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SEGA OF AMERICA, INC.
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SMPC
User's Manual

Doc. # ST-169-R1-072694

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Introduction

Explanation of Terminology

The terminology used in this manual is explained below.

SMPC (System Manager & Peripheral Control)

Controls peripheral equipment interfaces, such as SATURN system reset control, control PAD, etc.

The SMPC also has RTC (Real Time Clock) functions that can be backed up with a battery, making it possible to set and acquire calendar time.

SCSP (Saturn Custom Sound Processor)

Sound source LSI for multi-function games that integrate PCM sound source and sound DSP.

DSP (Digital Signal Processor)

High-speed calculation circuit used primarily for calculations (multiplication and addition).

VDP1 (Video Display Processor 1)

The LSI that controls the drawing of sprites and polygons. VRAM and a frame buffer are connected to the VDP1. These use the draw commands transferred to the VRAM from the CPU and execute drawing in the frame buffer. Then the draw data from the frame buffer is transferred to the VDP2 and displayed on a display device at the request from the VDP2.

VDP2 (Video Display Processor 2)

Contains scroll screen control functions and priority functions.

PLL (Phase Locked Loop)

All of the clock types (CPU, system control, image draw/display, sound, etc., clock generator) of the SATURN system.

SCU (System Control Unit)
Contains a CPU I/F, A-Bus I/F, and B-Bus I/F controller and smoothly transfers data between the various buses. The SCU also contains an internal DMA controller, interrupt controller, and DSP to perform DMA control, interrupt control, and high-speed calculation processing.

Main CPU
Contains a 32-bit RISC CPU SH-2 that controls the entire system.

MC68EC000
A sound control CPU with a SCSP that has SCSP control functions.

V-BLANK-IN
One of the three types of blanking interrupts. V-BLANK-IN shows the screen display end timing.

V-BLANK-OUT
One of the three types of blanking interrupts. V-BLANK-OUT shows the screen display start timing.

H-BLANK-IN
One of the three types of blanking interrupts. H-BLANK-IN shows the display end timing of one line.

Peripheral
Peripheral equipment connected to SATURN, such as control PAD, mouse, and keyboard.

Symbols Used in this Manual

The following symbols are used in this manual.

Binary

Shown by a "B" placed at the end. For example, 100B. When only 1 bit is used, however, the "B" is abbreviated.

Hexadecimal

Shown by an "H" at the end. For example, 00H or FFH.

Units

Shows that 1 KB is 1,024 bytes. Thus, 1 MB is 1,048,576 bytes.

MSB and LSB

In the structure of bytes and words, the left is the Most Significant Bit (MSB) and the right is the Least Significant Bit (LSB).

Undefined Bit

Undefined bits in the sound source register or DSP register are shown by "—."

(R)

Signifies a read dedicated register.

(W)

Signifies a write dedicated register.

(R/W)

Signifies a register in which both reading and writing are possible.

BCD

Binary Coded Decimal.

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Section 1 Overview

Section 1 Contents

1.1 System Configuration

The SMPC manages SATURN system reset control when the power is turned on and NMI requests to the master SH-2 when the reset button is pushed. In addition, commands from SH-2 turn each LSI on and off, sets and acquires calendar time, and collects data from peripherals. Also, the clock change command switches the horizontal resolution to and from 320 dots and 352 dots.

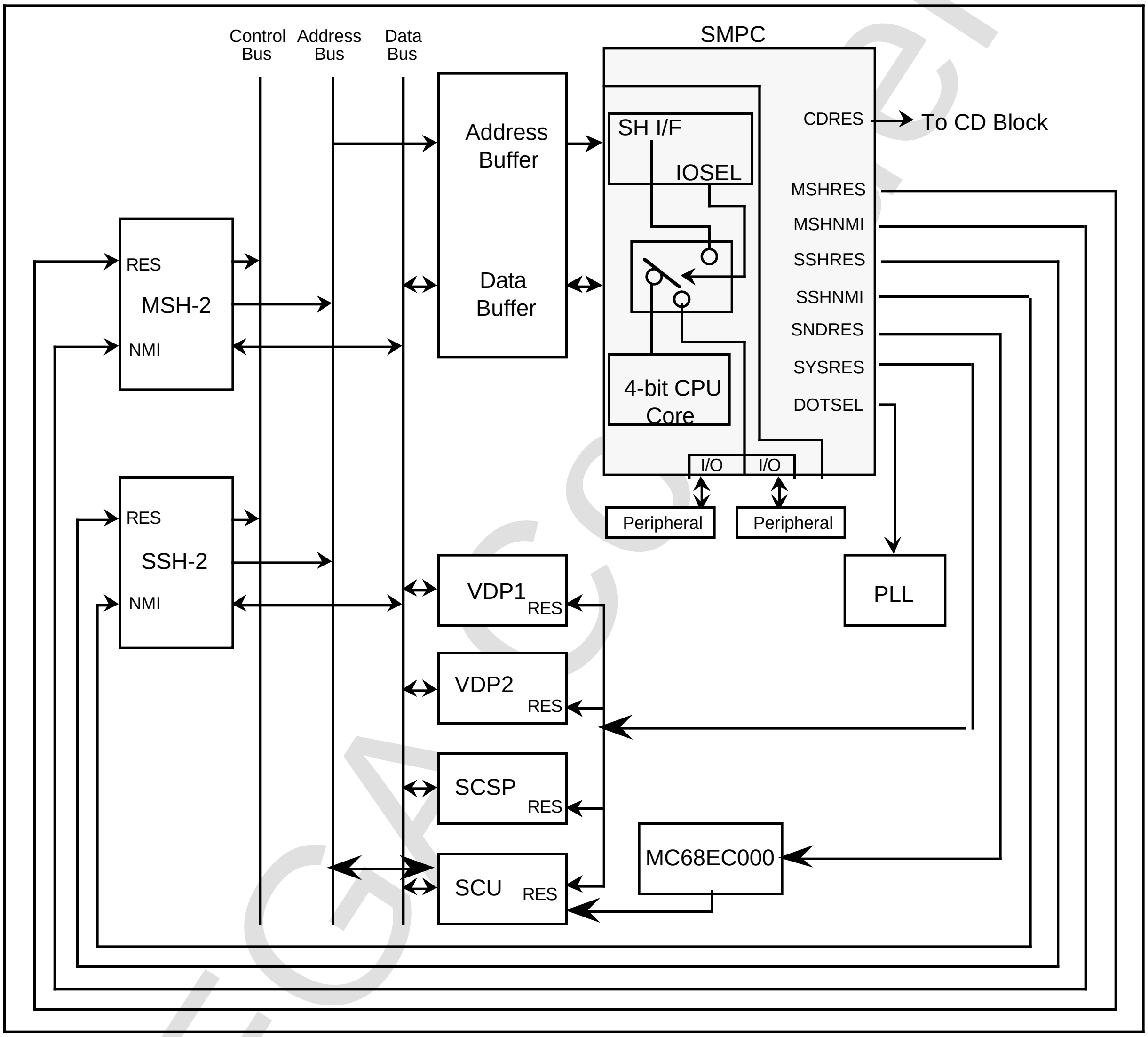


Figure 1.1 SMPC System Configuration

The SMPC has two sets of 7-bit parallel I/O ports. Access to I/O ports is controlled by the SMPC's internal firmware and there are two access methods that can be selected: the SMPC control mode which outputs collected data to the SMPC output register (OREG), and the SH-2 direct mode which has direct access from the SH-2. For details regarding the SMPC control mode and SH-2 direct mode, refer to Section 3.

During power on, the SATURN internal units are initialized as shown in Table 1.1.

Table 1.1 Initialization Status During Power On

Status	Description
Sound CPU OFF Status	A reset enters the sound CPU. Output by a power on vector by the SNDON command.
VDP1, VDP2, SCU, SCSP ON Status	A status where access from the SH-2 is possible.
Slave SH OFF Status	A reset enters the slave SH-2. Output by a power on vector by the SSHON command.
DOT SEL OFF Status	The PLL oscillation frequency is in the 320 mode (NTSC: 26.8741 MHz, PAL: 26.6875 MHz) and the VDP1, VDP2 and SH-2 are run at this frequency. Changed to run in 352 mode (NTSC: 28.6364 MHz, PAL: 28.4375 MHz) by the CKCHG352 command.
CD Block ON Status	A status where access from the SH-2 is possible.

Functions

The SMPC has three major functions: Real Time Clock (RTC), System Manager (SM), and Peripheral Control (PC).

The SMPC's main functions are shown in Table 1.2.

Table 1.2 SMPC Functions

RTC (Real Time Clock)	• Time setting and acquisition from SH-2. • Automatic update of date, day, time (Battery backup is possible when main power off)
SM (System Management)	• Sound CPU on and off • Master SH-2 and slave SH-2 on and off • System reset control • Clock switching (PLL switching) • Power on reset • NMI request to master SH-2 when front panel button is pushed down.
PC (Peripheral Control)	• Can support peripheral with SATURN peripheral interface specifications. • Automatic collection of peripheral data from control PAD, mouse, etc. • Also supports Mega Drive peripherals (3-button, 6-button, SEGA tap) (a conversion adapter is required, however)

PAD

The SATURN digital standard PAD has up, down, left, right, A, B, C, X, Y, Z, L, R, and Start buttons.

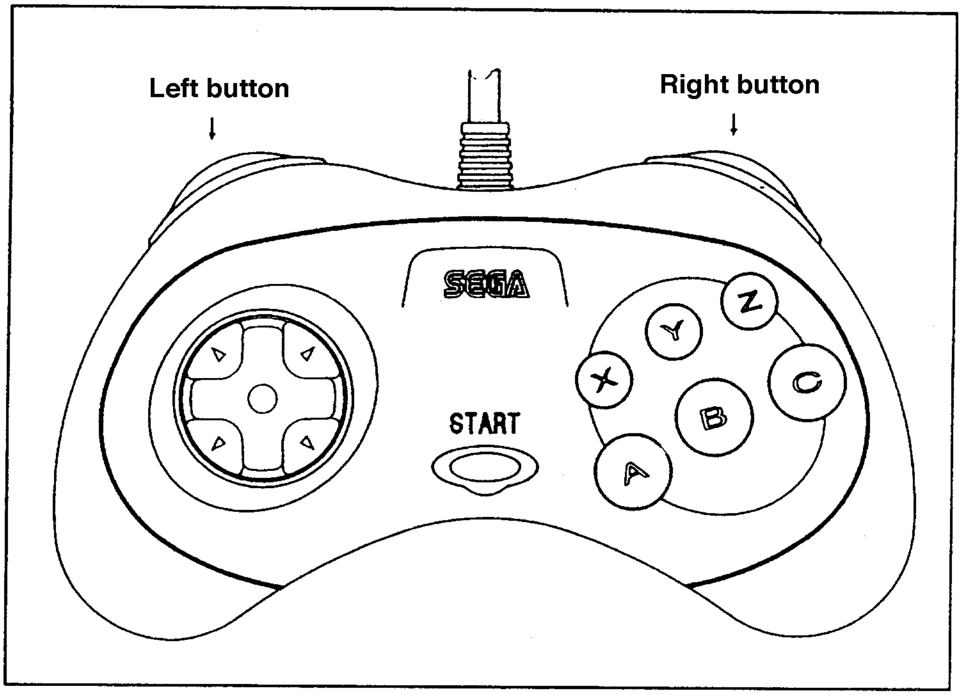


Figure 1.2 Standard Digital PAD for SATURN

1.2 SH-2 Interface

SH-2 Interface Registers

The SH-2 interface registers are registers that are used to receive commands, command parameters, and status display from the SH-2 and to output result parameters. Figure 1.3 shows the SH-2 interface register address map.

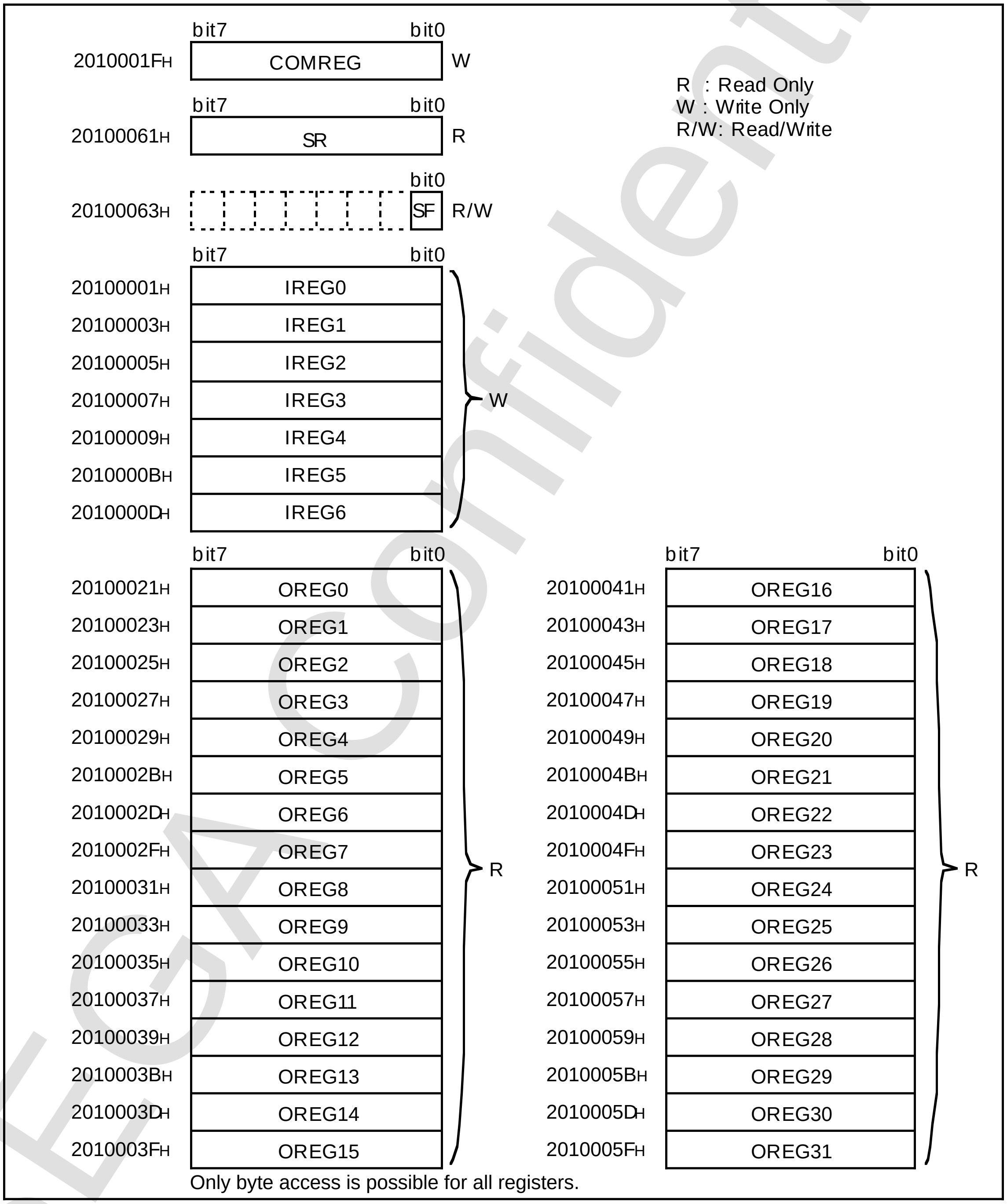


Figure 1.3 SH-2 Interface Register Address Map

The details on SH-2 interface registers are as follows:

COMREG (W): COMmand REGister

This is an 8-bit register used to receive commands from the SH-2. At the same time a command is written, the SMPC interprets and executes the command. The SMPC has resetable system management commands, non-resetable system management commands, and RTC commands. Use byte access from the SH-2.

SR (R): Status REGister

This 8-bit register is used to display the status after SMPC command execution. A read from the SH-2 can be done at any time regardless of the command being issued. For peripheral control, each peripheral control status is shown. Use byte access from the SH-2.

SF (R/W): Status Flag

This flag controls command issue. Flag set is performed by the SH-2 before command issue and the flag is reset by the SMPC when the command is ended. When from the SH-2, only set is possible, and when setting, write to 01H. During read, all bits except bit0 are undefined. Using this flag makes it possible to control the dual issue of commands.

IREG0~IREG6 (W): Input REGister 0~6

These 8-bit registers are used to receive command parameters from the SH-2. The SMPC has 7 IREG registers. Use byte access from the SH-2.

OREG0~OREG31 (R): Output REGister 0~31

These 8-bit registers are used to used to output result parameter and peripheral data to the SH-2. The SMPC has 32 OREG which are used when reading the cartridge code, area code, peripheral data, current time, etc. Use byte access from the SH-2.

Parallel I/O Registers

These registers are used to control the peripheral interface inside the SMPC. Figure 1.4 shows parallel I/O register address map. Write-only registers cannot be read, so caution regarding this is required.

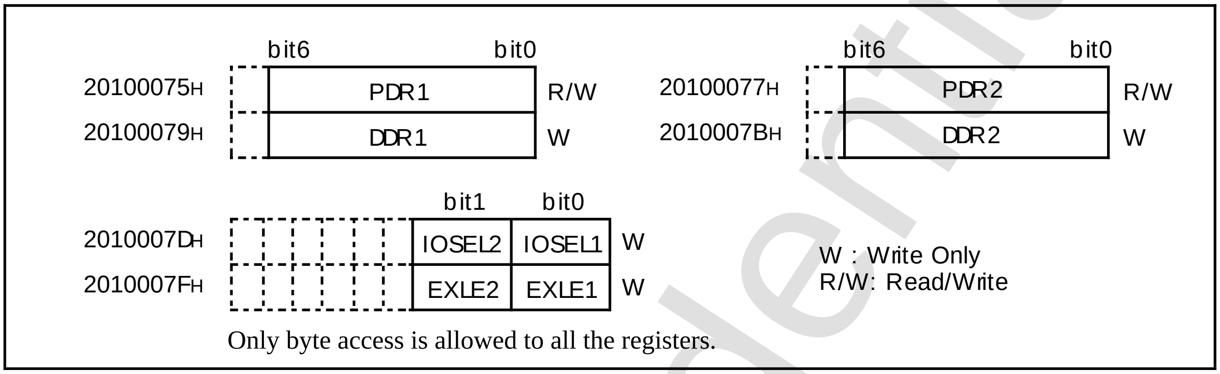


Figure 1.4 Parallel I/O Register Address Map

DDR1 (W): Data Direction Register 1

This is a 7-bit register used for setting, in bit units, the peripheral port 1 (P1) I/O direction. “0” is written to set for input and “1” is written to set for output. Please use byte access from the SH-2.

DDR2 (W): Data Direction Register 2

This is a 7-bit register used for setting, in bit units, the peripheral port 2 (P2) I/O direction. “0” is written to set for input and “1” is written to set for output. Please use byte access from the SH-2.

Table 1.3 DDR Functions

Bit	Function
0	Input Setting (Initial Value)
1	Output Setting

PDR1 (R or W): Port Data Register 1

The PDR1 is a 7-bit register that is used to store peripheral port 1 (P1) data. Whether all the PDR1 bits are at the input port or the output port is determined by DDR1 setting. The port terminal status that is set to output can be changed by writing data in this register. The port terminal status that is set to input can be changed by reading this register. Also, for ports set to output, the value written in to the PDR1 is read out rather than the terminal status. Please use byte access from the SH-2.

PDR2 (R or W): Port Data Register 2

The PDR2 is a 7-bit register that is used to store peripheral port 2 (P2) data. Whether all the PDR2 bits are at the input port or the output port is determined by DDR2 setting. The port terminal status that is set to output can be changed by writing data in this register. The port terminal status that is set to input can be changed by reading this register. Also, for ports set to output, the value written in to the PDR2 is read out rather than the terminal status. Please use byte access from the SH-2.

IOSEL1 (W): I/O SELect 1

The peripheral port 1 (P1) is set to SMPC control mode or SH-2 direct mode. Writing “0” specifies the SMPC control mode and writing “1” specifies the SH-2 direct mode. Use byte access from the SH-2.

IOSEL2 (W): I/O SELect 2

The peripheral port 2 (P2) is set to SMPC control mode or SH-2 direct mode. Writing “0” specifies the SMPC control mode and writing “1” specifies the SH-2 direct mode. Use byte access from the SH-2.

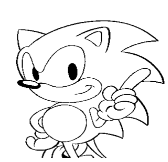
Table 1.4 IOSEL Functions

Bit	Function
0	Sets to SMPC control mode (Initial Value)
1	Sets to SH-2 direct mode

For details regarding each mode, refer to Section 3.

EXLE1 (W): EXternal Latch Enable 1

The peripheral port 1 (P1) bit 6 is a setting bit that is used for PAD interrupt and VDP2 external latch input. It is disabled by writing “0,” and the peripheral port 1 bit 6 is normally set as an I/O port. It is enabled by writing “1,” which allows the peripheral port 1 bit 6 to be used for PAD interrupt input or VDP2 external latch input. Use byte access from the SH-2.



EXLE2 (W): EXternal Latch Enable 2

The peripheral port 2 (P2) bit 6 is a setting bit that is used for PAD interrupt and VDP2 external latch input. It is disabled by writing “0,” and the peripheral port 1 bit 6 is normally set as an I/O port. It is enabled by writing “1,” which allows the peripheral port 1 bit 6 to be used for PAD interrupt input or VDP2 external latch input. Use byte access from the SH-2.

Table 1.5 EXLE Functions

Bit	Function
0	Disable (Initial Value)
1	Enable

EXLE is multiplexed in I/O port bit 6. Therefore, when using EXLE, the DDR1 and DDR2 bit 6 must be set to input. (Refer to VDP2 external latch functions and SCU PAD Interrupt.)

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Chapter 2 SMPC Commands

Section 2 Contents

2.1 SMPC Command List

SMPC commands are divided into three types; resetable system management commands, non-resetable system management commands, and RTC commands. Each of these commands is shown below.

Table 2.1 Resetable System Management Commands

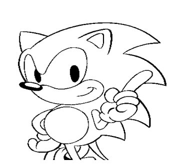
No	Command Name	Command Abbreviation	Command Code	SMPC Interrupt	SR	IREG	OREG	Execution Time sec	
								min	max
1	Master SH-2 ON	MSHON	00H	Unused	Unused	Unused	31	30µ	
2	Slave SH-2 ON	SSHON	02H	Unused	Unused	Unused	31	30µ	
3	Slave SH-2 OFF	SSHOFF	03H	Unused	Unused	Unused	31	30µ	
4	Sound ON	SNDON	06H	Unused	Unused	Unused	31	30µ	
5	Sound OFF	SNDOFF	07H	Unused	Unused	Unused	31	30µ	
6	CD ON	CDON	08H	Unused	Unused	Unused	31	40µ	
7	CD OFF	CDOFF	09H	Unused	Unused	Unused	31	40µ	
8	Reset Entire System	SYSRES	0DH	Unused	Unused	Unused	31	100m+ α	
9	Clock Change 352 Mode	CKCHG352	0EH	Unused	Unused	Unused	31	100m+ α	
10	Clock Change 320 Mode	CKCHG320	0FH	Unused	Unused	Unused	31	100m+ α	
11	NMI Request	NMIREQ	18H	Unused	Unused	Unused	31	30µ	
12	Reset Enable	RESENAB	19H	Unused	Unused	Unused	31	30µ	
13	Reset Disable	RESDISA	1AH	Unused	Unused	Unused	31	30µ	

Table 2.2 Non-Resetable System Management Commands

No	Command Name	Command Abbreviation	Command Code	SMPC Interrupt	SR	IREG	OREG	Execution Time sec	
								min	max
1	Interrupt Back	INTBACK	10H	Used	Used	0~2	0~31		320m
2	SMPC Memory Setting	SETSMEM	17H	Unused	Unused	0~3	31	40 µ	

Table 2.3 RTC Commands

No	Command Name	Command Abbreviation	Command Code	SMPC Interrupt	SR	IREG	OREG	Execution Time sec	
								min	max
1	Time Setting	SETTIME	16H	Unused	Unused	0~6	31	70 µ	



2.2 Command Issue

For commands to the SMPC, to issue commands when the command parameter is required after setting the SMPC status flag (SF) to “1,” set the command parameter, and write the command code in the SMPC command register.

When the SMPC command is issued, be careful of dual command issue. Prevention of dual issue of commands to the SMPC can be done using the SMPC status flag. When this flag is “1,” the SMPC is busy. When executing the command, verify that the status flag is “0” and then execute the command after setting “1.” The SMPC resets the status flag to “0” when the command is completed.

Command Execution Method

SMPC commands are classified by issue procedure and result parameter acquisition method according to the type of command execution contents, command parameter, and result parameter. These types and corresponding commands are shown in Table 2.4, and example issue methods for each type are shown in Figures 2.1 through 2.5.

(1) Type A This command resets the master SH-2 after command issue or changes to exception processing, such as NMI.

(2) Type B This command does not require the command parameter to be reset and the result parameter is not returned (except for OREG31, however).

(3) Type C This command requires the command parameter to be reset and the result parameter is not returned (except for OREG31, however).

(4) Type D This command requires the command parameter to be reset and the result parameter is returned, and also requires a SMPC interrupt at the time the result parameter is ready.

Table 2.4 Command Issue Types

Type	Command
A	MSHON, SYSRES, NMIREQ, CKCHG352, CKCHG320
B	SSHON, SSHOFF, SNDON, SNDOFF, CDON, CDOFF, RESENAB, RESDISA
C	SETTIME, SETSMEM
D	INTBACK

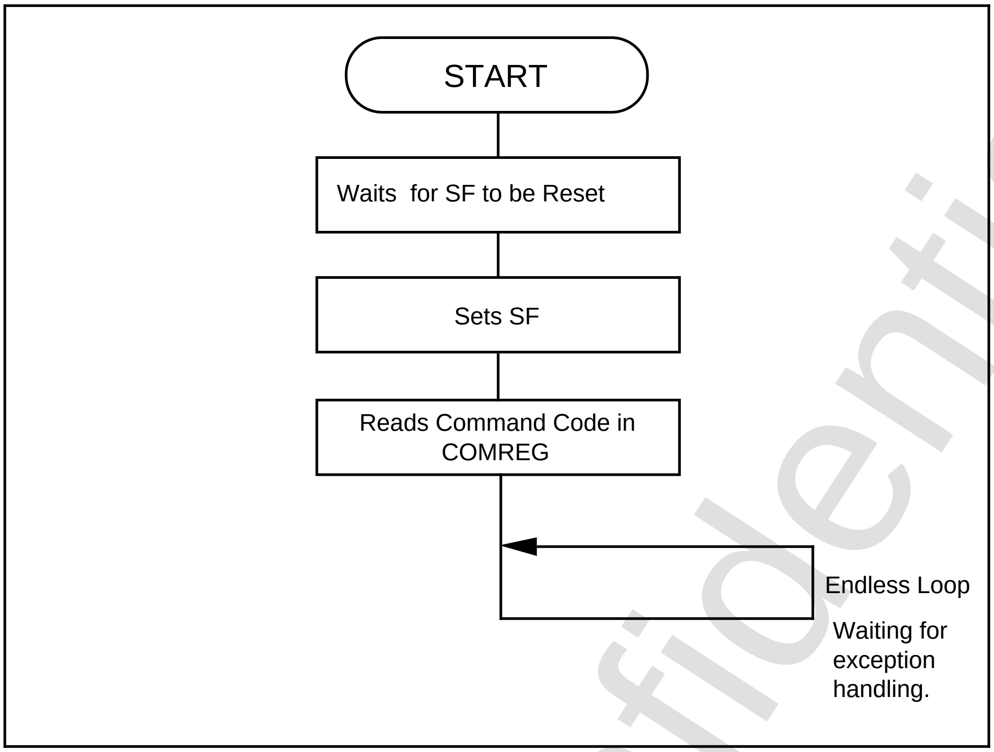


Figure 2.1 Type A Command Flow

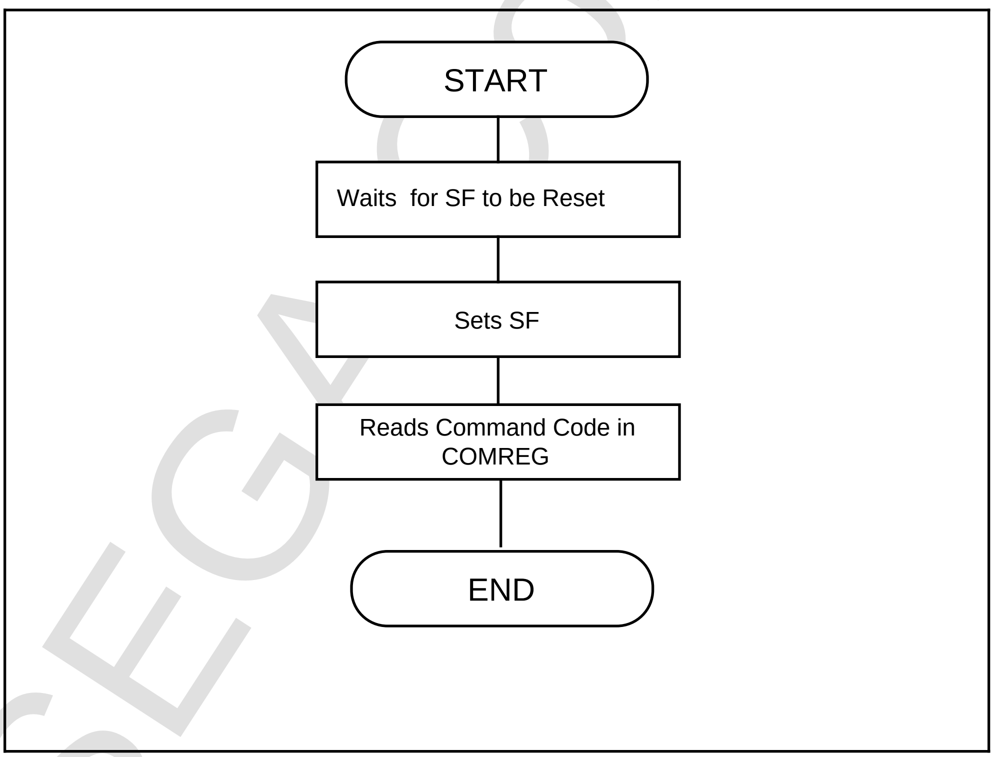
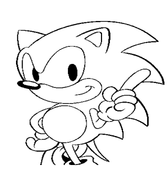


Figure 2.2 Type B Command Flow



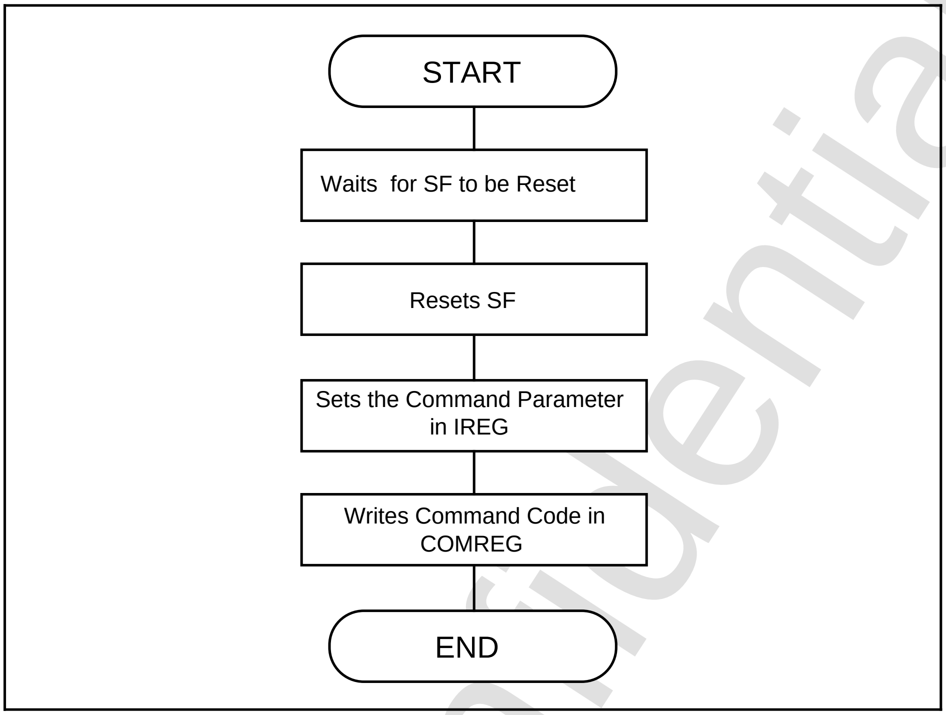


Figure 2.3 Type C Command Flow

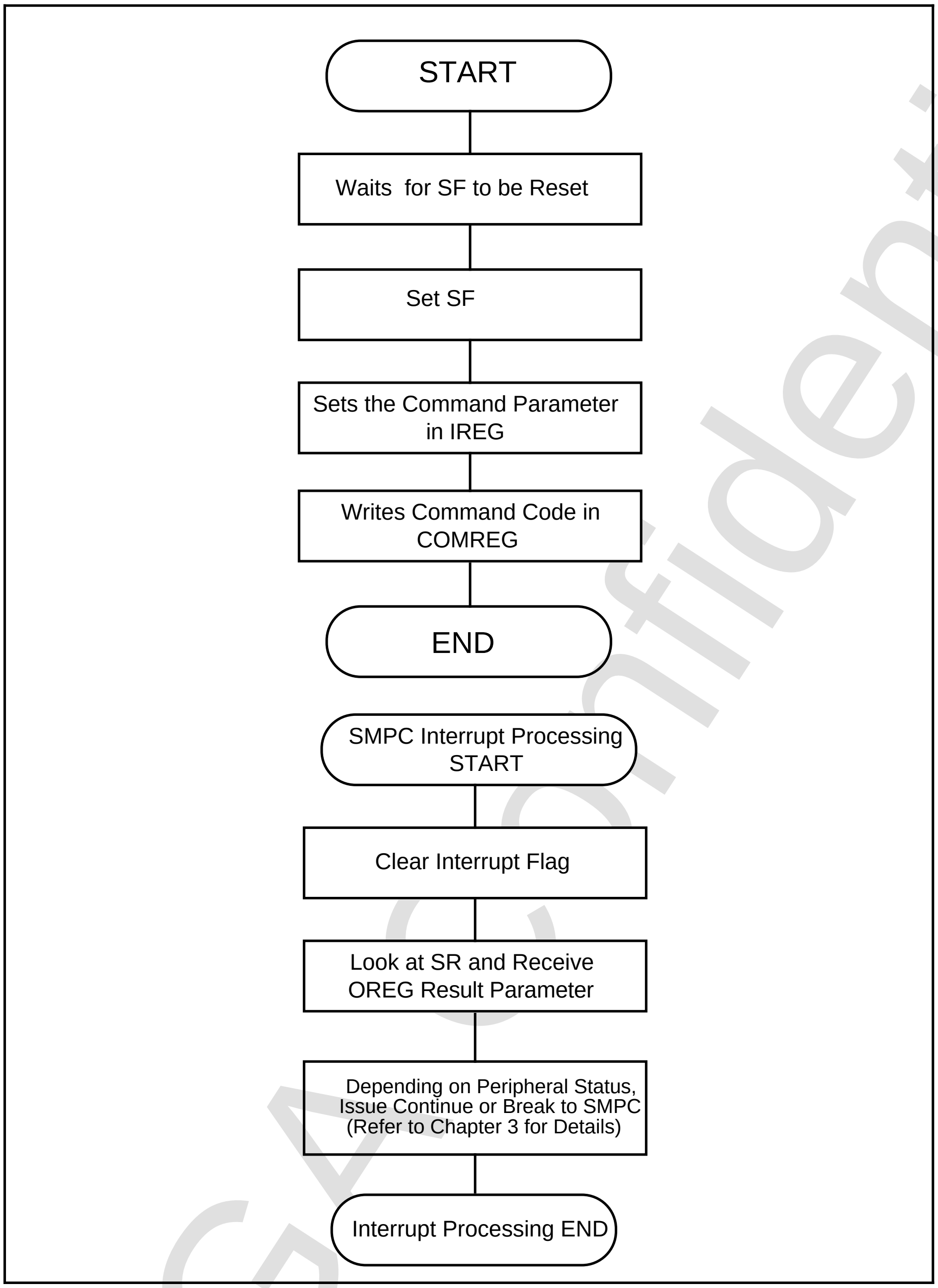
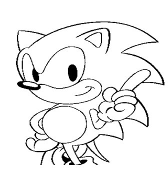


Figure 2.4 Type D Command Flow

Note: A routine similar to the SMPC interrupt routine can be executed by masking the SMPC routine (SMPC interrupt is not used) and conducting polling after the SMPC interrupt flag or SF clear is conducted.



Command Issue Timing

The SMPC uses the V-BLANK-IN interrupt to execute internal tasks. At this time, issuing commands for 300 ms from V-BLANK-IN is prohibited.

Also, the INTBACK command that is used to acquire the SMPC statuses and peripheral data has stricter issue timing than other commands. For details regarding the INTBACK command, refer to 2.4 “Non-Resetable System Management Commands” or Section 3 “Peripheral Control.”

- **Items Common to Command Issue Timing**
  As mentioned above, issuing commands for 300 µs from V-BLANK-IN is prohibited.

- **INTBACK Command**
  The INTBACK command begins collecting peripheral data at V-BLANK-OUT. To begin collecting peripheral data at V-BLANK-OUT, the INTBACK command must be issued in the period prior to V-BLANK-OUT after 300 µs following V-BLANK-IN..

  Figure 2.5 shows the INTBACK command execution timing.

  The INTBACK command is used in the following three ways.

  1) To acquire only the SMPC status.
  2) To collect peripheral data after acquiring the SMPC status.
  3) To acquire only peripheral data.

  When executing (2) “To collect peripheral data after acquiring the SMPC status,” a SMPC interrupt is generated at the time the SMPC status is OREG and a request for result parameter acquisition is made to the SH-2. The SMPC begins collecting peripheral data after the SH-2 makes a continue request.

  Here, even though a continue request has been issued after SMPC status acquisition, it is still necessary to issue an INTBACK command and request continue to begin collecting peripheral data at V-BLANK-OUT.

  SMPC status acquisition ends approximately 300 µs after INTBACK command issue, and a SMPC interrupt request is sent to the SMPC.

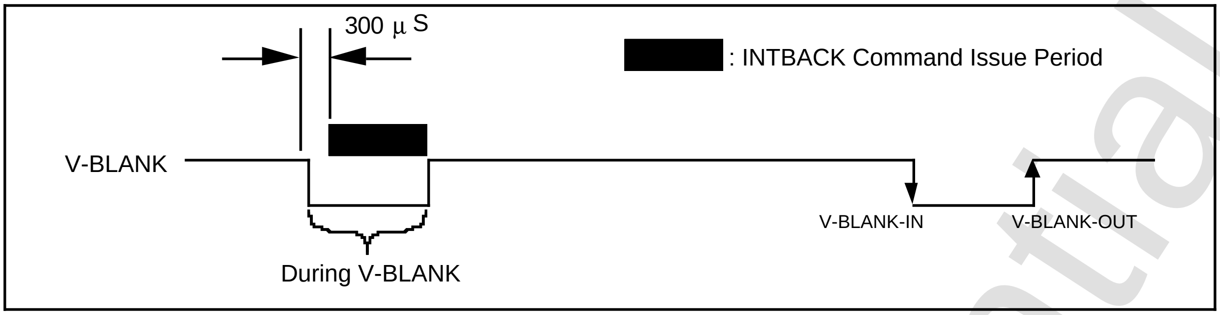


Figure 2.5 INTBACK Command Issue Timing

- **INTBACK Command Issue Timing after SYSRES, CKCHG320, CKCHG352 Command Execution**
  The command execution time for the above commands requires 100 msec or more. When an INTBACK command is issued after one of these commands is executed, wait to execute them until the next V-BLANK-IN. Figure 2.6 shows the INTBACK command issue timing after the SYSRES, CKCHG320, and CKCHG352 commands are executed.

  The SYSRES, CKCHG320, and CKCHG352 commands must be issued 300 µs after V-BLANK-IN and before the next V-BLANK-IN.

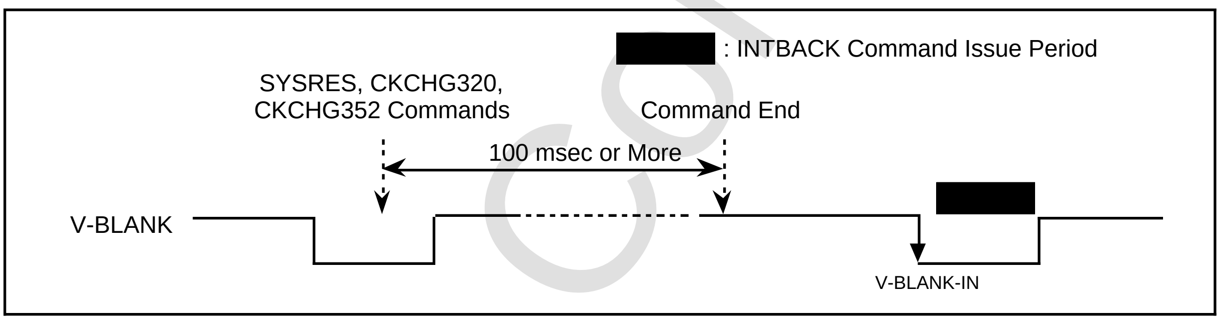
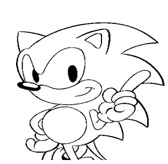


Figure 2.6 INTBACK Command Issue Timing After SYSRES, CKCHG320, and CKCHG352 Command Execution.

- **Issue Timing for Other Commands**
  When an INTBACK command is not issued in the same frame after one of the other commands is executed, the command must be issued 300 µs after V-BLANK-IN and before the next V-BLANK-IN. When an INTBACK command is issued in the same frame as one of the other commands that is issued 300 µs after V-BLANK-IN and before the next V-BLANK-IN, issue the INTBACK command before V-BLANK-OUT.

  Figure 2.7 shows the issue timing of other commands.



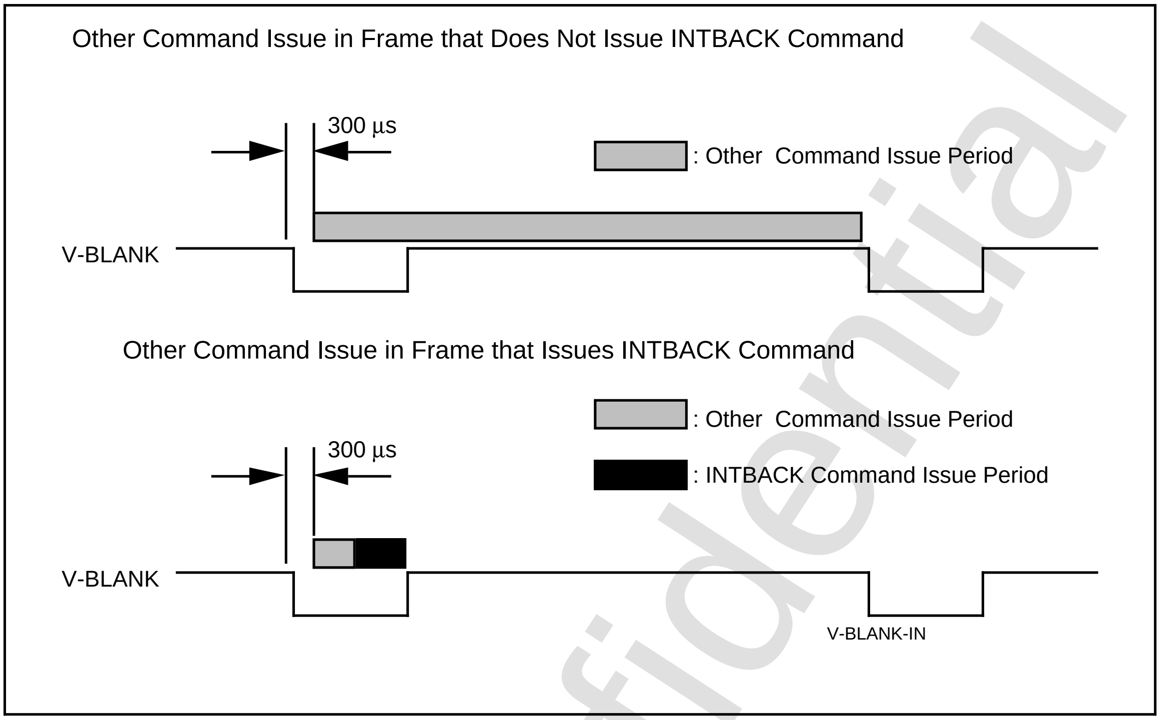


Figure 2.7 Issue of Other Commands

Command Issue Limitations

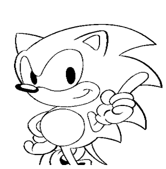
Following is an explanation of limitations when issuing commands.

- When conducting command issue processing for the SMPC, a maximum effort shall be made to conduct single tasks. If multiple issues are being processed, problems, such asdual command issue, could occur, which could cause the SMPC error or a deadlock to occur.

  When multiple tasks have to be executed, and when a command must be issued to the SMPC, always perform these executions by adding exclusion controls that do not generate dual command issue between tasks to the above described com mand issue methods.
- When commands are issued sequentially, always verify the status flag to make sure commands are not dually issued and only issue the next command after the previous command issue has finished.
- Perform real-time clock count up once every second. Also, conduct a detection of the SMPC's internal reset button immediately after V-BLANK-IN. If a command is issued while this processing is being conducted, this processing time will be added to the command processing time, so be careful because this will change the command processing time.
- SMPC commands can be issued from either the master or slave SH-2, but there are commands for which issue is limited, such as when system operation is stopped. Table 2.5 shows the SH-2 command issue limitations.

Table 2.5 SH-2 Command Issue Limitations

No.	Command Name	Command Abbreviation	Command Execution from Master SH-2	Command Execution from Slave SH-2
1	Master SH-2 ON	MSHON	O	O
2	Slave SH-2 ON	SSHON	O	X
3	Slave SH-2 OFF	SSHOFF	O	X
4	Sound ON	SNDON	O	O
5	Sound OFF	SNDOFF	O	O
6	CD ON	CDON	O	O
7	CD OFF	CDOFF	O	O
8	System Overall Reset	SYSRES	O	O
9	Clock Change 352	CKCHG352	O	X
10	Clock Change 320	CKCHG320	O	X
11	NMI Request	NMIREQ	O	O
12	Reset Enable	RESENAB	O	O
13	Reset Disable	RESDISA	O	O
14	Interrupt Back	INTBACK	O	X
15	SMPC Memory Setting	SETSMEM	O	O
16	Time Setting	SETTIME	O	O



2.3 Resetable System Management Commands

The details for the resetable system management commands are given in table format. The way to view the command tables and precaution items are given below. In addition, a status flag is used for each command to control the dual issue of commands.

SMPC Interrupt

The word "generation" means that a SMPC interrupt is generated by the SH-2 via the SCU when the command ends. In addition, the interrupt can be enabled or disabled by so setting the SCU.

IREG, OREG

- Shows the details of the IREG and OREG used by commands.
- A command parameter is a parameter that is set in IREG before the command is issued.
- A result parameter is a parameter that is set in OREG before the command is executed.
- Result parameter OREG31 is set when the SMPC begins command processing. The command code is output to OREG31. Also using it as a status flag (SF) makes it possible to determine:

  Which command is executing (SF=1)
  Which command has finished (SF=0)

Execution Time

Shows the execution time calculated from the number of SMPC internal firmware steps. When there is a collision with an internal task, such as an RTC increment, the command execution time is changed, so the minimum and maximum range values are given.

NO. 1	MSHON	Master SH-2 ON	Command Code	00H

SMPC Interrupt	Generation Not Possible	IREG	Unused	OREG	31	Execution Time	max	min
							XXX	30 μsec

Function Description	Turns on master SH-2.
Command Parameter	None
Result Parameter	OREG31 2010005FH (bit7 … bit0): 0 0 0 0 0 0 0 0
Remarks	

OREG31 2010005FH	bit7							bit0
	0	0	0	0	0	0	0	0

NO. 2	SSHON	Slave SH-2 ON	Command Code	02_H

SMPC Interrupt	Generation Not Possible	IREG	Unused	OREG	31	Execution Time	max	min
							XXX	30 μsec

Function Description	Turns on slave SH-2.
Command Parameter	None
Result Parameter	OREG31 $2010005F_H$ (see bit table below)
Remarks	

OREG31 $2010005F_H$

bit7							bit0
0	0	0	0	0	0	1	0

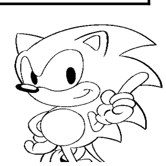
NO. 3	SSHOFF	Slave SH-2 OFF	Command Code	03H

SMPC Interrupt	Generation Not Possible	IREG	Unused	OREG	31	Execution Time	max XXX	min 30 µsec

Function Description	Turns off slave SH-2.
Command Parameter	None
Result Parameter	OREG31 2010005F H (bit7 … bit0): 0 0 0 0 0 0 1 1
Remarks	

OREG31 2010005F H

bit7							bit0
0	0	0	0	0	0	1	1



NO. 4	SNDON	Sound ON	Command Code	06H

SMPC Interrupt	Generation Not Possible	IREG	Unused	OREG	31	Execution Time	max XXX	min 30 µsec

Function Description	Turns on the sound CPU (MC68EC000).
Command Parameter	None
Result Parameter	OREG31 2010005F H
Remarks	

OREG31 2010005F H

bit7							bit0
0	0	0	0	0	1	1	0

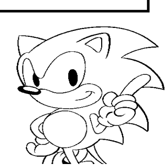
NO. 5	SNDOFF	Sound OFF	Command Code	07H

SMPC Interrupt	Generation Not Possible	IREG	Unused	OREG	31	Execution Time	max: XXX	min: 30 µsec

Function Description	Turns off the sound CPU (MC68EC000).
Command Parameter	None
Result Parameter	OREG31 2010005FH
Remarks	Even if the sound CPU is turned off using this command, the sound memory contents (4M DRAM) will be preserved.

OREG31 2010005FH

bit7							bit0
0	0	0	0	0	1	1	1



NO. 6	CDON	CD ON	Command Code	08H

SMPC Interrupt	Generation Not Possible	IREG	Unused	OREG	31	Execution Time	max	min
							XXX	40 µsec

Function Description	Turns on CD.
Command Parameter	None
Result Parameter	OREG31 2010005FH (bit7–bit0: 0 0 0 0 1 0 0 0)
Remarks	

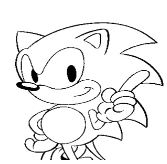
NO. 7	CDOFF	CD OFF	Command Code	09H

SMPC Interrupt	Generation Not Possible	IREG	Unused	OREG	31	Execution Time	max XXX	min 40 µsec

Function Description	Turns off CD.
Command Parameter	None
Result Parameter	OREG31 2010005FH
Remarks	The execution of this command will cause the CD buffer (DRAM) value not to be retained.

OREG31 2010005FH

bit7							bit0
0	0	0	0	1	0	0	1



NO. 8	SYSRES	Entire System Reset	Command Code	0DH

SMPC Interrupt	Generation Not Possible	IREG	Unused	OREG	31	Execution Time	100 msec + α

Function Description	Resets the entire SATURN system.
Command Parameter	None
Result Parameter	OREG31 2010005FH bit7 → bit0: 0 0 0 0 1 1 0 1
Remarks	Execution of this command resets (initializes) all functions, causes the SH-2 to run the power on vecter, and starts up the boot ROM. None of the memory, except for 256 Kbit battery backup RAM, will be retained.

NO. 9	CKCHG352	Clock Change 352 Mode	Command Code	0EH

SMPC Interrupt	Generation Not Possible	IREG	Unused	OREG	31	Execution Time	100 msec + α

Function Description

Switch the SATURN system clock from 320 mode to 352 mode.

Command Parameter

None

Result Parameter

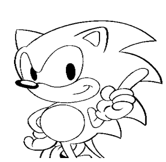
OREG31 2010005FH

bit7							bit0
0	0	0	0	1	1	1	0

Remarks

Issuing this command from an application is prohibited. Call the clock change routine in the SATURN boot ROM. When clock change routine is called, all LSI will become as follows.

- VDP1, VDP2, SCU, SCSP: Default value during power on.
- Master SH-2: Return from boot ROM clock change routine.
- Slave SH-2: OFF
- CD block: Retained
- Work RAM: Retained
- VRAM: Not retained



NO. 10	CKCHG320	Clock Change 320 Mode	Command Code	0FH

SMPC Interrupt	Generation Not Possible	IREG	Unused	OREG	31	Execution Time	100 msec + α

Function Description	Switch the SATURN system clock from 352 mode to 320 mode.
Command Parameter	None
Result Parameter	OREG31 2010005FH

OREG31 2010005FH

bit7							bit0
0	0	0	0	1	1	1	1

Remarks

Issuing this command from an application is prohibited. Call the clock change routine in the SATURN boot ROM. When clock change routine is called, all LSI will become as follows.

- VDP1, VDP2, SCU, SCSP: Default value during power on.
- Master SH-2: Return from boot ROM clock change routine.
- Slave SH-2: OFF
- CD block: Retained
- Work RAM: Retained
- VRAM: Not retained

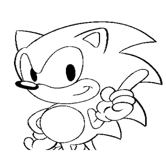
NO. 11	NMIREQ	NMI Request	Command Code	18H

SMPC Interrupt	Generation Not Possible	IREG	Unused	OREG	31	Execution Time	max XXX	min 30 µsec

Function Description	Sends NMI request to master SH-2.
Command Parameter	None
Result Parameter	OREG31 2010005FH
Remarks	NMI is requested unconditionally even if disabled by the RESDISA command.

OREG31 2010005FH

bit7							bit0
0	0	0	1	1	0	0	0



NO. 12	RESENAB	Reset Enable	Command Code	19H

SMPC Interrupt	Generation Not Possible	IREG	Unused	OREG	31	Execution Time	max XXX	min 30 µsec

Function Description	This is a command to enable NMI generation. In SATURN, NMI is generated when the main unit panel reset button is pushed. When power is on, the default is set disabled.
Command Parameter	None
Result Parameter	OREG31 2010005FH — bit7 to bit0: 0 0 0 1 1 0 0 1
Remarks	NMI is generated when the reset button is pushed during the 3VINT period to prevent chattering.

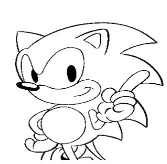
NO. 13	RESDISA	Reset Disable	Command Code	$1A_H$

SMPC Interrupt	Generation Not Possible	IREG	Unused	OREG	31	Execution Time	max XXX	min 30 µsec

Function Description	This is a command to disable NMI generation. In SATURN, generates NMI when main unit panel reset button is pushed. The defaut is "disabled" when the power is turned on.
Command Parameter	None
Result Parameter	OREG31 $2010005F_H$ (bit7 → bit0): 0 0 0 1 1 0 1 0
Remarks	The reset switch is only shown by the SR (status register) RESB bit (bit4) and does not output an NMI to the master SH-2. The RESB bit shows the button status at V-BLANK-IN.

OREG31 $2010005F_H$

bit7							bit0
0	0	0	1	1	0	1	0



2.4 Non-Resetable System Management Commands

The details for the non-resetable system management commands are given in table format.

The way to view the command tables and precaution items are given below. Also, a status flag is used for each command to control dual command issue.

SMPC Interrupt

The word “generation” means that a SMPC interrupt is generated by the SH-2 via the SCU when the command ends. In addition, the interrupt can be enabled or disabled by setting the SCU.

IREG, OREG

- Shows the details of the IREG and OREG used by commands.
- A command parameter is a parameter that is set in IREG before the command is issued.
- A result parameter is a parameter that is set in OREG before the command is executed.
- Result parameter OREG31 is set when the SMPC begins command processing. The command code is output to OREG31. Also using it as a status flag (SF) makes it possible to determine:
  Which command is executing (SF=1)
  Which command has finished (SF=0)

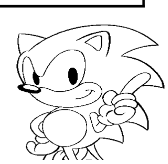
Execution Time

Shows the execution time calculated from the number of SMPC internal firmware steps. When there is a collision with an internal task, such as a RTC increment, the command execution time is changed, so the minimum and maximum range values are given.

NO. 1	INTBACK	Interrupt Back (SMPC Status Acquisition)	Command Code	10H

SMPC Interrupt	Generation	IREG	0~2	OREG	0~31	Execution Time	max 320 msec	min XXX

Function Description	Acquires the SMPC status and peripheral data. Here status acquisition will be explained. The acquisition of peripheral data will be explained in Section 3.
Command Parameter	Here, the INTBACK command's command parameter during peripheral data acquisition is also displayed. Refer to command parameter on the next page. The command parameter setting method during SMPC status acquisition is explained next after result parameter.
Result Parameter	The result parameter is explained after the command parameter. Here, the result parameter, which is limited by the SMPC status acquisition is displayed.
Remarks	



Command Parameter

IREG0 20100001H — bit7 to bit0: SMPC Status Acquisition Switch (00H or 01H)

Initial Value: Not Specified Write Only

IREG0: SMPC Status Acquisition Switch Setting Value

IREG0 Setting Value	Explanation
00H	Does not return data for time, cartridge code, area code, terminal status, SMEM, or reset button mode.
01H	Returns data for time, cartridge code, area code, terminal status, SMEM, or reset button mode.

When using the INTBACK command, be sure one of the above setting values has been set.
IREG0 is also used to control peripherals. Refer to Section 3 for details regarding peripheral control.

IREG1 20100003H

bit7			bit4	bit3			bit0
P2MD1	P2MD0	P1MD1	P1MD0	PEN	0	OPE	0
Unde.	Unde.	Unde.	Unde.	Unde.	Unde.	Unde.	Unde.
W	W	W	W	W	---	W	---

Bit7, 6: Port 2 Mode

Bit7	Bit 6	Explanation
P2MD1	P2MD0	
0	0	15-Byte Mode
0	1	255-Byte Mode
1	0	SEGA RESERVED (Setting Restricted)
1	1	0-Byte Mode

Bit5, 4: Port 1 Mode

Bit5	Bit 4	Explanation
P1MD1	P1MD0	
0	0	15-Byte Mode
0	1	255-Byte Mode
1	0	SEGA RESERVED (Setting Restricted)
1	1	0-Byte Mode

Bit3: Peripheral Data Enable

Bit3 PEN	Explanation
0	Peripheral Data Not Returned
1	Peripheral Data Returned

Bit1: Acquisition Time Optimization

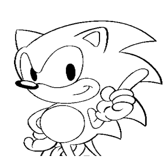
Bit1 OPE	Explanation
0	Peripheral Data Acquisition Time Optimized
1	Peripheral Data Acquisition Time not Optimized

IREG2
20100005H

bit7 … bit0
F0H

Initial Value: Not Specified Write Only

When executing the INTBACK command, be sure to set F0H in IREG2.



Result Parameter

SR 20100061H

bit7			bit4	bit3			bit0
0	1	PDE	RESB	---	---	---	---

•PDE 0: No remaining peripheral data.
1: Remaining peripheral data.
•RESB 0: Reset button off.
1: Reset button on.
Read can be performed without regard for the INTBACK command.

OREG0 20100021H

bit7			bit4	bit3			bit0
STE	RESD	---	---	---	---	---	---

•STE 0: Not SETTIME after SMPC cold reset Note 1
1: SETTIME is done after SMPC cold reset Note 1
•RESD 0: Reset enable
1: Reset disable (default)
Note 1: SMPC cold reset is generated under the following conditions.
(1) When the reset switch inside the SATURN backside battery box is pressed.
(2) When the main power is on while a battery is not installed or is dead.
(3) When a battery is installed while the power is off.

Register	bit7 – bit4	bit3 – bit0	
OREG1 20100023H	Year 1000s Place	Year 100s Place	(BCD)
OREG2 20100025H	Year 10s Place	Year 1s Place	(BCD)
OREG3 20100027H	Day Note 2	Month (Hexadecimal) Note 3	

Note 2: Day
0H: Sun 1H: Mon 2H: Tue 3H: Wed 4H: Thur 5H: Fri 6H: Sat
Note 3: Month
1H: Jan 2H: Feb 3H: Mar 4H: Apr 5H: May 6H: Jun
7H: July 8H: Aug 9H: Sep AH: Oct BH: Nov CH: Dec

Register	bit7 – bit4	bit3 – bit0	
OREG4 20100029H	Days 10s Place	Days 1s Place	(BCD)
OREG5 2010002BH	Hrs. 10s Place	Hrs. 1s Place	(BCD)
OREG6 2010002DH	Min. 10s Place	Min. 1s Place	(BCD)
OREG7 2010002FH	Sec. 10s Place	Sec. 1s Place	(BCD)

OREG8 20100031H

bit7							bit0
0	0	0	0	0	0	CTG1	CTG0

•CTG1: Cartridge Code 1
•CTG0: Cartridge Code 0

	bit7	bit0
OREG9 20100033H	Area Code (00H~0FH)	

Area Code

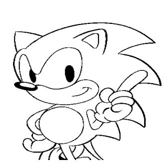
Code	Area	Major Country Names, Etc.
0H	Use Prohibited	
1H	Japan Area	Japan
2H	Asia NTSC area	Taiwan, Philippines
3H	SEGA RESERVED	
4H	North America area	U.S.A., Canada, Mexico
5H	Central/S. America NTSC area	Brazil
6H	Korea area	South Korea
7H	SEGA RESERVED	
8H	SEGA RESERVED	
9H	SEGA RESERVED	
AH	Asia PAL area	East Asia, China, Middle East
BH	SEGA RESERVED	
CH	Europe PAL area, etc.	Europe, Australia, South Africa
DH	Central/S. Amercia PAL area	
EH	SEGA RESERVED	
FH	Use Prohibited	

OREG10 20100035H	System Status 1

System Status 1 (Status of Control Signals Output by SMPC 0: OFF 1 :ON)
•b7 0B •b6 DOTSEL Signal Note •b5 1B
•b4 1B •b3 MSHNMI Signal •b2 1B
•b1 SYSRES Signal •b0 SNDRES Signal
Note: The DOTSEL signal is currently shown in the screen mode (horizontal resolution).
0: 320 1: 352

	bit7	bit0
OREG11 20100037H	System Status 2	

System Status 2 (Status of Control Signals Output by SMPC 0: OFF 1 :ON)
•b7 RESERVED •b6 CDRES Signal •b5 RESERVED
•b4 RESERVED •b3 RESERVED •b2 RESERVED
•b1 RESERVED •b0 RESERVED



Register	bit7 … bit0
OREG12 20100039H	SMEM 1 Saved Data
OREG13 2010003BH	SMEM 2 Saved Data
OREG14 2010003DH	SMEM 3 Saved Data
OREG15 2010003FH	SMEM 4 Saved Data

Register	bit7							bit0
OREG31 2010005FH	0	0	0	0	0	0	0	0

With peripheral data, however, the command code (OREG31) could be overwritten.

How to Use INTBACK Command when Acquiring SMPC Status

There are three ways the INTBACK command can be used.

1) Acquire only SMPC status.
2) Acquire peripheral data after acquiring SMPC status.
3) Acquire only peripheral data.

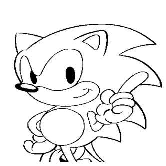
This section primarily explains how to acquire SMPC status. Here, acquiring status using methods 1) and 2) are explained. For an explanation regarding peripheral data acquisition, refer to Section 3.

Method for Acquiring Only SMPC Status

When acquiring status only, set the command parameter as shown below, and execute the INTBACK command.

IREG	Setting Value	Description
IREG0	01H	All data for time, cartridge code, area code, terminal status, SMEM, and reset button mode is returned.
IREG1	00H	Terminal 2 mode (P2MD1, P2MD0)=00B 15-byte mode Terminal 1 mode (P1MD1, P1MD0)=00B 15-byte mode Peripheral data enable (PEN)=0B Peripheral data not returned Acquisition time optimization (OPE)=0B Performs peripheral acquisition time optimization.
IREG2	F0H	Set F0H without conditions.

This setting can clear the SF, ends the INTBACK command, and acquires the result data. Also, when the command ends, a SMPC interrupt request is sent. The execution time is from minimum TBD to maximum TBD.



Method for Acquiring Peripheral Data After Acquiring SMPC Status

When acquiring peripheral data after acquiring SMPC status acquisition, set the command parameter as shown below and issue the INTBACK command. The IREG1 setting value can be set to the value desired for the application.

IREG	Setting Value	Description
IREG0	01H	All data for time, cartridge code, area code, terminal status, SMEM, and reset button mode is returned.
IREG1	08H	Terminal 2 mode (P2MD1, P2MD0)=00B 15-byte mode Terminal 1 mode (P1MD1, P1MD0)=00B 15-byte mode Peripheral data enable (PEN)=1B Peripheral data returned Acquisition time optimization (OPE)=0B Performs peripheral acquisition time optimization.
IREG2	F0H	Set F0H without conditions.

This setting executes the SMPC command and requests a SMPC interrupt when the result parameter is set. When the SMPC interrupt is requested, the SF is changed to busy "1." The execution time from command issue to result parameter setting completion is minimum TBD to maximum TBD. After the result parameter for the status is acquired, the value of the IREG0 bit7 is changed, then the SMPC understands this as continue and continues acquiring peripheral data.

This method is effective for use with applications that acquire all status types for each frame and that acquire peripheral data.

NO. 2	SETSMEM	SMPC Memory Setting	Command Code	17H

SMPC Interrupt	Generation Possible	IREG	0~3	OREG	31	Execution Time	max XXX	min 40 µsec

Function Description

The SMPC has a 4-byte battery backupable memory (SMEM)
This command sets data to the SMEM.

Command Parameter

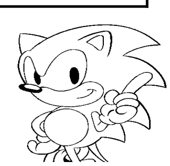
Register	Address	bit7 … bit0
IREG0	20100001H	Setting Data to SMEM1
IREG1	20100003H	Setting Data to SMEM2
IREG2	20100005H	Setting Data to SMEM3
IREG3	20100007H	Setting Data to SMEM4

Result Parameter

Register	Address	bit7							bit0
OREG31	2010005FH	0	0	0	1	0	1	1	1

Remarks

- The SMEM contents are cleared to 0 when the SMPC is cold reset.
  A SMPC cold reset is generated under the following conditions.
  (1) When the reset switch in the SATURN backside battery box is pushed.
  (2) When the main power is turned on while no battery is installed or when the battery is dead.
  (3) Cleared to 0 when a battery is installed while the power is off. Becomes 0 after the main power is first turned on.
- With the SETSMEM command, 4 bytes can be set at the same time. When the contents are updated, use the INTBACK command to read, modify, or write the currently saved data.
- If the power is turned off when the SETSMEM command is issued:
  (1) All data is updated when the SETSMEM command internal processing is executed first by the power off sequence.
  (2) When the power off sequence is executed first, the data before the command was issued is saved.



2.5 RTC Commands

The details for the RTC commands are given in table format. The way to view the command tables and precaution items are given below. Also, a status flag is used for each command to control dual command issue.

SMPC Interrupt

The word “generation” means that a SMPC interrupt is generated by the SH-2 via the SCU when the command ends. In addition, the interrupt can be enabled or disabled by setting the SCU.

IREG, OREG

- Shows the details of the IREG and OREG used by commands.
- A command parameter is a parameter that is set in IREG before the command is issued.
- A result parameter is a parameter that is set in OREG before the command is executed.
- Result parameter OREG31 is set when the SMPC begins command processing. The command code is output to OREG31. Also using it as a status flag (SF) makes it possible to determine:

  Which command is executing (SF=1)
  Which command has finished (SF=0)

Execution Time

Shows the execution time calculated from the number of SMPC internal firmware steps. When there is a collision with an internal task, such as a RTC increment, the command execution time is changed, so the minimum and maximum range values are given.

NO. 1	SETTIME	Time Setting	Command Code	16H

SMPC Interrupt	Interrupt Generation Not Possible	IREG	0~6	OREG	31	Execution Time	max XXX	min 70 µsec

Function Description

Sets the RTC time.

Command Parameter

	bit7 – bit4	bit3 – bit0	
IREG0 20100001H	Year 1000s Place	Year 100s Place	(BCD)
IREG1 20100003H	Year 10s Place	Year 1s Place	(BCD)
IREG2 20100005H	Day Note 1	Month (Hexadecimal) Note 2	
IREG3 20100007H	Days 10s Place	Days 1s Place	(BCD)
IREG4 20100009H	Hour 10s Place	Hour 1s Place	(BCD)
IREG5 2010000BH	Minute 10s Place	Minute 1s Place	(BCD)
IREG6 2010000DH	Second 10s Place	Second 1s Place	(BCD)

Note 1: Days
0H: Sun. 1H: Mon. 2H: Tue. 3H: Wed. 4H: Thur. 5H: Fri. 6H: Sat.

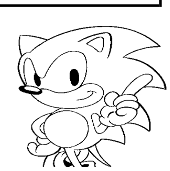
Note 2: Month
1H: Jan 2H: Feb 3H: Mar 4H: Apr 5H: May 6H: Jun
7H: July 8H: Aug 9H: Sep AH: Oct BH: Nov CH: Dec

Result Parameter

	bit7							bit0
OREG031 25FC00BCH	0	0	0	1	0	1	1	0

Remarks

- The time is initialized to "12/31/93 Friday 23:59:59" and the count is started during SMPC cold reset.
  The SMPC cold reset is generated under the following conditions.
  (1) When the reset switch in the SATURN background battery box is pushed down.
  (2) When the battery is not installed or is dead and the main power is on.
  (3) When 0 cleared when the battery is installed when the power is off.
- When data that does not actually exist, a day higher than 7, a month higher than 12, a date for a month not supported (correction is made for leap years until 2099), hours above 24, minutes above 60, or seconds above 60 are set, the set value or the count up value becomes undefined.
- If the SETTIME command is issued while the power is off:
  (1) All data is updated if the SETTIME command internal processing is executed before the power off sequence.
  (2) The data before command issuance is preserved when the power off sequence is executed first.



Chapter 3 Peripheral Control

Section 3 Contents

3.1 Peripheral Control Mode

The SH-2 can control peripherals via the SMPC. There are two peripheral control methods. They are:
1) SMPC Control Mode
2) SH-2 Direct Mode

SMPC Control Mode

Block Diagram

Figure 3.1 shows the SMPC control mode block diagram. The SMPC control mode sets the command parameter in the SH-2 interface register's IREG and is started up by issuing an INTBACK command. The peripheral data collection results are output to the OREG as a result parameter.

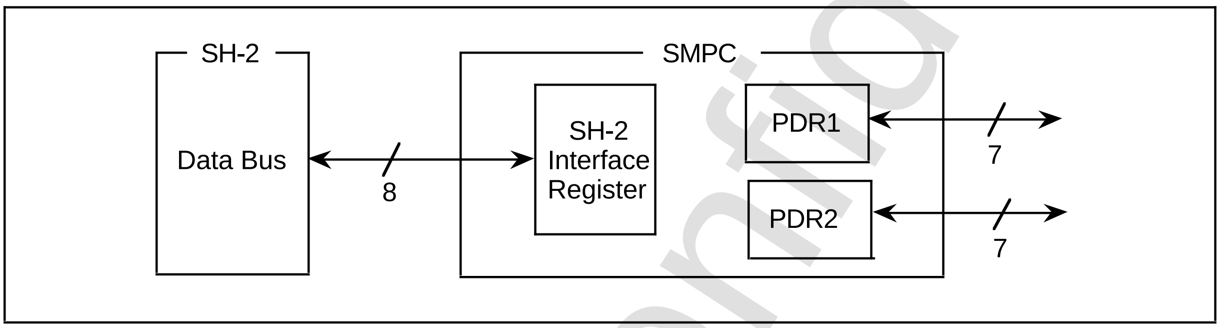


Figure 3.1 SMPC Control Mode Block Diagram

Characteristics

Used as an effective method to keep overhead to a minimum when accessing peripherals from inside an application.

Settings for Using SMPC Control Mode

Figure 3.2 shows an setting example for using the SMPC control mode for port 1. Mode settings are set independently for each port.

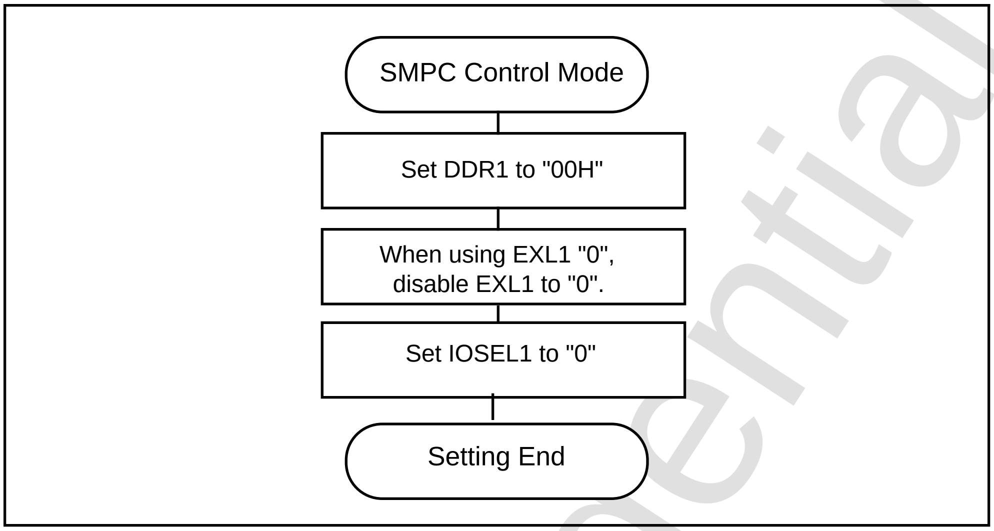


Figure 3.2 SMPC Control Mode Setting Example.

- **Parallel I/O Register Default Value During Power On**
  During power-on, the parallel I/O register is set to the default values shown in Table 3.1.

Table 3.1 Parallel I/O Register Default Values During Power-On

Register Name	Setting Value	Description
IOSEL1/2	0_H	SMPC control mode
EXL1/2	0_H	PAD interrupt VDP2 external latch disable
DDR1/2	00_H	Input of all bits

SMPC Control Mode Use Method

When using the INTBACK command and acquiring peripheral data, the collected peripheral data is output to the OREG as a result parameter. However, it is possible that the collected peripheral data is larger than the OREG capacity. At this time, in the SMPC control mode, peripheral data acquisition is stopped when the OREG becomes full. When the OREG becomes full with peripheral data, the SMPC generates an SMPC interrupt and sends a request for peripheral data acquisition to the SH-2.

Also, when there is still peripheral data that should be collected, it is displayed that data still remains in the status register. After the SH-2 acquires the peripheral data, a continue request is sent to the SMPC which causes the SMPC to begin acquiring peripheral data again. When the remaining peripheral data is not needed, peripheral data acquisition is ended by a break request.

The above sequence is illustrated in Figures 3.3 and 3.4.

Continue Request

A continue request from the SH-2 to the SMPC is done by reversing the IREG bit 7.

Break Request

A break request from the SH-2 to the SMPC is made by writing "1" in the IREG0's bit 6.

Precautions Regarding Continue and Break Requests

When requesting continue or break, be aware of the conditions given in Table 3.2.

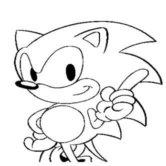
Table 3.2 Continue and Break Issue Conditions

Issue to be requested			
Continue	Break	Received Condition	SMPC Operation
X	X	Hold	Request Wait
X	O	Break	Peripheral data collection is stopped and INTBACK command is terminated.
O	X	Continue	Peripheral data collection is continued.
O	O	Prohibited	No guarantee

Termination Conditions for INTBACK Command that Acquires Peripheral Data

The INTBACK command that acquires peripheral data is terminated by the following conditions.

1) When all peripheral data acquisition is completed.
2) When peripheral data collection could not be completed by V-BLANK-IN (time over).
3) Peripheral data collection was terminated by a break request from the SH-2.



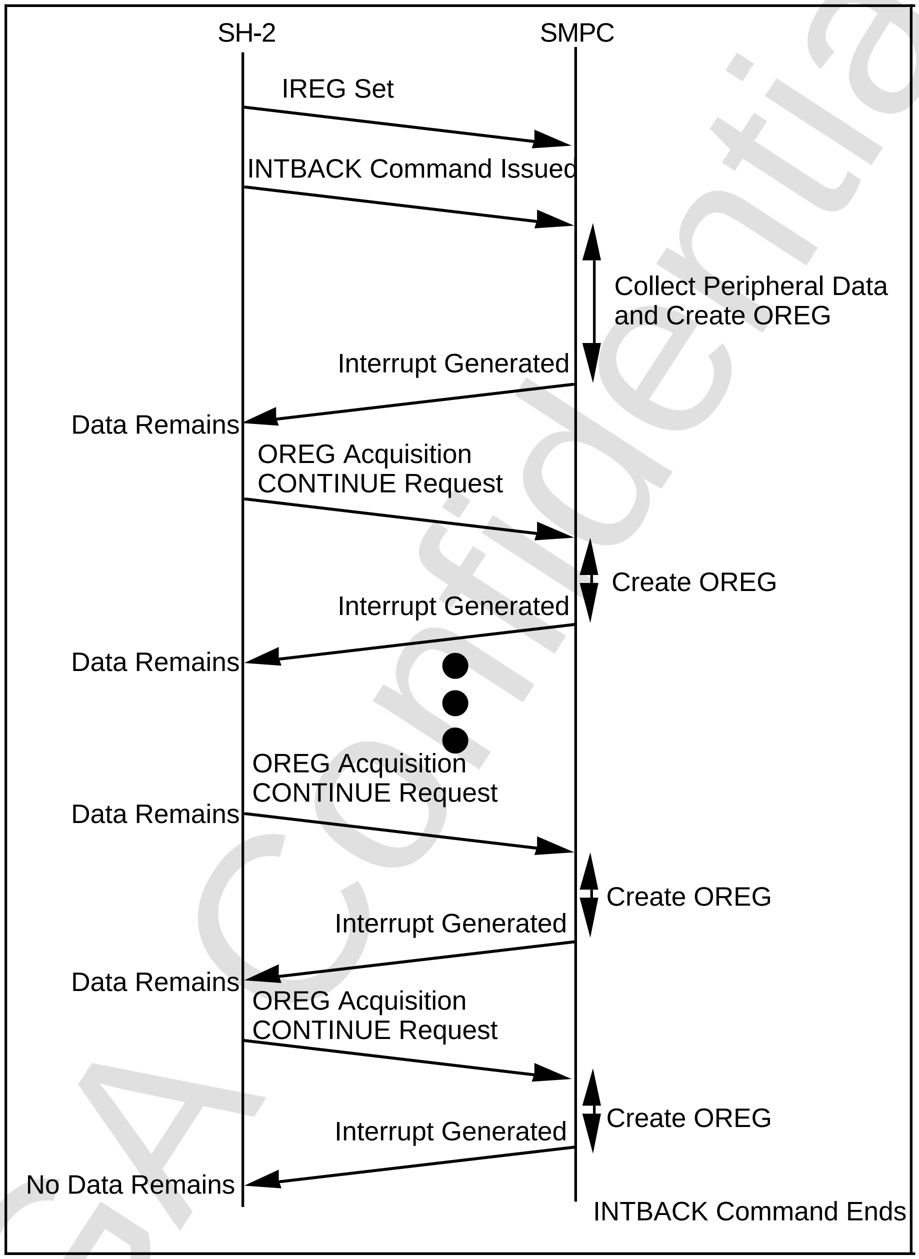


Figure 3.3 All Peripheral Data Acquisition Sequence

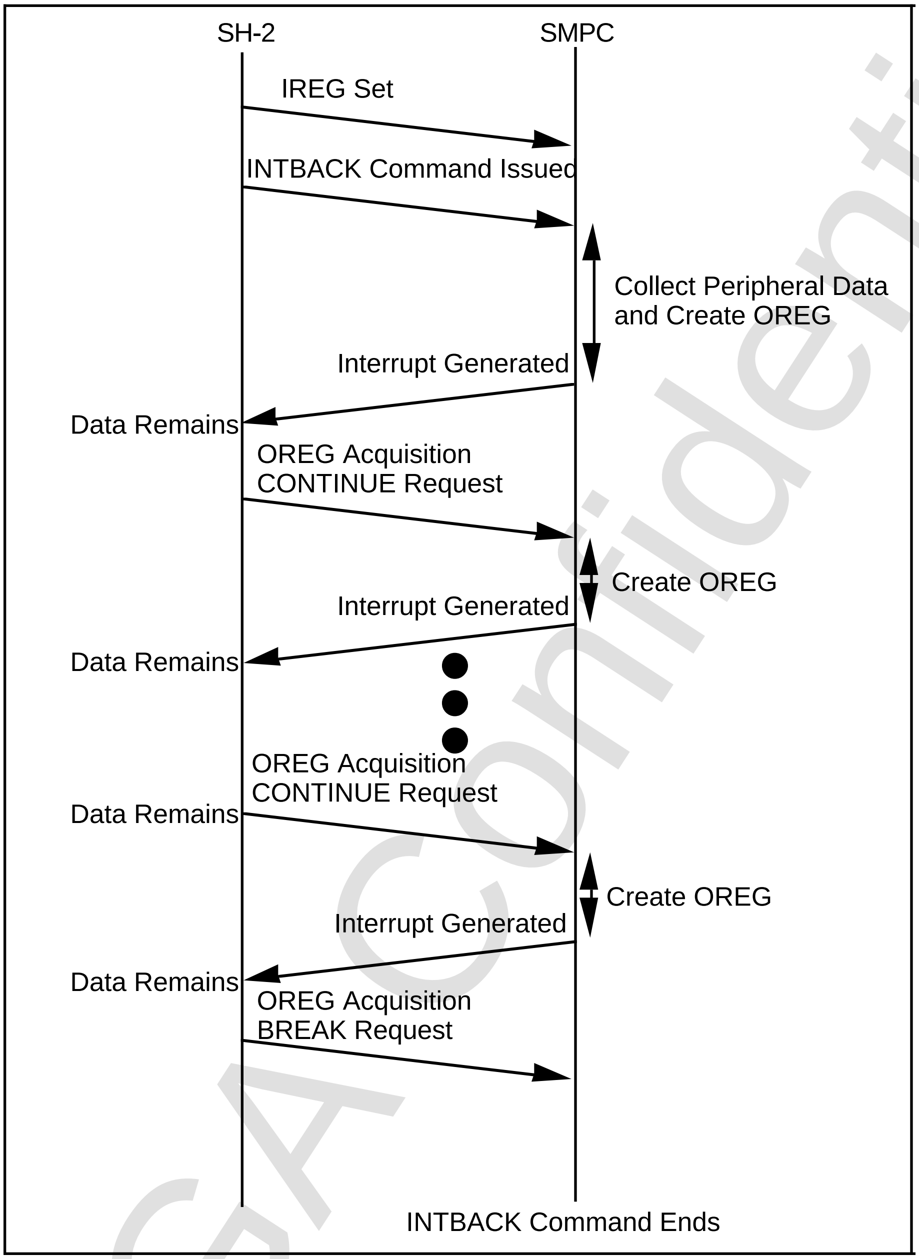


Figure 3.4 Peripheral Data Acquisition Cancel Sequence Due to Break Request

Methods for Using INTBACK Command in SMPC Control Mode

Section 2 explained how to acquire SMPC status using the INTBACK command. As was explained in Section 2, the INTBACK command can be used in three ways.

1) To acquire only the SMPC status.
2) To acquire peripheral data after acquiring SMPC status.
3) To acquire only peripheral data.

This section continues on mainly explaining the peripheral control functions by explaining (2) “to acquire peripheral data after acquiring SMPC status” and (3) “to acquire only peripheral data.”

How to Acquire Peripheral Data After Acquiring SMPC Status

Here the procedure for acquiring peripheral data after acquiring the SMPC status is explained. The procedure for acquiring SMPC status is explained in Section 2, so the following only explains the procedure after status data acquisition. (Refer to Figures 3.3 and 3.4)

1) Continue request or break request (SH-2)
2) Peripheral data acquisition and result parameter setting (SMPC)
3) SMPC interrupt generation (SMPC)
4) Peripheral data acquisition (SH-2)
   If peripheral data still remains, repeat processing from (1).
5) INTBACK command end

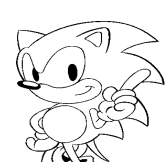
How to Acquire Only Peripheral Data

The procedure for using the INTBACK command to acquire only peripheral data is explained below. (Refer to Figures 3.3 and 3.4)

1) Command parameter setting (SH-2).
2) INTBACK command issue (SH-2). Examples are given in Table 3.3.
3) Peripheral data collection and result parameter setting (SMPC).
4) SMPC interrupt generation (SMPC).
5) Peripheral data acquisition (SH-2)
   When no peripheral data remains, the INTBACK command ends (SMPC).
6) Continue request or break request (SH-2)
7) When continue is requested the processing in (3) is repeated.
8) INTBACK command end.

Table 3.3 Example Acquisition Command Parameter Setting When Only Peripheral Data Is Acquired

IREG	Setting Value	Description
IREG0	00_H	The data and time, cartridge code, area code, terminal status, SMEM, and reset button mode data are not returned.
IREG1	Application specifications (except PEN bit)	Port 2 mode (P2MD1, P2MD0)=from application specifications Port 1 mode (P1MD1, P1MD0)=from application specifications Peripheral data enable (PEN)=1B return peripheral data Acquisition time optimization (OPE)=from application specifications
IREG2	$F0_H$	Set unconditionally in $F0_H$.



Peripheral Data Collection Time Optimization

The application processing cycle for the SMPC was created as follows.

1) Peripheral data is prepared until V-BLANK-IN.
2) The sprite and control screen parameter in the peripheral are calculated and output.
3) 3D calculation, etc.
4) Sprite and polygon drawing.
5) Display

The purpose of optimizing the peripheral data collection time is to collect the peripheral data as close to V-BLANK-IN as possible. In other words, the start of peripheral data collection is made as close as possible to V-BLANK-IN to shorten the time from peripheral data collection to peripheral data acquisition by SH-2. Figure 3.5 shows an operation overview of peripheral data collection time optimization.

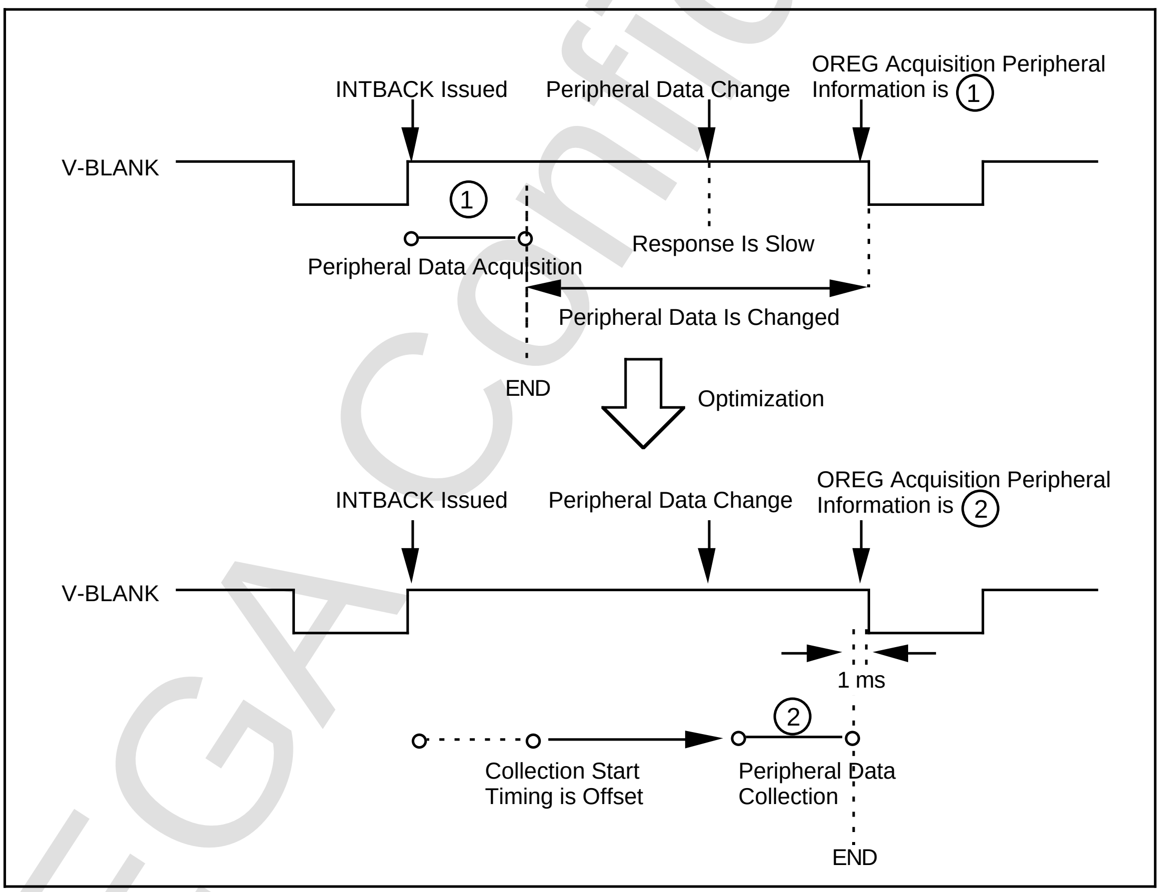


Figure 3.5 Overview of Peripheral Data Collection Time Optimization

Operations when Peripheral Data Collection Time Is Not Optimized

Issue the INTBACK command after 300 μs prior to V-BLANK-IN and before V-BLANK-OUT. This makes it possible to accurately start peripheral data collection at V-BLANK-OUT. Peripheral data collection starts when the SMPC detects V-BLANK-OUT. The INTBACK command terminates at the time peripheral data collection is finished.

Precautions when Peripheral Data Collection Time Is Not Optimized

The peripheral data collection end timing varies depending on the type and number of peripherals that are connected. For example, for a SATURN standard PAD 2 unit configuration, all the peripheral data is put in the OREG much faster than V-BLANK-IN.

If an SMPC interrupt is used in this case, peripheral data can be acquired faster than with V-BLANK-IN. Also, as above, when less than 32 OREG are used, peripheral data can be acquired using V-BLANK-IN timing without using an SMPC interrupt.

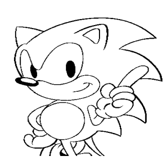
Operations for Optimizing Peripheral Data Collection Time

Issue the INTBACK command after 300 μs after V-BLANK-IN and before V-BLANK-OUT. This makes it possible to accurately start peripheral data collection at V-BLANK-OUT.

When optimizing peripheral data collection time, the SMPC first collects peripheral data without optimization and measures the collection time. The peripheral data collection start timing is the timing when the SMPC detects V-BLANK-OUT, as in the case when peripheral data collection time is not optimized.

From the next frame, a 1 msec margin is added to the measured time, and this time is used as the peripheral data collecting time. The peripheral data is collected using this timing. Refer to Figure 3.5 for more.

After that, the peripheral data collection time is constantly monitored and the data collection time is optimized. Also, if a time-over occurs after optimization, the next time optimization is be performed, V-BLANK-OUT will be used as the start timing.



Precautions when Optimizing Peripheral Data Collection Time

The peripheral data collection timing varies depending on the type and number of peripherals that are connected. When performing peripheral data collection time optimization, verify the types, number, and configuration of connected peripherals and make a sufficient evaluation to prevent time-over from occurring.

In addition, when using continue as well, the continue request wait-time is measured as part of the peripheral data collection time. Therefore, make the time from SMPC interrupt generation to continue request as short as possible, and be sure to execute them at a set time.

INTBACK Command's Command Parameters During Peripheral Data Acquisition

Following is an explanation of command parameters when peripheral data is acquired using the INTBACK command.

IREG0

There are two IREG0 settings: when the INTBACK command is issued and when continue or break is requested.

- **When INTBACK Command Is Issued**
  The IREG0 uses the SMPC status acquisition switch.

IREG0 20100001H — bit7 … bit0: Status Acquisition Switch (00H or 01H)

Initial Value: Not Specified Write Only

IREG0: SMPC Status Acquisition Switch Setting Value

IREG0 Setting Value	Explanation
00H	All data for date and time, cartridge code, area code, terminal status, SMEM, and reset button mode are not returned.
01H	All data for date and time, cartridge code, area code, terminal status, SMEM, and reset button mode are returned.

Figure 3.6 IREG0 (During INTBACK Command Issue)

- **During Continue and Break Request**
  The IREG0 uses the continue and break requests sent to the SMPC.
  When the SMPC receives a continue request, it begins collecting the remaining peripheral data. When it receives a break request, it stops collecting peripheral data and terminates the INTBACK command.

	bit7							bit0
IREG0	CONT	BR	---	---	---	---	---	---

CONT: CONTINUE Request Bit
CONTINUE is requested by changing the value of this bit.
BR: BREAK Request Bit
A BREAK request is made by changing this bit to "1."
---: Possible for both 0_H and 1_H.

Figure 3.7 IREG0 (During Continue and Break Requests)

Note: When the CONT.BR request value that has reached maximum is also written in IREG0, it cannot be guaranteed which operation the SMPC will execute. Refer to Table 3.2.

IREG1

The IREG1 uses the peripheral data collection mode.

IREG1 20100003H

	bit7			bit4	bit3			bit0
IREG1 20100003H	P2MD1	P2MD0	P1MD1	P1MD0	PEN	0	OPE	0
	Unde.	Unde.	Unde.	Unde.	Unde.	Unde.	Unde.	Unde.
	W	W	W	W	W	---	W	---

Bit7, 6: Port 2 Mode

Bit7	Bit 6	Explanation
P2MD1	P2MD0	
0	0	15-Byte Mode
0	1	255-Byte Mode
1	0	SEGA RESERVED (Setting Restricted)
1	1	0-Byte Mode

Bit5, 4: Port 1 Mode

Bit7	Bit 6	Explanation
P1MD1	P1MD0	
0	0	15-Byte Mode
0	1	255-Byte Mode
1	0	SEGA RESERVED (Setting Restricted)
1	1	0-Byte Mode

Bit3: Peripheral Data Enable

Bit3	Explanation
PEN	
0	Peripheral Data Not Returned
1	Peripheral Data Returned

Bit1: Acquisition Time Optimization

Bit1	Explanation
OPE	
0	Peripheral Data Acquisition Time Optimized
1	Peripheral Data Acquisition Time not Optimized

Figure 3.8 IREG1

Note: When both the SH-2 direct mode and SMPC control mode are both used (example: port 1=SH-2 direct mode, port 2=SMPC control mode), use the 0 byte mode in the port used by SH-2 direct mode when the INTBACK command is issued.

IREG2

	bit7	bit0
IREG2 20100005H	$F0_H$	

Initial Value: Not Specified Write Only

When issuing the INTBACK command, be sure to set $F0_H$ in IREG2.

Figure 3.9 IREG2

INTBACK Command Result Parameter During Peripheral Data Acquisition

Following is an explanation of the result parameter when peripheral data is acquired using the INTBACK command.

Basic Configuration of Result Parameter Acquired Using INTBACK Command

When the INTBACK command is executed, the result parameter shown in Figure 3.10 is configured in the status register and OREG.

The peripheral control status shows the statuses used during peripheral control mode. Port 1 status and port 2 status show their respective port peripheral connection states. The connected peripheral's ID and peripheral data are output in the port 1 data and port 2 data. When the peripheral is directly connected to the peripheral port, the peripheral data for one unit is output. When a multitap is connected, the peripheral data for several taps is output.

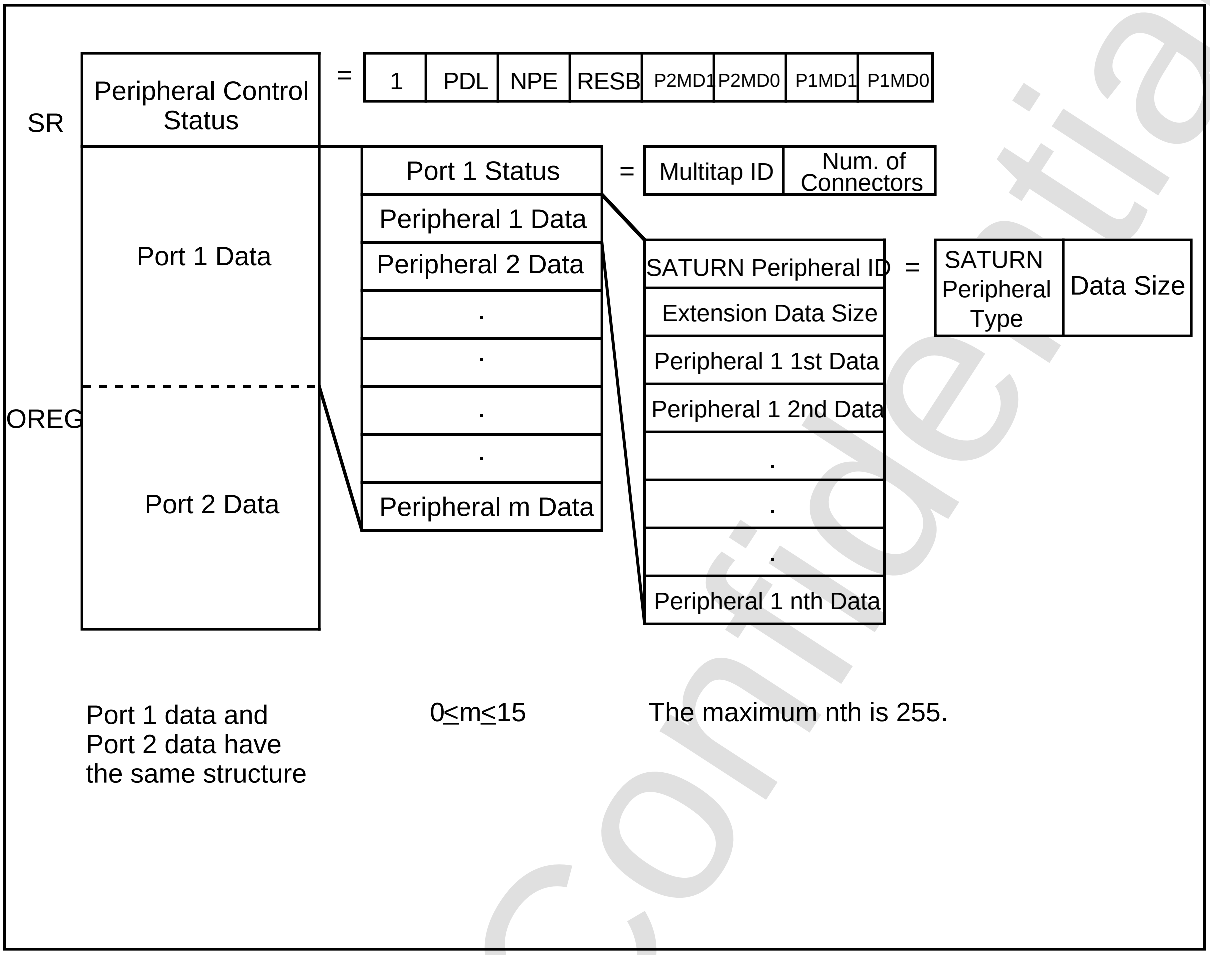
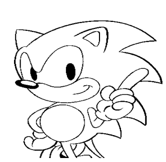


Figure 3.10 **Result Parameter Standard Configuration Acquired Using INTBACK Command**



Result Parameter Configuration During 0 Byte Mode

When one of the ports is set to 0 byte mode, the port data set in 0 byte mode is removed to make a smaller configuration. Figure 3.11 shows the data configuration during 0 byte mode.

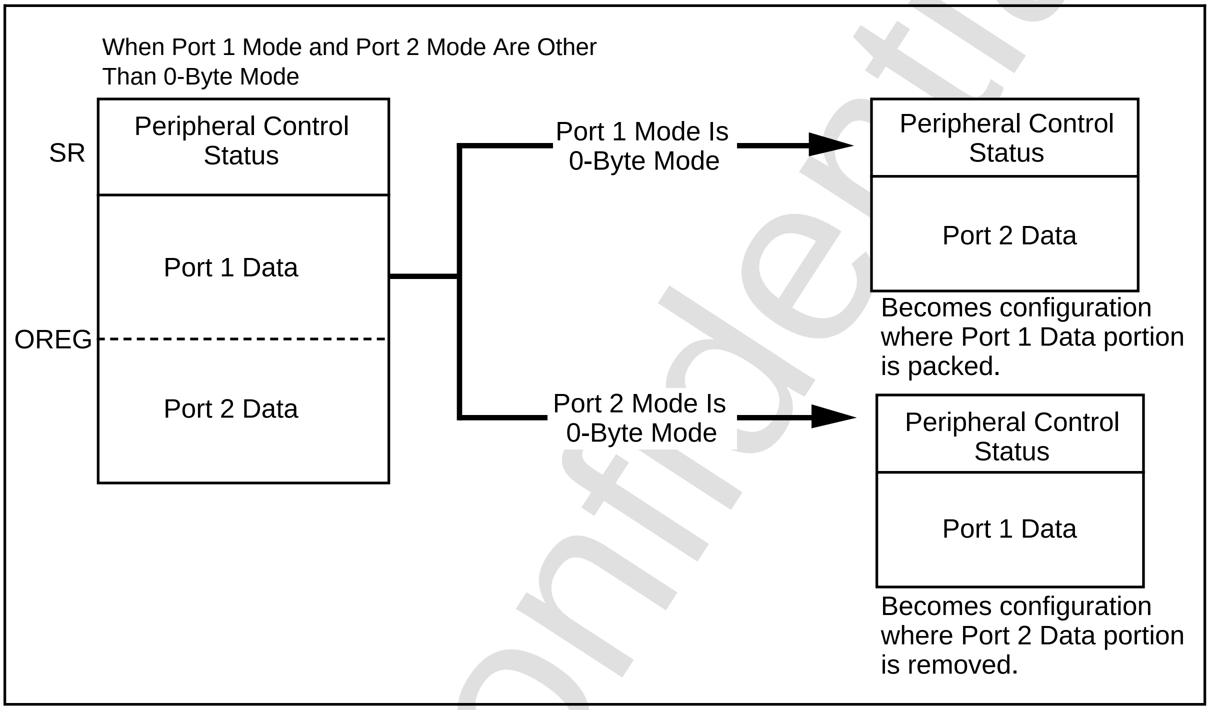


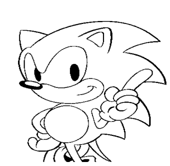
Figure 3.11 Result Parameter Configuration when One Port is 0 Byte Mode

As shown above, the result parameter varies depending on the command parameter setting conditions. Table 3.4 shows the relation between the command parameter setting conditions and the created result parameter configuration.

Table 3.4 Command Parameter Setting Conditions and Peripheral Data Configuration

Command Parameter Setting Conditions				Result Parameter Configuration		
Returns SMPC Status	Returns Peripheral Data	Has Port 1 Control	Has Port 2 Control	SMPC Status	Port 1 Data	Port 2 Data
X	X	X	X	X	X	X
X	X	X	O	X	X	X
X	X	O	X	X	X	X
X	X	O	O	X	X	X
X	O	X	X	X	X	X
X	O	X	O	X	X	O
X	O	O	X	X	O	X
X	O	O	O	X	O	O
O	X	X	X	O	X	X
O	X	X	O	O	X	X
O	X	O	X	O	X	X
O	X	O	O	O	X	X
O	O	X	X	O	X	X
O	O	X	O	O	X	O
O	O	O	X	O	O	X
O	O	O	O	O	O	O

Use Prohibited



Peripheral Data Configuration

The peripheral data configuration is shown in Figure 3.12. Peripheral data consists of the SATURN peripheral ID and peripheral data. The peripheral data body without the SATURN peripheral ID has a maximum of 255 bytes.

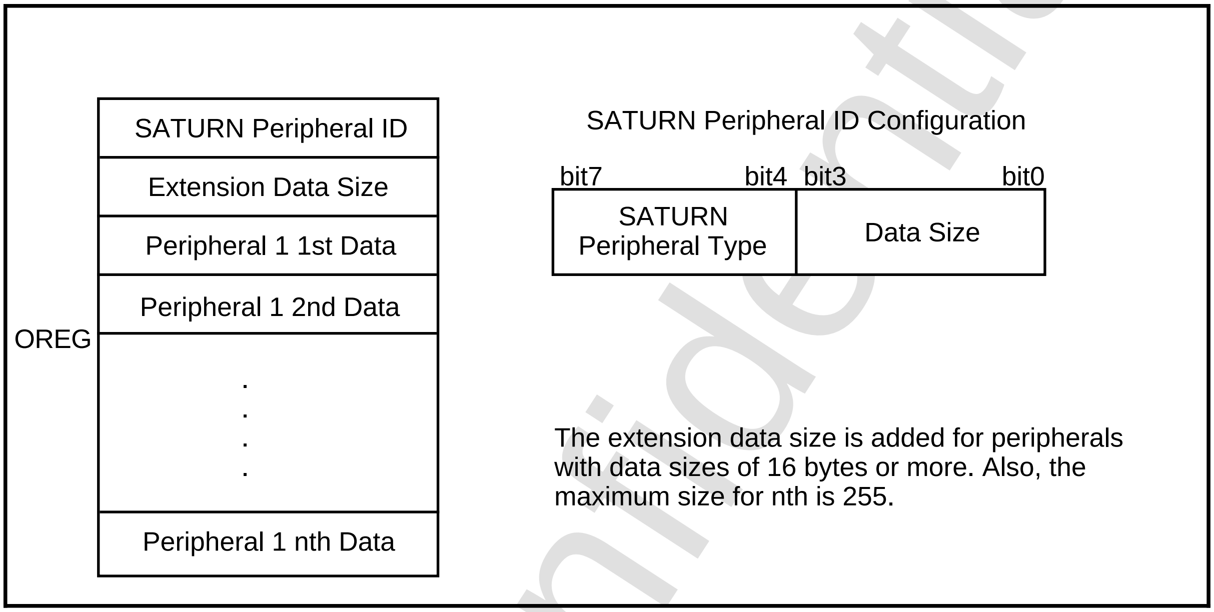


Figure 3.12 Peripheral Data Configuration

Result Parameter Details

Peripheral Control Status

The SMPC outputs the peripheral control status to the status register (SR) when the SMPC control mode is used. The status register (SR) is a register that can be read without regard for the INTBACK command. However, when the register is read when the INTBACK command is not in use, all bits except the RESB bit will be undefined.

	bit7							bit0
SR	1	PDL	NPE	RESB	P2MD1	P2MD0	P1MD1	P1MD0

P1MD: Port 1 Mode
- 00: 15-byte mode (Returns peripheral data up to a maximum of 15 bytes.)
- 01: 255-byte mode (Returns peripheral data up to a maximum of 255 bytes.)
- 10: Unused
- 11: 0-byte mode (Port is not accessed.)

P2MD: Port 2 Mode
- 00: 15-byte mode (Returns peripheral data up to a maximum of 15 bytes.)
- 01: 255-byte mode (Returns peripheral data up to a maximum of 255 bytes.)
- 10: Unused
- 11: 0-byte mode (Port is not accessed.)

RESB: Reset Button Status Bit
- 0: Reset Button OFF
- 1: Reset Button ON

  Reading without regard for INTBACK command is possible. (Shows status for each V-BLANK-IN.)

NPE: Remaining Peripheral Existence Bit
- 0: No remaining data
- 1: Remaining data

PDL: Peripheral Data Location Bit
- 0: 2nd or above peripheral data
- 1: 1st peripheral data

bit7: Always 1

Figure 3.13 Peripheral Control Status

Port Status

The port status is 1-byte data that shows the state of the peripheral connected to the port. Using the port status makes it possible to determine if the peripheral is directly connected to the corresponding port or if a multitap is connected. Figure 3.14 shows the port status configuration.

bit7 — bit4	bit3 — bit0
Multitap ID	Number of Connectors

Figure 3.14 Port Status Configuration

- **Number of Connectors**

  If the peripheral is directly connected to the peripheral port, 1H is shown; only one peripheral can be connected to the port. If a multitap is connected, the number of taps in the multitap is shown. When nothing is connected to the peripheral port, or when a peripheral that the SMPC does not recognize is connected to the port, 0H is shown.

  Table 3.5 shows the relation between the number of connectors and the connected peripheral.

Table 3.5 Relation Between the Number of Connections and Peripherals

Number of Connectors	Connected Peripheral
0H	• Not connected • SMPC UNKNOWN peripheral is connected
1H	• Peripheral is directly connected
2H~FH	• Number of taps in the multitap

- **Multitap ID**

The multitap ID is classified as follows depending on the peripheral connected.

1) When a peripheral is directly connected to the peripheral port, or none is connected at all, the multitap ID is shown as F_H.
2) When a multitap is connected to the peripheral port, 0_H~E_H is shown.
3) When a device not recognized by the SMPC (UNKNOWN device) is connected to the peripheral port, the Mega Drive peripheral ID (hereafter MD PID) is shown.

The connection of a SMPC UNKNOWN device is determined during the initial phase between the SMPC and the peripheral by the transmission of a MD PID that the SMPC does not support. When a justifier (*Lethal Enforcers*), etc., is used, connection determination is performed by the SMPC control mode, and can be handled by using the SH-2 direct mode after port status acquisition. In addition, if an error occurs in the circuit between the SMPC and the peripheral during initial phase, the peripheral is also determined to be UNKNOWN.

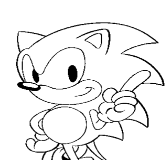
Table 3.6 Relation Between Connected Peripherals and Multitap ID

Peripheral Connected to the Peripheral Port	Data Shown in Multitap ID
Peripheral is directly connected or not connected	F_H
Multitap is connected	0_H~E_H
UNKNOWN device is connected.	MD-PID

The multitap ID is collected separately from the SATURN peripheral ID. The multitap ID is supplied by the multitap specifications. The multitap IDs and number of connectors currently supported are shown in Table 3.7.

Table 3.7 Multitap ID and Number of Connectors

Multitap Name	Multitap ID	Number of Connectors
SEGA Tap	0_H	4_H
SATURN 6P Multitap	1_H	6_H



SATURN Peripheral ID

SATURN Peripheral ID Configuration

The SATURN peripheral ID is configured from the peripheral type and data size. The peripheral data configuration and contents can be recognized from the SATURN peripheral ID. The SATURN peripheral ID is shown in Figure 3.15.

bit7 – bit4	bit3 – bit0
SATURN Peripheral Type	Data Size

Figure 3.15 SATURN Peripheral ID Configuration

- **SATURN Peripheral Type**
  The SATURN peripheral type shows the type of peripheral. Therefore, it is used to recognize how the peripheral data is aligned. Currently, four peripheral types are defined for SATURN and are presented as the standard format. For details, please refer to the item covering "SATURN Peripheral Standard Format."

- **Data Size**
  The data size shows how many bytes after the SATURN peripheral ID are being output. Therefore, using the data size makes it possible to recognize from how many bytes the peripheral data table is configured. It also makes it possible to recognize where the start of the next peripheral data table is.

SATURN Peripheral ID Details

- **When a Peripheral Is Directly Connected to the Peripheral Port**
  SATURN peripherals can define a data size up to a maximum of 255 bytes. There are two types of SATURN peripherals; those of 15 bytes or less and those of 16 bytes or more up to 255 bytes. There are also two port modes; 15-byte mode and 255-byte mode. Therefore, as shown in Table 3.8, there are four combinations that can be made from the peripheral data size and port mode. The SATURN peripheral ID and peripheral data configuration are shown from Figure 3.16 to Figure 3.18.

Table 3.8 Combinations of Peripheral Data Size and Port Mode (Peripheral Is Connected Directly to Peripheral Port)

		Port Mode (IREG1 Setting)	
		15	255
Peripheral Data Size (Byte)	15	Peripheral Data Configuration 1	
	16-255	Peripheral Data Configuration 2	Peripheral Data Configuration 3

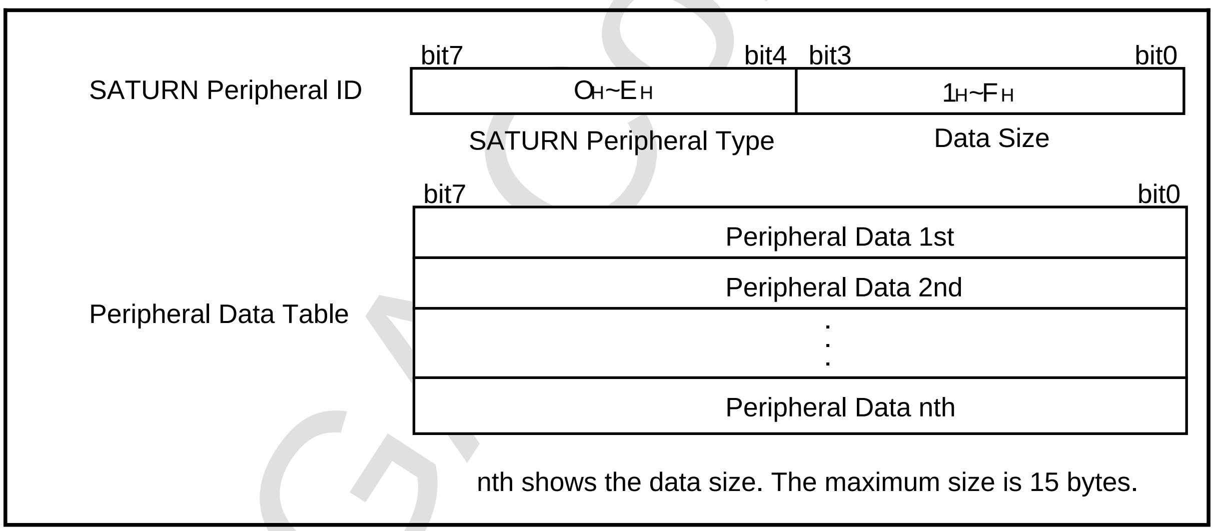
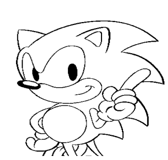


Figure 3.16 Peripheral Data Configuration 1



	bit7–bit4	bit3–bit0
SATURN Peripheral ID	0_H~E_H	0_H
	SATURN Peripheral Type	Data Size
Extension Data Size	0_H	F_H
Peripheral Data Table	Peripheral Data 1st	
	Peripheral Data 2nd	
	⋮	
	Peripheral Data 15th	

Extension data size is limited to 15 bytes.
When accessed using 255-byte mode and the extension data size is a combination of 0FH, permission will not be given by the peripheral development side.

Figure 3.17 Peripheral Data Configuration 2

	bit7–bit4	bit3–bit0
SATURN Peripheral ID	0_H ~E_H	0_H
	SATURN Peripheral Type	Data Size
Extension Data Size	10_H ~FF_H	
Peripheral Data Table	Peripheral Data 1st	
	Peripheral Data 2nd	
	⋮	
	Peripheral Data nth	

nth shows the data size. The maximum size is 255 bytes.

Figure 3.18 Peripheral Data Configuration 3

- **When a Multitap Is Connected to the Peripheral Port**

When the multitap is connected, the port mode shows the maximum data size that can be collected from the peripherals connected to each tap. (This is not the total number of data that can be collected from the entire multitap.)

If the connected peripheral is 15 bytes or less, the peripheral data configuration 1 will be used whether the port mode is 15 bytes or 255 bytes. If the connected peripheral is 16 bytes or more and the port mode is the 15-byte mode, only up to 15 bytes of data can be collected as for peripheral data configuration 2. If the connected peripheral is 16 bytes or more and the port mode is the 255-byte mode, all the peripheral data can be collected as in peripheral data configuration 3.

Also, if the specifications for the multitap itself are limited to 15 bytes or less, all data of 16 bytes and beyond is cut off. With a multitap, it is possible to mix the connection of peripherals of 15 bytes or less and 16 bytes or more. However, when an INTBACK command is issued, the port mode can only be set to either 15-byte or 255-byte mode.

Here, the specifications of the multitap define the maximum data size that can be collected for each tap. When a multitap is used, the port mode setting is set to follow the tap's maximum data size. In other words, if the multitap's specification is a maximum of 15 bytes, the port mode should be set to 15-byte mode, and if the multitap's maximum specification is 255 bytes, the port mode should be set to 255-byte mode.

The SATURN 6P multitap is a maximum of 15 bytes per tap. Use the 15-byte mode for the port mode. Table 3.9 shows combinations of the multitap data size and the port mode. The peripheral data configurations 1~3 in Table 3.9 are the same as those shown in Figures 3.16~3.18.

The connection state of all taps when using a multitap is shown by each tap's SATURN peripheral ID. When no peripheral is connected to the tap, or when the connected device is UNKNOWN, the SATURN peripheral ID is output as shown in Figures 3.19 and 3.20.

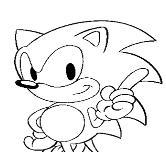


Table 3.9 Combinations of Peripheral Data Size and Port Mode (Multitap)

		Port Mode (IREG1 Setting)	
		15	255
Peripheral Data Size (Byte)	15	Peripheral Data Configuration 1	
	16-255	Peripheral Data Configuration 2	Peripheral Data Configuration 3
	Not Connected	Tap Peripheral Not Connected	
	UNKNOWN	Tap Peripheral UNKNOWN	

Figure 3.19 SATURN Peripheral ID when Tap Unconnected

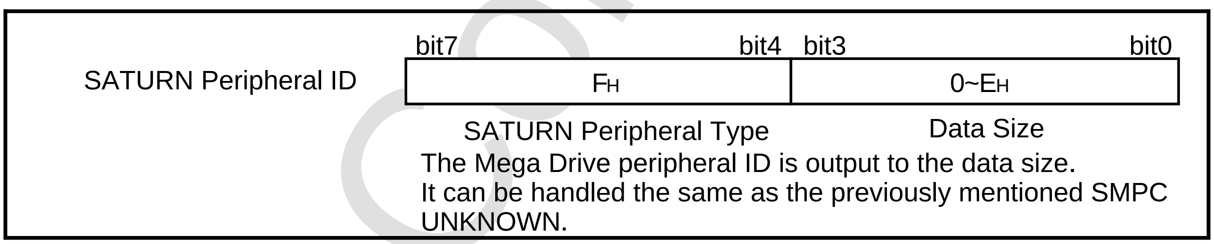


Figure 3.20 SATURN Peripheral ID when Tap Unknown

SH-2 Direct Mode

Block Diagram

Figure 3.21 shows the block diagram for the SH-2 direct mode. The SH-2 can directly access peripherals via the two I/O port data registers (PDR1, PDR2) in the SMPC.

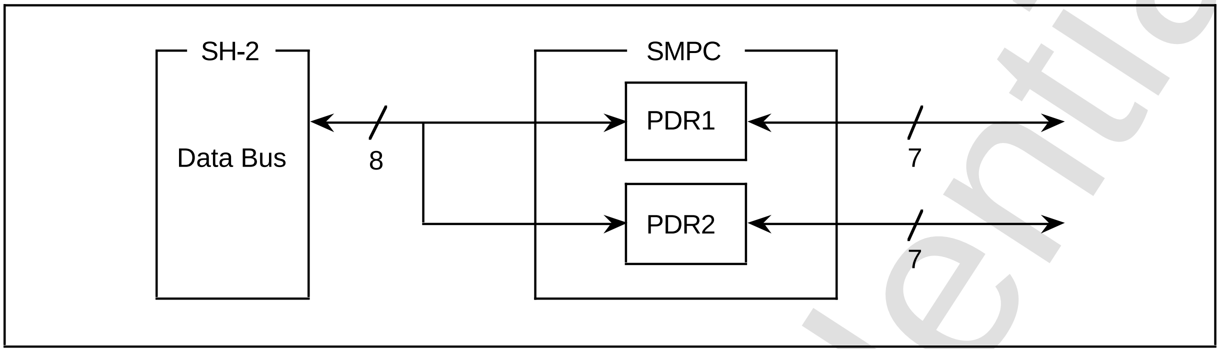


Figure 3.21 SH-2 Direct Mode Block Diagram

Characteristics

This mode becomes an effective means during the following procedures:

1) When controlling peripherals that require high-speed access that is faster than the access speed possible in the SMPC control mode.
2) When data output from the peripherals is required.
3) When access to peripherals that need an external latch is required.
4) When access is required to a peripheral that is not supported by the SMPC.

Settings for Using the SH-2 Direct Mode

Figure 3.22 shows an example of a setting for using the SH-2 direct mode and shows an example of a setting to port 1. Mode settings can be done independently for each port.

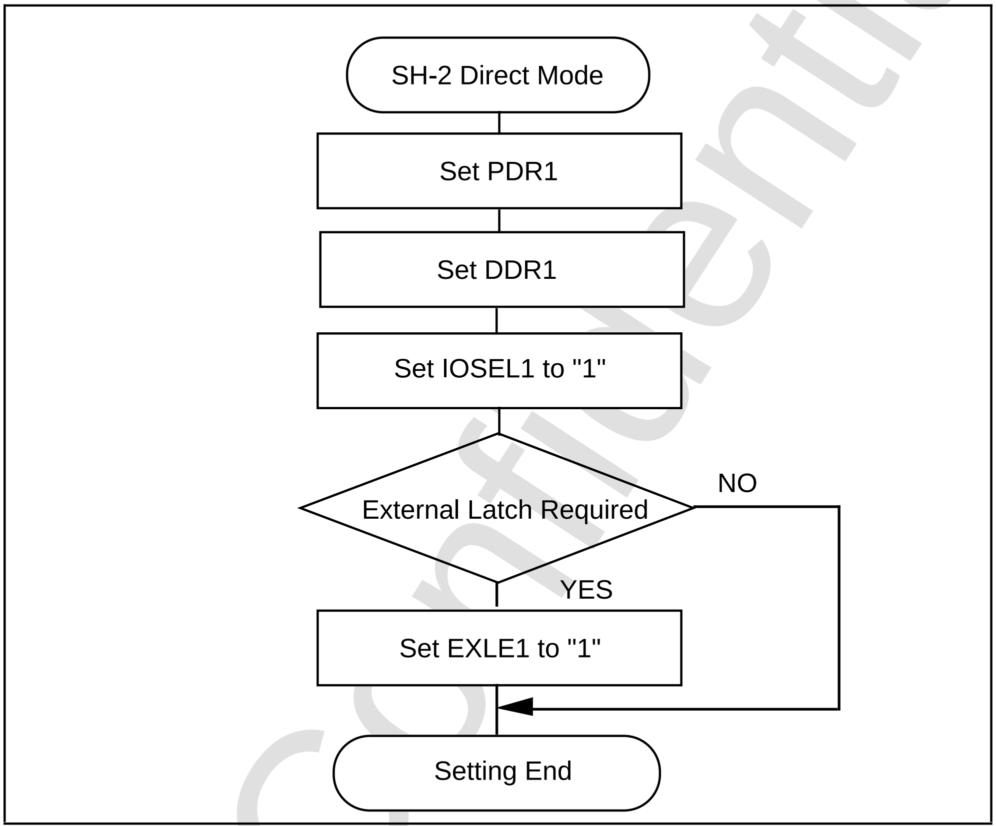


Figure 3.22 SH-2 Direct Mode Setting Example

When both the SH-2 direct mode and the SMPC control mode are used (example: port 1=SH-2 direct mode, port 2=SMPC control mode), use the 0 byte mode for the port used by the SH-2 direct mode at an INTBACK command issue.

3.2 SATURN Peripheral Standard Formats

Purpose of SATURN Peripheral Standard Formats

The SATURN peripheral standard format was prepared for the following purposes.

1) To be able to control multiplay even though the peripheral data configurations, types, and meanings are different.
2) To be able to perform multiplay and to use any upward compatible peripherals, such as increase buttons, increased number of analog channels, and added extension data, that may be sold in the future; as well as controlling previously sold applications.

SATURN Standard Format Types and Data Formats

There are currently four SATURN standard formats that were created for the above stated purposes. An explanation of these is given below.

- **SATURN Digital Device**

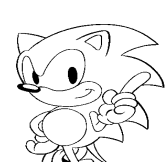
  This is a device that is only configured with buttons and is represented by the SATURN standard PAD. The basic peripheral type is 0H and the data size is 2 bytes. The format characteristic is that the 1st Data is configured with the same value as the Mega Drive 3 button.

  Compatibility is preserved by adding the 1st Data to the application, which makes it possible to control the application. Table 3.10 shows the SATURN digital device format.

Table 3.10 SATURN Digital Device Standard Format

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
SATURN Peripheral ID	0	0	0	0	Data Size			
1st Data	Right	Left	Down	Up	Start	A TRG	C TRG	B TRG
2nd Data	R TRG	X TRG	Y TRG	Z TRG	L TRG	Extension Data		
3rd Data	Extension Data							
:	Extension Data							
:	Extension Data							
nth Data	Extension Data							

Right, Left, Down, Up, Start, A TRG, C TRG, B TRG, R TRG, X TRG, Y TRG, Z TRG, and L TRG become 0 when the button is pushed down.



- **SATURN Analog Device**

These devices, such as the analog joystick, analog steering wheel, and tablet, contain an A/D converter. The basic peripheral type is 1H and the data size is 5 bytes. The format characteristic is that the 1st Data is configured with the same value as the Mega Drive 3-button PAD.

Compatibility is preserved by adding the 1st Data to the application, which makes it possible to control the application. Table 3.11 shows the SATURN analog device standard format.

Table 3.11 SATURN Analog Device Standard Format

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
SATURN Peripheral ID	0	0	0	1	Data Size			
1st Data	Right	Left	Down	Up	Start	A TRG	C TRG	B TRG
2nd Data	R TRG	X TRG	Y TRG	Z TRG	L TRG	Extension Data		
3rd Data	AX7	AX6	AX5	AX4	AX3	AX2	AX1	AX0
4th Data	AY7	AY6	AY5	AY4	AY3	AY2	AY1	AY0-
5th Data	AZ7	AZ6	AZ5	AZ4	AZ3	AZ2	AZ1	AZ0
6th Data	Extension Data							
:	Extension Data							
:	Extension Data							
nth Data	Extension Data							

Right, Left, Down, Up, Start, A TRG, C TRG, B TRG, R TRG, X TRG, Y TRG, Z TRG, and L TRG become 0 when the button is pushed down.

AX7~AX0, AY7~AY0, and AZ7~AZ0 are the absolute values of the unsigned A/D converter output.

For AX7~AX0 and AY7~AY0, the upper left is (0,0) and the bottom right is (255,255).

For AZ7~AZ0, the bottom is 0 and the top is 255.

- **Pointing Device**

This device outputs rotary encoder movement quantities, such as those from a mouse or trackball. The peripheral type is 2H and the basic data size is 3 bytes. The format characteristic is that unlike the data tables for digital devices, analog devices, and keyboard devices. The data table for pointing devices does not have data with the same value as the Mega Drive 3-button PAD.

In addition, the X and Y data movement is output as the amount of movement of the rotary encoder (Δ delta), so if all three of the defined bytes are not supported, compatibility cannot be maintained. Table 3.12 shows the SATURN pointing device standard format.

Table 3.12 SATURN Pointing Device Standard Format

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
SATURN Peripheral ID	0	0	1	0	Data Size			
1st Data	Y Over	X Over	Y Sign	X Sign	Start	Middle	Right	Left
2nd Data	XD7	XD6	XD5	XD4	XD3	XD2	XD1	XD0-
3rd Data	YD7	YD6	YD5	YD4	YD3	YD2	YD1	YD0
4th Data	Extension Data							
:	Extension Data							
:	Extension Data							
nth Data	Extension Data							

Y Over, X Over	0: X or Y data is valid. 1: Data is over flowing. (255 exceeded)
Y Sign, X Sign	0: X and Y data have positive values. 1: X and Y data have negative values.
XD7~XD0, YD7~YD0	Absolute value of amount of mouse movement.
Start, Middle, Right, Left	Becomes 1 when button is pushed.

- **Keyboard Device**

  Devices used for personal computers, represented by full keyboards. The peripheral type is 3H and the data size is 4 bytes. The format characteristic is that the 1st Data is configured with the same value as for the Mega Drive 3-button PAD. Compatibility is maintained by combining the 1st Data with the application to control the application. Table 3.13 shows the SATURN keyboard device standard format.

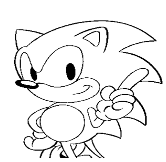


Table 3.13 SATURN Keyboard Device Standard Format

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
SATURN Peripheral ID	0	0	1	1	Data Size			
1st Data	Right	Left	Down	Up	Start	A TRG	C TRG	B TRG
2nd Data	R TRG	X TRG	Y TRG	Z TRG	L TRG	Extension Data		
3rd Data	0	Caps Lock	Num Lock	Scroll Lock	Make	1	1	Break
4th Data	D7	D6	D5	D4	D3	D2	D1	D0
5th Data	Extension Data							
:	Extension Data							
:	Extension Data							
nth Data	Extension Data							

Right, Left, Down, Up, Start, A TRG, C TRG, B TRG, R TRG, X TRG, Y TRG, Z TRG, and L TRG become 0 when the button is pushed down. The corresponding values for each button and keyboard key are given below.

Button	Key
Right	→
Left	←
Down	↓
Up	↑
Start	ESC
A TRG	Z
C TRG	C
B TRG	X
R TRG	Q
X TRG	A
Y TRG	S
Z TRG	D
L TRG	E

For Caps Lock	1: Caps Lock is locked (Caps Lock LED is lit.)
For Num Lock	1: Num Lock is locked (Num Lock LED is lit.)
For Scroll Lock	1: Scroll Lock is locked (Scroll Lock LED is lit.)
For Make	1 is shown when there is a valid Make code (a key that shows D7~D0 code is pushed down) in D7~D0.
For Break	1 is shown when there is a valid Break code (a key that shows D7~D0 code is pushed down) in D7~D0.
	D7~D0 show the key No. They are used with both Make and Break.

Future Expansion of Standard Formats

At the present time, four types of formats have been prepared. More will be prepared in the future when required.

Precautions when Using Standard Formats

Because the system conforms to standard formats, when the data is larger than the standard format size the extra data is deleted. Further, when the data size is smaller than the standard format, other data will be added to make up the insufficiency. In addition, As an example of how handling is done on the peripheral end, there is analog X-Y control as for the analog joystick. When there is no appropriate digital input, a value that is higher than that of the analog X-Y data is used on the peripheral end to make it possible to turn on and off the U, D, L, and R bits.

3.3 Support Peripheral Data Format in SMPC Control Mode

This section describes the SMPC support peripheral data format in the SMPC control mode. For detailed data on each peripheral, refer to the manual for each peripheral.

Mega Drive 3-Button PAD

Table 3.14 shows the Mega Drive 3-button PAD data format for SMPC control mode.

Table 3.14 Mega Drive 3-Button PAD Data Format in SMPC Control Mode

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
SATURN Peripheral ID	1	1	1	0	0	0	0	1
1st Data	Right	Left	Down	Up	Start	A TRG	C TRG	B TRG

Right, Left, Down, Up, Start, A TRG, C TRG, and B TRG become 0 when the button is pushed.

Mega Drive 6-Button PAD

Table 3.15 shows the Mega Drive 6-button PAD data format for SMPC control mode.

Table 3.15 Mega Drive 6-Button PAD Data Format in SMPC Control Mode

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
SATURN Peripheral ID	1	1	1	0	0	0	1	0
1st Data	Right	Left	Down	Up	Start	A TRG	C TRG	B TRG
2nd Data	MODE	X TRG	Y TRG	Z TRG	1	1	1	1

Right, Left, Down, Up, Start, A TRG, C TRG, B TRG, MODE, X TRG, Y TRG, and Z TRG become 0 when the button is pushed.

SATURN Mouse (Provisional Name)

Table 3.16 shows the SATURN mouse data format for SMPC control mode.

Table 3.16 SATURN Mouse Data Format in SMPC Control Mode

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
SATURN Peripheral ID	1	1	1	0	0	0	1	1
1st Data	Y Over	X Over	Y Sign	X Sign	Start	Middle	Right	Left
2nd Data	XD7	XD6	XD5	XD4	XD3	XD2	XD1	XD0
3rd Data	YD7	YD6	YD5	YD4	YD3	YD2	YD1	YD0

Y Over, X Over	0: X or Y data is valid. 1: Data is over-flowing. (255 exceeded)
Y Sign, X Sign	0: X and Y data have positive values. 1: X and Y data have negative values.
XD7~XD0, YD7~YD0	Absolute value of amount of mouse movement.
Start, Middle, Right, Left	Becomes 1 when button is pushed.

SEGA Tap

In the SMPC control mode, the port status shown in Table 3.17 is output. The SEGA Tap is connected to the Mega Drive 3-button PAD, Mega Drive 6-button PAD, and SEGA mouse. For information regarding peripheral data, refer to each peripheral data format.

Table 3.17 SEGA Tap Port Status in SMPC Control Mode

Multitap ID	No. of Connectors
0_H	4_H

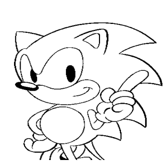
SATURN Standard PAD (Provisional Name)

Table 3.18 shows the SATURN standard PAD data format for SMPC control mode.

Table 3.18 SATURN Standard PAD Data Format in SMPC Control Mode

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
SATURN Peripheral ID	0	0	0	0	0	0	1	0
1st Data	Right	Left	Down	Up	Start	A TRG	C TRG	B TRG
2nd Data	R TRG	X TRG	Y TRG	Z TRG	L TRG	1	1	1

Right, Left, Down, Up, Start, A TRG, C TRG, B TRG, R TRG, X TRG, Y TRG, Z TRG and L TRG become 0 when the button is pushed.



SATURN Analog Joystick (Provisional Name)

Table 3.19 shows the SATURN analog joystick data format for SMPC control mode. The data AX7~AX0, AY7~AY0, and AZ7~AZ0 are the absolute values output by the A/D converter.

Table 3.19 SATURN Analog Joystick Data Format in SMPC Control Mode

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
SATURN Peripheral ID	0	0	0	1	0	1	0	1
1st Data	Right	Left	Down	Up	Start	A TRG	C TRG	B TRG
2nd Data	R TRG	X TRG	Y TRG	Z TRG	L TRG	1	1	1
3rd Data	AX7	AX6	AX5	AX4	AX3	AX2	AX1	AX0
4th Data	AY7	AY6	AY5	AY4	AY3	AY2	AY1	AY0
5th Data	AZ7	AZ6	AZ5	AZ4	AZ3	AZ2	AZ1	AZ0

Right, Left, Down, Up, Start, A TRG, C TRG, B TRG, R TRG, X TRG, Y TRG, Z TRG, and L TRG become 0 when the button is pushed down.

AX7~AX0, AY7~AY0, and AZ7~AZ0 are the absolute values of the unsigned A/D converter output.

For AX7~AX0 and AY7~AY0, the upper left is (0,0) and the bottom right is (255,255).

For AZ7~AZ0, the bottom is 0 and the top is 255.

SATURN Keyboard (Provisional Name)

Table 3.20 shows the SATURN keyboard data format for SMPC control mode.

Table 3.20 SATURN Keyboard Data Format in SMPC Control Mode

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
SATURN Peripheral ID	0	0	1	1	0	1	0	0
1st Data	Right	Left	Down	Up	Start	A TRG	C TRG	B TRG
2nd Data	R TRG	X TRG	Y TRG	Z TRG	L TRG	KB TYPE2	KB TYPE1	KB TYPE0
3rd Data	0	Caps Lock	Num Lock	Scroll Lock	Make	1	1	Break
4th Data	D7	D6	D5	D4	D3	D2	D1	D0

Right, Left, Down, Up, Start, A TRG, C TRG, B TRG, R TRG, X TRG, Y TRG, Z TRG, and L TRG become 0 when the button is pushed down.

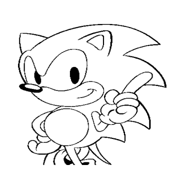
The corresponding values for each button and keyboard key are given below.

Button	Key
Right	→
Left	←
Down	↓
Up	↑
Start	ESC
A TRG	Z
C TRG	C
B TRG	X
R TRG	Q
X TRG	A
Y TRG	S
Z TRG	D
L TRG	E

KBTYPE2~0 — 000: SATURN Keyboard
001~110: SEGA RESERVED
111: UNKNOWN

The KBTYPE shown here is used for the IBM keyboard conversion adapter format. When IBM keyboards 101, 102, and 106 are connected to the conversion adapter, 000 is displayed. When a keyboard not supported by the conversion adapter, or when a device not recognized as a keyboard is connected to the conversion adapter, 111 is output. In the future, with the integration accompanying the commercialization of the keyboard, the system will be configured to output 000.

For Caps Lock	1: Caps Lock is locked (Caps Lock LED is lit.)
For Num Lock	1: Num Lock is locked (Num Lock LED is lit.)
For Scroll Lock	1: Scroll Lock is locked (Scroll Lock LED is lit.)
For Make	1 is shown when there is a valid Make code (a key that shows D7~D0 code is pushed down) in D7~D0.
For Break	1 is shown when there is a valid Break code (a key that shows D7~D0 code is pushed down) in D7~D0.
D7~D0	Shows the key No. They are used with both Make and Break.



SATURN 6P Multitap (Provisional Name)

In the SMPC control mode, the port status shown in Table 3.21 is output. The SATURN 6P multitap is connected to the Mega Drive 3-button PAD, Mega Drive 6-button PAD, SATURN standard PAD (provisional name), SATURN analog joystick (provisional name), SATURN mouse (provisional name), and SATURN standard keyboard (provisional name). For information regarding peripheral data, refer to each peripheral data format.

For the SATURN 6P multitap, the maximum data size for each tap is 15 bytes. Use the 15-byte port mode.

Table 3.21 SATURN 6P Multitap Port Status

Multitap ID	No. of Connectors
1H	6H

3.4 Support Peripheral Data Format in SH-2 Direct Mode

This section explains about peripheral access protocols and data formats in the SH-2 direct mode.

About Peripheral Port Bit Names

The SMPC peripheral ports were configured to succeed Mega Drive peripheral ports to maintain compatibility. The naming method for port bit names was also kept. Table 3.22 shows the relationship between the port bit number and port bit name. Hereafter, this manual will give explanations using port bit names.

Table 3.22 Relationship Between Port Bit Number and Port Bit Name

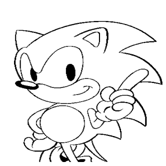
Port Bit Number	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Port Bit Name	TH	TR	TL	R	L	D	U

Mega Drive Peripheral ID Computing Method in SH-2 Direct Mode

The Mega Drive peripheral ID calculation formula is given below, and is shown by the four bits ID3, ID2, ID1, and ID0.

ID3=R # L (TH=1)
ID2=D # U (TH=1)
ID1=R # L (TH=0)
ID0=D # U (TH=0)

signifies the logical sum OR.



Port Setting During Mega Drive Peripheral ID Acquisition

The port direction register setting values during Mega Drive peripheral ID acquisition are shown in Table 3.23. When the port direction is set as shown below, Read is performed when TH=1 for RLDU and TH=0 for RLDU, and the Mega Drive peripheral ID can be output using the above explained formula.

After TH is changed, read the R, L, D, and U after 2 µS.

Table 2.23 Port Direction Register Setting Value During Mega Drive Peripheral ID Acquisition

Port Bit Name	TH	TR	TL	R	L	D	U
Port Direction	Set to Output	Set to Input					

Peripheral Interface Protocol

There are three types of peripheral interface protocols. Following is given an overview of each peripheral protocol and the peripherals they support.

TH Control Method

The TH control method interface protocol is a method that acquires data when TH=1 for TR, TL, R, L, D, and U and when TH=0 for TR, TL, R, L, D, and U. The peripherals that support this protocol are the Mega Drive 3-button PAD and Mega Drive 6-button PAD.

TH and TR Control Method

The TH and TR control method interface protocol is a method that acquires data when the 4-bit pattern for TH and TR is R, L, D, and U. The peripheral that supports this protocol is the Saturn Standard PAD.

3-Line Handshake Method

The 3-line handshake method SEL (select) the peripheral when TH=0, transfers REQ (request) from TR, and then returns an ACK (acknowledgment) to TL when the R, L, D, and U data has been verified. The 3-line handshake method is a method that acquires data after confirming the status using the above three control signals. The peripherals that support this protocol are the SEGA tap, SEGA mouse, SATURN analog joystick, SATURN keyboard, and SATURN 6P multitap.

Mega Drive Peripheral ID for Each Port

The Mega Drive peripheral ID for each peripheral is given in Table 3.24.

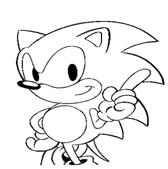
Table 3.24 Mega Drive Peripheral ID for Each Peripheral

Peripheral Name	Mega Drive Peripheral ID
Mega Drive 3-Button PAD	DH
Mega Drive 6-Button PAD	DH&CH
SEGA Mouse	3H
SEGA Tap	7H
SATURN Standard PAD	BH
SATURN Analog Joystick	5H
SATURN Keyboard	5H
SATURN Multitap	5H

Access Sequence in SH-2 Direct Mode for Peripherals that Have a Mega Drive ID Other Than 5H

The access sequence in SH-2 direct mode to peripherals that have Mega Drive peripheral ID's other than 5H is given below.

1) Acquire the Mega Drive peripheral ID.
2) Determine the type of peripheral from the Mega Drive peripheral ID. Execute the appropriate sequence for the peripheral and acquire the data. The SATURN peripheral ID is not returned for peripherals that have Mega Drive peripherals other than 5H.



Access Sequence in SH-2 Direct Mode for Peripherals that Have a 5H Mega Drive ID

The access sequence in SH-2 direct mode to peripherals that have a 5H Mega Drive peripheral ID's.

1) Acquire the Mega Drive peripheral ID.
2) Execute the appropriate protocol required for the Mega Drive peripheral ID and acquire the Saturn peripheral ID.

   The protocol is determined by the D and U that comprise the Mega Drive peripheral ID. Other combinations are SEGA RESERVED.

   3-Line Handshake Method Peripherals

   D, U = 0, 1 (TH=1)
   D, U = 0, 1 (TH=0)

3) Acquire the SATURN peripheral ID, perform the number of accesses required for the data size, and receive all peripheral data.

Mega Drive 3-Button PAD

The Mega Drive 3-button PAD is a TH control method peripheral. The access protocol operates by having the 1st Data and 2nd Data alternately output by repeatedly changing the TH bit value. The Mega Drive peripheral ID is DH. Table 3.25 shows the Mega Drive
3-button PAD access protocol and data format for the SH-2 direct mode.

After the TH is changed, read the TR, TL, R, L, D, and U after 2 µS.

Table 3.25 Mega Drive 3-Button PAD Data Format for SH-2 Direct Mode

	Output	Input					
	TH	TR	TL	R	L	D	U
1st Data	1	C TRG	B TRG	Right	Left	Down	Up
2nd Data	0	Start	A TRG	0	0	Down	Up

Mega Drive Peripheral ID Acquisition Sequence

Right, Left, Down, Up, Start, A TRG, C TRG, and B TRG become 0 when the button is pushed down.

Mega Drive 6-Button PAD

The Mega Drive 6-button PAD is a TH control method peripheral. The access protocol operates by having the 1st Data to the 8th Data repeatedly output by repeatedly changing the TH bit value. To preserve the compatibility with the Mega Drive 3-button PAD, the Mega Drive 6-button PAD uses the same Mega Drive peripheral ID. With the 6-button PAD, continuing ID identification until the 6th Data will change the ID from DH to CH. Table 3.26 shows the Mega Drive 6-button PAD data format for the SH-2 direct mode.

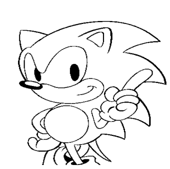
After the TH is changed, read the TR, TL, R, L, D, and U after 2 µS. After data acquisition, have TH=1 remain for over 2 mS until the next acquisition.

Table 3.26 Mega Drive 6-Button PAD Data Format for SH-2 Direct Mode

	Output	Input					
	TH	TR	TL	R	L	D	U
1st Data	1	C TRG	B TRG	Right	Left	Down	Up
2nd Data	0	Start	A TRG	0	0	Down	Up
3rd Data	1	C TRG	B TRG	Right	Left	Down	Up
4th Data	0	Start	A TRG	0	0	Down	Up
5th Data	1	C TRG	B TRG	Right	Left	Down	Up
6th Data	0	Start	A TRG	0	0	0	0
7th Data	1	C TRG	B TRG	MD	X TRG	Y TRG	Z TRG
8th Data	0	Start	A TRG	1	1	1	1

Mega Drive Peripheral ID Acquisition Sequence

Right, Left, Down, Up, Start, A TRG, C TRG, and B TRG become 0 when the button is pushed down.



SATURN Mouse (Provisional Name)

The SATURN mouse is a 3-line handshake method peripheral. There are three sequence types for the SATURN mouse: power on reset, reset, and data request.

1) Power On Reset
   When the power is turned on the mouse is automatically initialized. While the mouse is being initialized the TL bit is made 0_B to notify the SH-2 that the mouse is being initialized.

   Do not make a data request until initialization is finished. Table 3.27 shows the data format during SATURN mouse power on reset in SH-2 direct mode.

Table 3.27 Data Format During SATURN Mouse Power On Reset for SH-2 Direct Mode

	Output		Input				
	TH	TR	TL	R	L	D	U
During Reset	1	1	0	0	0	0	0
Reset Finished	1	1	1	0	0	0	0

2) Reset
   This is the sequence that resets the SATURN mouse from the SH-2.
   A mouse reset request can be made by changing TR to 0_B when TH is 1_B. The SATURN mouse answers the request by changing TL to 0_B. Initialization begins when the SH-2 changes TR to 1_B.

   Do not make a data request until initialization is completed. Table 3.28 shows the data format during SATURN mouse reset in the SH-2 direct mode.

Table 3.28 Data Format During SATURN Mouse Reset for SH-2 Direct Mode

	Output		Input				
	TH	TR	TL	R	L	D	U
Initial Status	1	1	1	0	0	0	0
Reset Request	1	0	1	0	0	0	0
Reset Acknowledge	1	0	0	0	0	0	0
Reset Execute	1	1	0	0	0	0	0
Reset End	1	1	1	0	0	0	0

3) Data Request

This sequence acquires data from the mouse. It is started by changing TH to 0B, and ended by changing both TH and TR to 1B.

The first data is the Mega Drive ID acquisition phase. Data is acquired by changing TH to 0B from 1B. After TH is changed, read R, L, D, and U after 2 μs. Later data is acquired by a handshake with TR and TL. Table 3.29 shows the data format during SATURN mouse data request in the SH-2 direct mode.

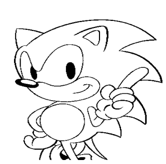


Table 3.29 Data Format During SATURN Mouse Data Request for SH-2 Direct Mode

	Output		Input				
	TH	TR	TL	R	L	D	U
1st Data	1	1	1	0	0	0	0
2nd Data	0	1	1	1	0	1	1
	0	0	1	x	x	x	x
3rd Data	0	0	0	1	1	1	1
	0	1	0	x	x	x	x
4th Data	0	1	1	1	1	1	1
	0	0	1	x	x	x	x
5th Data	0	0	0	Y Over	X Over	Y Sign	X Sign
	0	1	0	x	x	x	x
6th Data	0	1	1	Start	Middle	Right	Left
	0	0	1	x	x	x	x
7th Data	0	0	0	XD7	XD6	XD5	XD4
	0	1	0	x	x	x	x
8th Data	0	1	1	XD3	XD2	XD1	XD0
	0	0	1	x	x	x	x
9th Data	0	0	0	YD7	YD6	YD5	YD4
	0	1	0	x	x	x	x
10th Data	0	1	1	YD3	YD2	YD1	YD0
End Request	1	1	x	x	x	x	x
End	1	1	1	0	0	0	0

■ Mega Drive Peripheral ID Acquisition Sequence

Y Over, X Over	0: X or Y data is valid. 1: Data is over flowing. (255 exceeded)
Y Sign, X Sign	0: X and Y data have positive values. 1: X and Y data have negative values.
XD7~XD0, YD7~YD0	Absolute value of amount of mouse movement.
Start, Middle, Right, Left	Becomes 1 when button is pushed.

SEGA Tap

The SEGA tap is a 3-line handshake method peripheral. There are two sequence types for the SEGA tap: power on reset and data request.

1) Power On Reset
   When the power is turned on the tap is automatically initialized. While the tap is being initialized the TL bit is made 0B to notify the SH-2 that the mouse is being initialized. Do not make a data request until initialization is finished. Table 3.30 shows the data format during SEGA tap power on reset in SH-2 direct mode.

Table 3.30 Data Format During SEGA Tap Power On Reset for SH-2 Direct Mode

	Output		Input				
	TH	TR	TL	R	L	D	U
During Reset	1	1	0	0	0	0	0
Reset Finished	1	1	1	0	0	0	0

2) Data Request
   This is the sequence to acquire data from the SEGA tap. A data request is started by changing TH to 0B and ended by changing TH and TR to 1B. The first data is the Mega Drive ID acquisition phase. Data is acquired by changing TH to 0B from 1B. After TH is changed, read R, L, D, and U after 2 µs. Acquire the data thereafter with a handshake with TR and TL. Table 3.31 shows the data format during SEGA tap data request in the SH-2 direct mode.

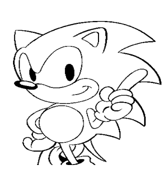


Table 3.31 Data Format During SEGA Tap Data Request for SH-2 Direct Mode

	Output		Input				
	TH	TR	TL	R	L	D	U
1st Data	1	1	1	0	0	1	1
2nd Data	0	1	1	1	1	1	1
	0	0	1	x	x	x	x
3rd Data	0	0	0	0	0	0	0
	0	1	0	x	x	x	x
4th Data	0	1	1	0	0	0	0
	0	0	1	x	x	x	x
5th Data	0	0	0	1P DevID3	1P DevID2	1P DevID1	1P DevID0
	0	1	0	x	x	x	x
6th Data	0	1	1	2P DevID3	2P DevID2	2P DevID1	2P DevID0
	0	0	1	x	x	x	x
7th Data	0	0	0	3P DevID3	3P DevID2	3P DevID1	3P DevID0
	0	1	0	X	X	X	X
8th Data	0	1	1	4P DevID3	4P DevID2	4P DevID1	4P DevID0
	0	0	1	x	x	x	x
9th Data and Later	0	0	0	D3	D2	D1	D0
End Request	1	1	x	x	x	x	x
End	1	1	1	0	0	1	1

Mega Drive Peripheral ID Acquisition Sequence

The 1P~4P DevID in Table 3.31 shows the ID of the peripherals connected to SEGA tap. The peripherals that can be connected to SEGA tap are the Mega Drive 3-button PAD, Mega Drive 6-button PAD, and SEGA mouse. Table 3.32 shows the ID of the connected devices.

Table 3.32 Connected Peripherals and ID

ID	Peripheral Name
0H	Mega Drive 3-button PAD
1H	Mega Drive 6-button PAD
2H	SEGA mouse
FH	Unconnected or Unknown

The data of devices connected to bits D3~D0 of the 9th Data and later from Table 3.31 continues. The data format of each device is given on the following page.

(a) Mega Drive 3-Button PAD
Table 3.33 shows the Mega Drive 3-button PAD data format when connected to SEGA tap.

Table 3.33 Mega Drive 3-Button PAD Data Format During Connection to SEGA Tap

bit3	bit2	bit1	bit0
Right	Left	Down	Up
Start	A TRG	C TRG	B TRG

Right, Left, Down, Up, Start, A TRG, C TRG, and B TRG are 0 when the button is pushed down.

(b) Mega Drive 6-Button PAD
Table 3.34 shows the Mega Drive 6-button PAD data format when connected to SEGA tap.

Table 3.34 Mega Drive 6-Button PAD Data Format During Connection to SEGA Tap

bit3	bit2	bit1	bit0
Right	Left	Down	Up
Start	A TRG	C TRG	B TRG
MODE	X TRG	Y TRG	Z TRG

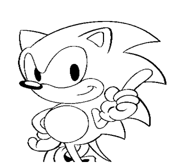
Right, Left, Down, Up, Start, A TRG, C TRG, B TRG, MODE, X TRG, Y TRG, and Z TRG are 0 when the button is pushed down.

(c) SEGA Mouse
Table 3.35 shows the SEGA mouse data format when connected to SEGA tap.

Table 3.35 SEGA Mouse Data Format During Connection to SEGA Tap

bit3	bit2	bit1	bit0
Y Over	X Over	Y Sign	X Sign
Start	Middle	Right	Left
XD7	XD6	XD5	XD4
XD3	XD2	XD1	XD0
YD7	YD6	YD5	YD4
YD3	YD2	YD1	YD0

Y Over, X Over	0: X or Y data is valid. 1: Data is over flowing. (255 exceeded)
Y Sign, X Sign	0: X and Y data have positive values. 1: X and Y data have negative values.
XD7~XD0, YD7~YD0	Absolute value of amount of mouse movement.
Start, Middle, Right, Left	Becomes 1 when button is pushed.



SATURN Standard PAD (Provisional Name)

The SATURN standard PAD is a TH and TR control method peripheral.
Data is output by repeating the specified bit pattern in the TH and TR bits. After TH and TR have been changed, read the R, L, D, and U after 2 µs. Table 3.36 shows the SATURN standard PAD data format in the SH-2 direct mode.

Table 3.36 SATURN Standard PAD Data Format for SH-2 Direct Mode

	Output		Input				
	TH	TR	TL	R	L	D	U
1st Data	1	1	1	L TRG	1	0	0
2nd Data	0	1	1	Right	Left	Down	Up
3rd Data	1	0	1	Start	A TRG	C TRG	B TRG
4th Data	0	0	1	R TRG	X TRG	Y TRG	Z TRG

Mega Drive Peripheral ID Acquisition Sequence

Right, Left, Down, Up, Start, A TRG, C TRG, B TRG, R TRG, X TRG, Y TRG, Z TRG, and L TRG become 0 when the button is pushed down.

SATURN Analog Joystick (Provisional Name)

The SATURN analog joystick is a 3-wire handshake method peripheral. Start is done by changing TH to 0B and end is done by changing TH and TR to 1B.

The first data is the Mega Drive ID acquisition phase. Data is acquired by changing TH to 0B from 1B. After TH is changed, read R, L, D, and U after 2 µs. Acquire later data by making a handshake with TR and TL. Table 3.37 shows the SATURN analog joystick data format in SH-2 direct mode.

Table 3.37 SATURN Analog Joystick Data Format for SH-2 Direct Mode

	Output		Input				
	TH	TR	TL	R	L	D	U
1st Data	1	1	1	0	0	0	1
2nd Data	0	1	1	0	0	0	1
	0	0	1	x	x	x	x
3rd Data	0	0	0	0	0	0	1
	0	1	0	x	x	x	x
4th Data	0	1	1	0	1	0	1
	0	0	1	x	x	x	x
5th Data	0	0	0	Right	Left	Down	Up
	0	1	0	x	x	x	x
6th Data	0	1	1	Start	A TRG	C TRG	B TRG
	0	0	1	x	x	x	x
7th Data	0	0	0	R TRG	X TRG	Y TRG	Z TRG
	0	1	0	X	X	X	X
8th Data	0	1	1	L TRG	α1TRG	α2TRG	α3TRG
	0	0	1	x	x	x	x
9th Data	0	0	0	AX7	AX6	AX5	AX4
	0	1	0	x	x	x	x
10th Data	0	1	1	AX3	AX2	AX1	AX0
	0	0	1	x	x	x	x
11th Data	0	0	0	AY7	AY6	AY5	AY4
	0	1	0	x	x	x	x
12th Data	0	1	1	AY3	AY2	AY1	AY0
	0	0	1	x	x	x	x
13th Data	0	0	0	AZ7	AZ6	AZ5	AZ4
	0	1	0	x	x	x	x
14th Data	0	1	1	AZ3	AZ2	AZ1	AZ0
	0	0	1	x	x	x	x
15th Data	0	0	0	0	0	0	0
	0	1	0	x	x	x	x
16th Data	0	1	1	0	0	0	1
End Request	1	1	x	x	x	x	x
End	1	1	1	0	0	0	1

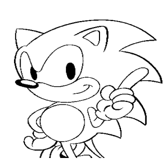
Mega Drive Peripheral ID Acquisition Sequence
SATURN Peripheral ID Acquisition Sequence

Right, Left, Down, Up, Start, A TRG, C TRG, B TRG, R TRG, X TRG, Y TRG, Z TRG, and L TRG become 0 when the button is pushed down.

AX7~AX0, AY7~AY0, and AZ7~AZ0 are the absolute values of the unsigned A/D converter output.

For AX7~AX0 and AY7~AY0, the upper left is (0,0) and the bottom right is (255,255).

For AZ7~AZ0, the bottom is 0 and the top is 255.



SATURN Keyboard

The SATURN keyboard is a 3-wire handshake method peripheral. Start is done by changing TH to 0B and end is done by changing TH and TR to 1B.

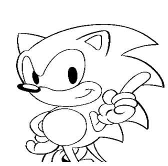
The first data is the Mega Drive ID acquisition phase. Data is acquired by changing TH to 0B from 1B. After TH is changed, read R, L, D, and U after 2 µs. Acquire later data by making a handshake with TR and TL. Table 3.38 shows the SATURN keyboard data format in SH-2 direct mode.

Table 3.38 SATURN Keyboard Data Format for SH-2 Direct Mode

	Output		Input				
	TH	TR	TL	R	L	D	U
1st Data	**1**	**1**	**1**	**0**	**0**	**0**	**1**
2nd Data	**0**	**1**	**1**	**0**	**0**	**0**	**1**
	0	0	1	x	x	x	x
3rd Data	0	0	0	**MDID3**	**MDID2**	**MDID1**	**MDID0**
	0	1	0	x	x	x	x
4th Data	0	1	1	**DSIZE 3**	**DS9ZE 2**	**DSIZE 1**	**DSIZE 0**
	0	0	1	x	x	x	x
5th Data	0	0	0	Right	Left	Down	Up
	0	1	0	x	x	x	x
6th Data	0	1	1	Start	A TRG	C TRG	B TRG
	0	0	1	x	x	x	x
7th Data	0	0	0	R TRG	X TRG	Y TRG	Z TRG
	0	1	0	X	X	X	X
8th Data	0	1	1	L TRG	KBTYPE2	KBTYPE1	KBTYPE0
	0	0	1	x	x	x	x
9th Data	0	0	0	0	Caps Lock	Num Lock	Scroll Lock
	0	1	0	x	x	x	x
10th Data	0	1	1	Make	1	1	Break
	0	0	1	x	x	x	x
11th Data	0	0	0	D7	D6	D5	D4
	0	1	0	x	x	x	x
12th Data	0	1	1	D3	D2	D1	D0
	0	0	1	x	x	x	x
13th Data	0	0	0	0	0	0	0
	0	1	0	x	x	x	x
14th Data	0	1	1	0	0	0	1
End Request	1	1	x	x	x	x	x
End	1	1	1	0	0	0	1

Mega Drive Peripheral ID Acquisition Sequence
SATURN Peripheral ID Acquisition Sequence

Right, Left, Down, Up, Start, A TRG, C TRG, B TRG, R TRG, X TRG, Y TRG, Z TRG, and L TRG become 0 when the button is pushed down.



The corresponding values for each button and keyboard key are given below.

Button	Key
Right	→
Left	←
Down	↓
Up	↑
Start	ESC
A TRG	Z
C TRG	C
B TRG	X
R TRG	Q
X TRG	A
Y TRG	S
Z TRG	D
L TRG	E

KBTYPE2~0	000: SATURN Keyboard 001~110: SEGA RESERVED 111: UNKNOWN

The KBTYPE shown here is used for the IBM keyboard conversion adapter format. When IBM keyboards 101, 102, and 106 are connected to the conversion adapter, 000 is shown. When a keyboard not supported by the conversion adapter, or when a device not recognized as a keyboard is connected to the conversion adapter, 111 is output. In the future, with the integration accompanying the commercialization of the keyboard, the system will be configured to output 000.

For Caps Lock	1: Caps Lock is locked (Caps Lock LED is lit.)
For Num Lock	1: Num Lock is locked (Num Lock LED is lit.)
For Scroll Lock	1: Scroll Lock is locked (Scroll Lock LED is lit.)
For Make	1 is shown when there is a valid Make code (a key that shows D7~D0 code is pushed down) in D7~D0.
For Break	1 is shown when there is a valid Break code (a key that shows D7~D0 code is pushed down) in D7~D0.
D7~D0	Shows the key No. They are used with both Make and Break.

SATURN 6P Multitap (Provisional Name)

The SATURN 6P tap is a 3-line handshake method peripheral. The peripherals that can be connected to this tap are the Mega Drive 3-button PAD, Mega Drive 6-button PAD, SEGA mouse, SATURN standard PAD, SATURN analog joystick, and SATURN keyboard. The maximum data size for each tap of the SATURN 6P multitap is 15 bytes. If peripherals of 16 bytes or more are connected, only the data up to 15 bytes will be collected. Data is output from the SATURN 6P multitap in the SMPC control mode as explained previously. The SATURN peripheral ID is added as a header to the data of all supported peripherals.

Data collection is started by changing TH to 0B and ended by changing TH and TR to 1B. The first data is the Mega Drive ID acquisition phase. Data is acquired by changing TH from 1B to 0B. After TH is changed, read R, L, D, and U after 2 µs. Acquire later data using a handshake with TR and TL. Table 3.39 shows the SATURN 6P multitap data format in the SH-2 direct mode.

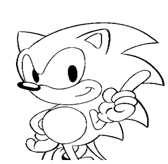


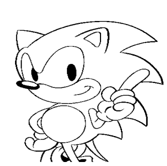
Table 3.39 SATURN 6P Multitap Data Format for SH-2 Direct Mode

	Output		Input				
	TH	TR	TL	R	L	D	U
1st Data	**1**	**1**	**1**	**0**	**0**	**0**	**1**
2nd Data	**0**	**1**	**1**	**0**	**0**	**0**	**1**
	0	0	1	x	x	x	x
3rd Data	0	0	0	\\\\ 0 \\\\	\\\\ 0 \\\\	\\\\ 0 \\\\	\\\\ 0 \\\\
	0	1	0	x	x	x	x
4th Data	0	1	1	//// 0 ////	//// 0 ////	//// 0 ////	//// 1 ////
	0	0	1	//// x ////	//// x ////	//// x ////	//// x ////
5th Data	0	0	0	//// 0 ////	//// 1 ////	//// 1 ////	//// 0 ////
	0	1	0	//// x ////	//// x ////	//// x ////	//// x ////
6th Data	0	1	1	0	0	0	0
	0	0	1	x	x	x	x
7th Data	0	0	0	CH1-M6ID3	CH1-M6ID2	CH1-M6ID1	CH1-M6ID0
	0	1	0	x	x	x	x
8th Data	0	1	1	CH1-DSIZE3	CH1-DSIZE2	CH1-DSIZE1	CH1-DSIZE0
	0	0	1	x	x	x	x
?th Data	0	0	0	CH1-DATA	CH1-DATA	CH1-DATA	CH1-DATA
	0	:	:	:	:	:	:
?th Data	0	:	:	CH2-M6ID3	CH2-M6ID2	CH1-M6ID1	CH1-M6ID0
	0	:	:	x	x	x	x
?th Data	0	:	:	CH2-DSIZE3	CH2-DSIZE2	CH2-DSIZE1	CH2-DSIZE0
	0	:	:	x	x	x	x
?th Data	0	:	:	CH2-DATA	CH2-DATA	CH2-DATA	CH2-DATA
	0	:	:	:	:	:	:
?th Data	0	:	:	CH3-M6ID3	CH3-M6ID2	CH3-M6ID1	CH3-M6ID0
	0	:	:	x	x	x	x
?th Data	0	:	:	CH3-DSIZE3	CH3-DSIZE2	CH3-DSIZE1	CH3-DSIZE0
	0	:	:	x	x	x	x
?th Data	0	:	:	CH3-DATA	CH3-DATA	CH3-DATA	CH3-DATA
	0	:	:	:	:	:	:
?th Data	0	:	:	CH4-M6ID3	CH4-M6ID2	CH4-M6ID1	CH4-M6ID0
	0	:	:	x	x	x	x
?th Data	0	:	:	CH4-DSIZE3	CH4-DSIZE2	CH4-DSIZE1	CH4-DSIZE0
	0	:	:	x	x	x	x
?th Data	0	:	:	CH4-DATA	CH4-DATA	CH4-DATA	CH4-DATA
	0	:	:	:	:	:	:
?th Data	0	:	:	CH5-M6ID3	CH5-M6ID2	CH5-M6ID1	CH5-M6ID0
	0	:	:	x	x	x	x
?th Data	0	:	:	CH5-DSIZE3	CH5-DSIZE2	CH5-DSIZE1	CH5-DSIZE0
	0	:	:	x	x	x	x
?th Data	0	:	:	CH5-DATA	CH5-DATA	CH5-DATA	CH5-DATA
	0	:	:	:	:	:	:
?th Data	0	:	:	CH6-M6ID3	CH6-M6ID2	CH6-M6ID1	CH6-M6ID0
	0	:	:	x	x	x	x
?th Data	0	:	:	CH6-DSIZE3	CH6-DSIZE2	CH6-DSIZE1	CH6-DSIZE0
	0	:	:	x	x	x	x
?th Data	0	:	:	CH6-DATA	CH6-DATA	CH6-DATA	CH6-DATA
	0	:	:	:	:	:	:
nth Data	0	0	0	0	0	0	0
	0	1	0	x	x	x	x
n+1th Data	0	1	1	0	0	0	1
end	1	1	1	0	0	0	1

(shaded)	Mega Drive Peripheral ID Acquisition Sequence
\\\\	SATURN Peripheral ID Acquisition Sequence
/////	Port Status

Index

Alphabetical Listing



Command Abbreviations

Command Names