g**  
Rotation about the Z axis.

The matrix stored in the rotation parameter table will, in general, be the product of a Z-rotation matrix and either an X-rotation matrix or a Y-rotation matrix. The Z-rotation is normally performed first.

The coordinates of the point around which these rotations are performed are specified in the rotation parameter table as three 14-bit signed integers at offsets 0x3c, 0x3e, and 0x40. If the coordinates of the center of rotation are  $(C_X C_Y C_Z)$ , then a more complete expression of the formula used for rotating points during these steps of the transformation process would be

$$(X-C_X \ Y-C_Y \ Z-C_Z) * \begin{vmatrix} A & B & C \\ D & E & F \\ G & H & I \end{vmatrix} + (C_X \ C_Y \ C_Z) = (X_T \ Y_T \ Z_T)$$

The rotation parameter table stores the matrix entries as 14-bit signed fixed point numbers at offsets 0x1c through 0x30. Only the first two rows of the matrix are stored. The class of rotations supported by the hardware is sufficiently restricted that the third row can be done without.

Step 3. It is at this stage that the coefficient table comes into play. A coefficient must be calculated for each row or column of the display, depending on whether rotation was performed about a horizontal axis or a vertical axis. Each coefficient specifies the amount of perspective distortion to apply to each line or column of the screen. Smaller coefficients cause a greater degree of magnification. The coefficients are fixed-point numbers, and a couple of formats are available (see p. 165 of the *VDP2 User's Manual*). The coefficient tables may also be used to scale the projected image: multiplying all of the coefficients by a constant causes the image on the screen to zoom in or out. Scaling the image can also be accomplished with the matrix in the rotation parameter table.

Refer to the file scl\_ro00.C in the Saturn Basic Library to see how the coefficients are actually calculated. The calculations are performed in the functions SCL\_RotateX and SCL\_RotateY. Look for assignments to SclK\_TableBuff[TbNum][i].

The range of Z coordinates that get projected onto the screen, as well as the degree of perspective compression, is determined by the point of view. The coordinates of the point of view  $(P_X P_Y P_Z)$  are 14-bit signed integers found at offsets 0x34, 0x36, and 0x38 in the rotation parameter table. The Z coordinate of the point of view corresponds to the distance from the point of view to the background before any transformations are performed. The X and Y coordinates are normally set to the center of the screen, e.g. 160 and 112 for a 320x224 screen.

Step 4. The final rotation of the projected image about the Z axis is a 2D rotation, and it is performed by scanning the projected image "diagonally." The rotation parameter table specifies the horizontal and vertical offsets from the unrotated upper-left-hand corner of the screen to the rotated upper-left-hand corner of the screen using a pair of 23-bit signed fixed-point values (Xst and Yst) at offsets 0 and 4. In addition, delta-x and delta-y values giving the angles of the rotated X and Y axes are specified in the rotation parameter table as 13-bit signed fixed-point numbers at offsets 0xc and 0x10 (for the rotated Y axis) and 0x14 and 0x18 (for the rotated X axis).

If X or Y rotation is being performed, then the coefficient table must also be scanned differently in order to perform this final Z rotation. Both the rate and the direction in which the coefficient table is scanned for each row and for each column of pixels varies

with the angle of rotation. This is controlled by the values  $K_{Ast}$ ,  $\Delta K_{Ast}$  and  $\Delta K_{Ax}$  at offsets 0x54, 0x58, and 0x5c in the rotation parameter table.  $K_{Ast}$  determines where scanning of the coefficient table begins;  $\Delta K_{Ast}$  determines the increment which will be used to step through the coefficient table line-by-line, and  $\Delta K_{Ax}$  determines the increment which will be used to step through the table column-by-column. Note that these values are fixed-point values, and fractional increments are possible. Refer to the file `scl_ro00.C` in the Saturn Basic Library to see how to set these values. The values are set in the functions `SCL_RotateX()` and `SCL_RotateY()`. Look for assignments to `SclRotregBuff[TbNum].k_tab`, `SclRotregBuff[TbNum].k_delta.x`, and `SclRotregBuff[TbNum].k_delta.y`.

## SEGA SATURN TECHNICAL BULLETIN #SOA-12

**To:** SEGA and Third Party Developers  
**From:** Developer Technical Support  
**Date:** October 24, 1995  
**Re:** Security Codes in the IP.BIN File

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In the IP.BIN file, at address 40H, all games must have the appropriate area symbols for the regions in which the game is to be released, along with the corresponding area code at address E00H. For example:

040H UT  
...

E00H ....For USA and CANADA. (32 characters)  
.....For TAIWAN and PHILIPINES. (32 characters)

Please make sure that the area symbols and area codes match in order, and also pad out any unnecessary area codes with spaces making sure not to change other parts of the code. The final IP.BIN must be 4096 bytes.