Memory Stick Standard

Memory Stick PRO
Specification Summary
- Non-Licensee version -

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Sony Corporation SanDisk Corporation

- Contents -

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1. Introduction

1.1 Overview

Silicon media is a new and innovative recording medium. This type of medium is expected to create many possibilities in the digital era.

Memory Stick is the medium that provides a higher data transfer rate, more flexibility for a variety of digital contents, and higher interchangeability among various devices than the other new media.

Memory Stick PRO specified in this document is the medium with which a higher speed data transfer rate and higher data capacity than the conventional Memory Stick are attained.

This document provides the physical specifications, electrical specifications, serial and parallel interface protocols, data format specifications, and command operation procedures to which Memory Stick PRO compliant products shall conform.

For compatibility in the application layer, details are specified in an appropriate Application Format for each application described separately.

1.2 Scope

This document provides the specifications of a product corresponding to Memory Stick PRO.

1.3 Layer Structure

A product to use a Memory Stick PRO shall have the layer structure shown below.

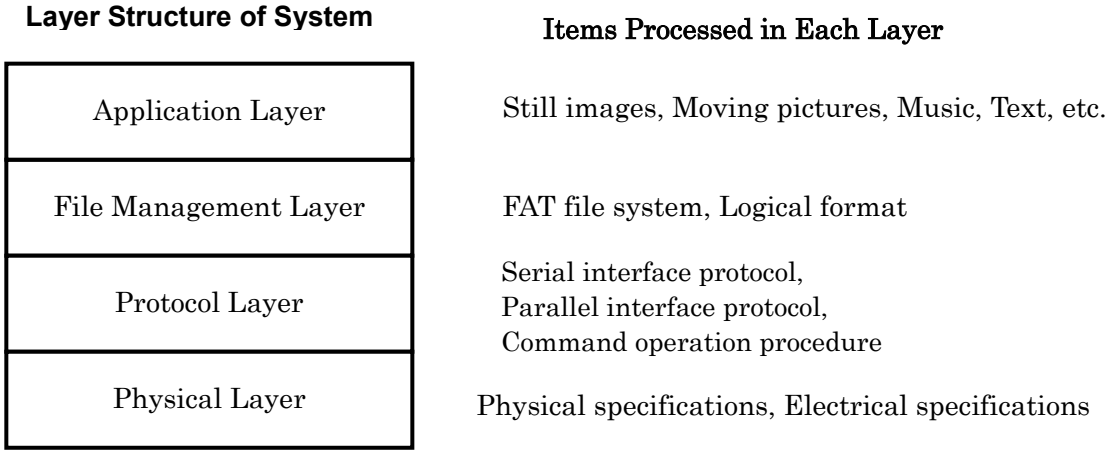

Fig. 1.3.1 Layer Structure of System

This document describes the physical layer, the protocol layer, and the file management layer in the above figure.

1.4 Reference Materials

Reference materials are shown below.

PC Card Standard March 1997 (Volume 3) Physical Specification
PC Card Standard March 1997 (Volume 7) Media Storage Formats Specification
Memory Stick Standard Format Specifications ver.1.x

1.5 Abbreviations

BS	: Bus State
CIS	: Card Information Structure
CRC	: Cyclic Redundancy Check
ECC	: Error Correcting Code
FAT	: File Allocation Table
Hi-Z	: High Impedance
IDI	: Identify Drive Information
I/F	: Interface
LBA	: Logical Block Addressing
LSB	: Least Significant Bit
MBR	: Master Boot Record
MSB	: Most Significant Bit
NVM	: Non-Volatile Memory
PBR	: Partition Boot Record
TPC	: Transfer Protocol Command
DCIM	: Digital Camera Image
SCLK	: Serial Clock
Serial I/F	: Serial Interface
Parallel I/F	: Parallel Interface
SDIO	: Serial Data I/O
X signal name	: Negative logic of “signal name”
Z (Hi-Z)	: High Impedance
X	: Not applicable

1.6 Notation

- In this specification, a Host Product means the product compliant with Memory Stick PRO.
- Unless otherwise specified, a numerical value is written by big-endian.
- Unless otherwise specified, a numerical value is the decimal numeral, when an end finishes it as “h”, the number notates of hexadecimal and an end finishes it as “b”, the number notates of binary numeral.
- Although the value of 0 is usually written in the portion expressed as Reserved, no matter what other values may be written, it shall be ignored.

2. Physical Specifications

2.1 Overview

2.1.1 Outside Dimensions

2.1.2 Material Specifications

2.1.2.1 Environmental Protection Measures

The following materials shall not be used.

- Harmful substances
- Banned substances
- Substances likely to be banned in the future
- Ozone-destroying substances
- Environmental pollutants

2.1.2.2 Electrode Portion

Plating specifications : Au-plating surface

2.1.2.3 Substrate Portion

Flame resistance : UL94HB equivalent

2.1.2.4 Outer Case

Flame resistance : UL94V2 equivalent

2.2 Connector

The connector herein refers to a connector used in a host product.

2.2.1 Requirements

The connector shall conform to PC Card Standard (Volume 3) Physical Specifications.

2.2.2 Temperature and Humidity Characteristics under Various Environments

2.2.2.1 Operating Environment

Ambient air temperature : -25 ~ 85 [°C]

Ambient air humidity : Max 95 [%] (Saturated state)

2.2.2.2 Storage Environment

Ambient air temperature : -40 ~ +100 [°C]

Ambient air temperature : Max 95 [%] (Saturated state)

2.2.3 Durability

2.2.3.1 Room Environment

Plug/Unplug: 12,000 times (Reciprocating)

The connector shall conform to PC Card Standard (Volume 3) Physical Specifications Section 8.1.

2.2.3.2 Harsh Environment

Plug/Unplug: 6,000 times (Reciprocating)

The connector shall conform to PC Card Standard (Volume 3) Physical Specifications Section 8.2.

2.2.5 Shapes of Connector Portions

2.2.5.1 Contact Timing

- When a Memory Stick PRO is inserted, Pin1 (VSS) or Pin10 (VSS) shown in "Fig. 4.2.1 Terminal Name" shall first make contact with the connector contact point. When a Memory Stick PRO is removed, Pin1 or Pin10 shall make contact with the connector contact point until it is completely removed.
- When a Memory Stick PRO is inserted, Pin6 (INS) shown in "Fig. 4.2.1 Terminal Name" should last make contact with the connector contact point.

2.3 Options

Other options are shown below.

2.3.1 Label

When applying a label on a Memory Stick PRO, following conditions shall be provided.

Material:	High-quality paper, a thickness of 0.15mm (Maximum)
Peel strength:	Unsticking or peeling shall not be allowed under storage conditions.
Number of labels:	1 label (Two or more labels shall not be overlapped)
Label area:	Within the Memory Stick PRO labeling area

2.4 Memory Stick Duo Adapter

If a Memory Stick PRO Duo is set into a Memory stick Duo Adapter, it will be mechanically and electrically compatible with the Memory Stick PRO.

Thus, a Memory Stick PRO Duo will be compatible with Memory Stick PRO compliant products.

3. Reliability Test Criteria

4. Electrical Specifications

This section describes the electrical characteristics of a Memory Stick PRO.

4.1 Overview

Electrical specifications of a Memory Stick PRO

- Number of connector pins : 10
- Connector shape : Planar electrode one-row
- Maximum transfer rate : 19.7 [MByte/s] *1
- Maximum capacity : 32 [GByte]
- Maximum transfer measure : 512 [Byte]
  Power source voltage : 2.7～3.6 [V]
- Maximum data transmission clock : 20 [MHz] (Serial)
  40 [MHz] (Parallel)

*1:Burst data transfer rate in consideration of overhead.

4.1.1 Block Diagram

"Fig. 4.1.1 An example of Memory Stick PRO Block Diagram" shows a sample block diagram of a Memory Stick PRO, incorporating non-volatile memory and a controller.

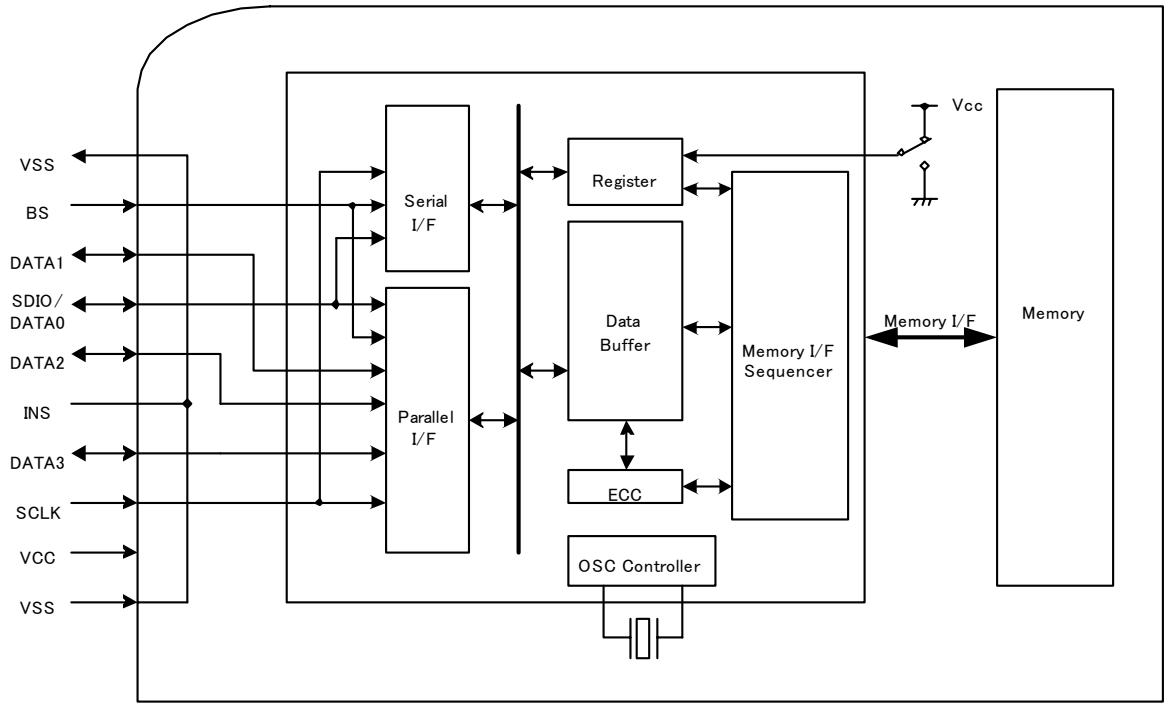

Fig. 4.1.1 An example of Memory Stick PRO Block Diagram

4.1.2 Interface Overview

A Memory Stick PRO can be controlled, as shown in "Fig. 4.1.2 Interface (Serial)" and "Fig. 4.1.3 Interface (Parallel)" , through the communication with the three-wire half-duplex serial protocol, or through communication with the six-wire half-duplex parallel protocol.

In the subsequent figures for the explanation of the parallel interface, the 4 signal lines (DATA3 ~ DATA0) are collectively denoted as DATA[3:0].

For details on interfaces, refer to "5. Interface" .

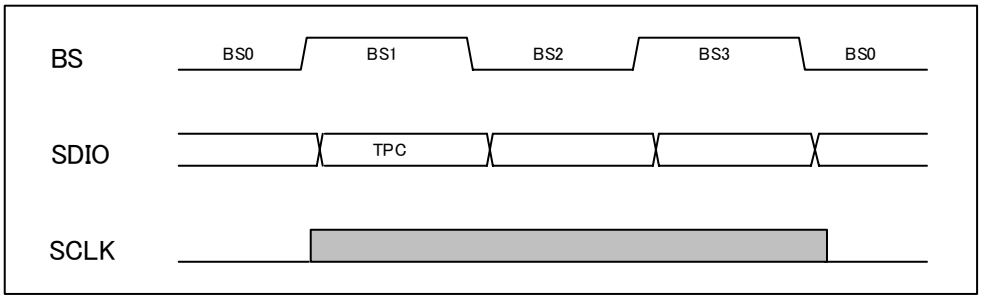

Fig. 4.1.2 Interface (Serial)

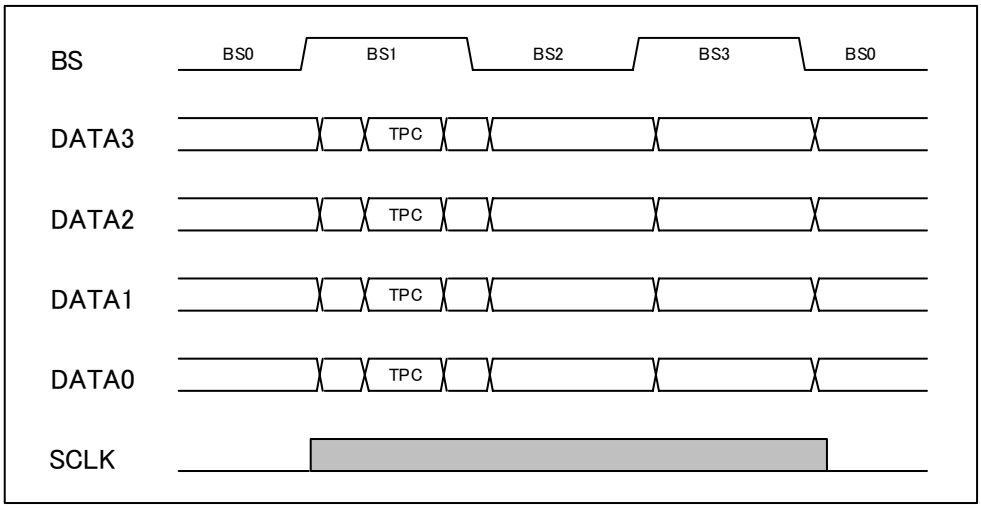

Fig. 4.1.3 Interface (Parallel)

4.2 Terminal Name

"Fig. 4.2.1 Terminal Name" shows the terminal names of a Memory Stick PRO.

Pin1	VSS
Pin2	BS
Pin3	DATA1
Pin4	SDIO / DATA0
Pin5	DATA2
Pin6	INS
Pin7	DATA3
Pin8	SCLK
Pin9	VCC
Pin10	VSS

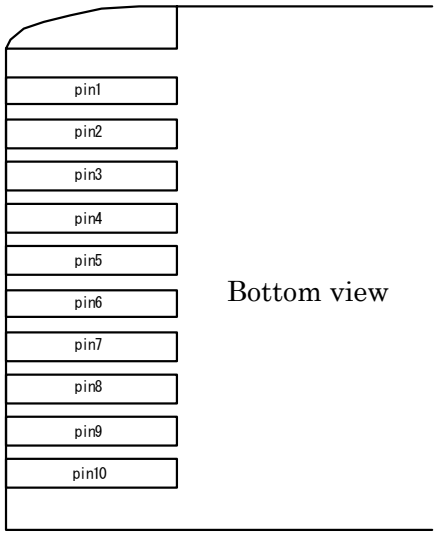

Fig. 4.2.1 Terminal Name

Note: Both Pin1 and Pin10 shall be connected to V_{SS}.

For a product supporting parallel interface, the left figure of "Fig. 4.2.1 Terminal Name" shall be used.

For a product supporting serial interface only, Pin3, Pin5, and Pin7 shall be open.

4.3 Terminal Functions

The terminal functions of a Memory Stick PRO are shown below.

Table 4.3.1 Terminal Functions

Pin #	Terminal Name	I/O	Terminal functions	
			Serial transfer	Parallel Transfer
1	VSS		Vss	
2	BS	I	Bus State signal	
3	DATA1	I/O	Hi-Z	Data signal 1
4	SDIO/DATA0	I/O	Data signal	Data signal 0
5	DATA2	I/O	Hi-Z	Data signal 2
6	INS	O	Memory Stick PRO Insertion/Removal detection terminal	
7	DATA3	I/O	Hi-Z	Data signal 3
8	SCLK	I	clock signal	
9	VCC		Vcc	
10	VSS		Vss	

5. Interface

This chapter provides the specifications of interfaces and protocols used in a Memory Stick PRO.

5.1 System Configuration

A Memory Stick PRO consists of six blocks, the Serial I/F, Parallel I/F, Registers, Data Buffer, Memory I/F Sequencer, and Memory blocks.

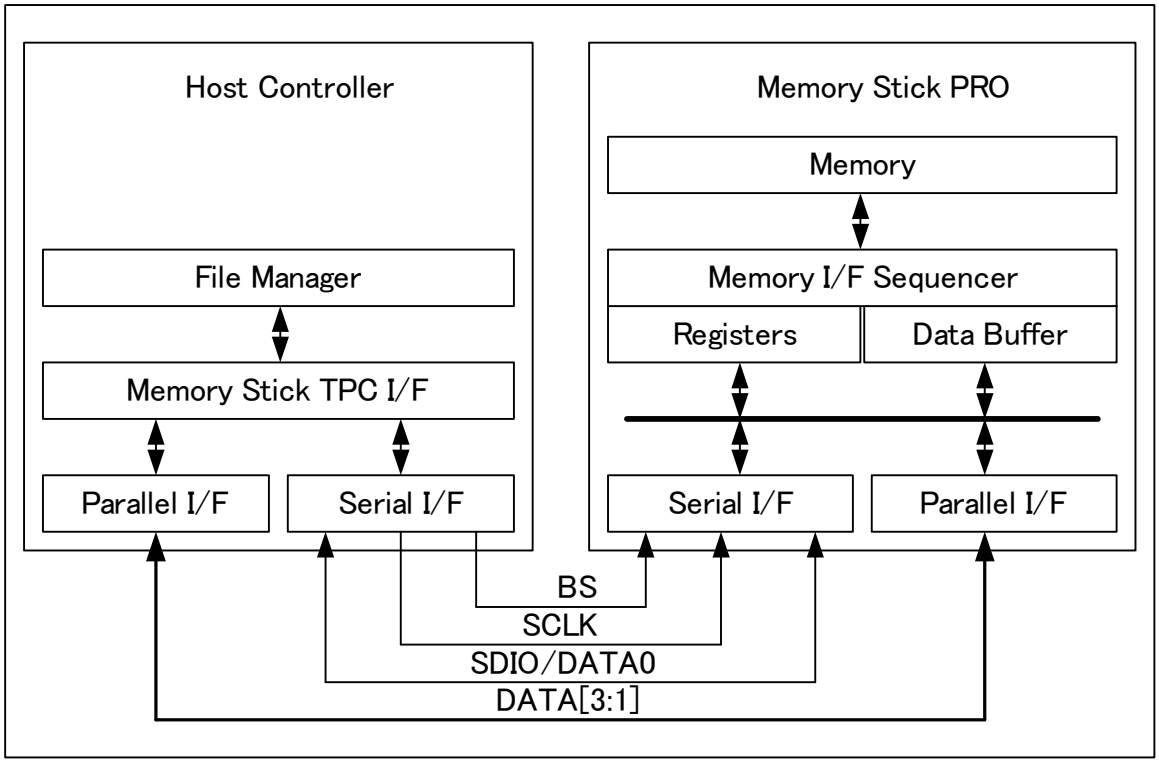

Fig. 5.1.1 System Configuration

The Serial I/F provides protocols to transfer data with three signal lines, SCLK, BS, and SDIO.

The Parallel I/F provides protocols to transfer data with six signal lines, SCLK, BS, and DATA [3:0].

A host product accesses the Registers and Data Buffer with command groups called TPC (Transfer Protocol Command).

Memory I/F Sequencer transfers data between Data Buffer and Memory based on parameters set in Registers or sent by an EX_SET_CMD TPC, then reads, writes, and erases data.

When a Memory Stick PRO is turned on, it operates in the Serial I/F mode and can be switched to the Parallel I/F mode with a TPC. It can be also switched from the Parallel I/F mode to the Serial I/F mode with the TPC.

5.2 Interface

The following provides the specifications of interfaces used in communicating with a Memory Stick PRO.

5.2.1 Serial Interface

A host product and a Memory Stick PRO are connected with six signal lines. When communicating via the Serial I/F, three of those signal lines, BS, SDIO, and SCLK shall be used. "Table 5.2.1 Specifications of Serial Interface Signals" shows specifications of respective signal lines. The host product always initiates communication.

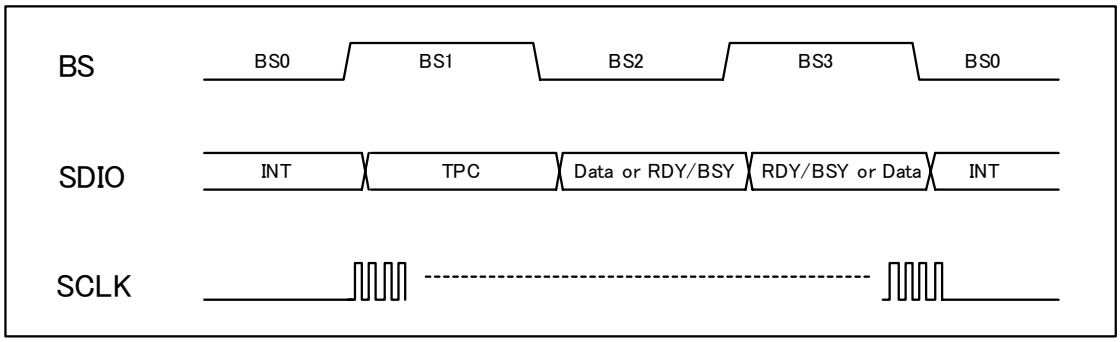

Fig. 5.2.1 Serial Interface Signals

Table 5.2.1 Specifications of Serial Interface Signals

Signals	Host Product	Explanation
BS (Bus State)	Out	Indicates the Bus State (0 ~ 3) on the SDIO and the timing to start signal transfer. For details on the Bus State, refer to "5.2.3 Bus State" .
SCLK (Serial CLocK)	Out	A host product outputs signals on BS and SDIO at a falling edge and inputs (latches) at a rising edge. SCLK is always output during BS1 ~ BS3.
SDIO (Serial Data In/Out)	In/Out	Serial Data Bus. Transfer direction and types of data change depending on the Bus State.

In the Serial I/F, a TPC and data shall be transferred from the MSB (Most Significant Bit) to the LSB (Least Significant Bit) in 1 bit by 1 SCLK. "Fig. 5.2.2 Data Transfer Order in Serial I/F" shows data transfer order in the Serial I/F.

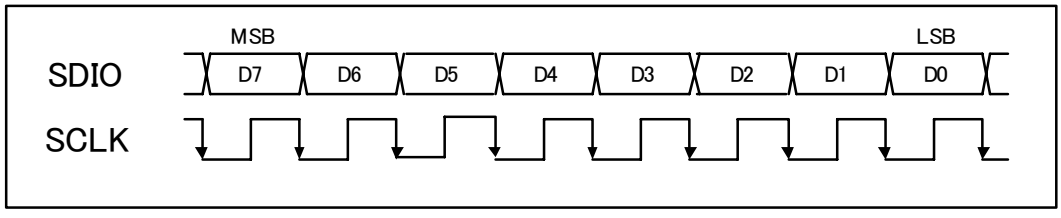

Fig. 5.2.2 Data Transfer Order in Serial I/F

5.2.2 Parallel Interface

A host product and a Memory Stick PRO are connected with six signal lines. When communicating via the Parallel I/F, those six signal lines, BS, DATA[3:0], and SCLK are used. Specifications of each signal line are shown in "Table 5.2.2 Specifications of Parallel I/F Signals" .

The host product always initiates communication.

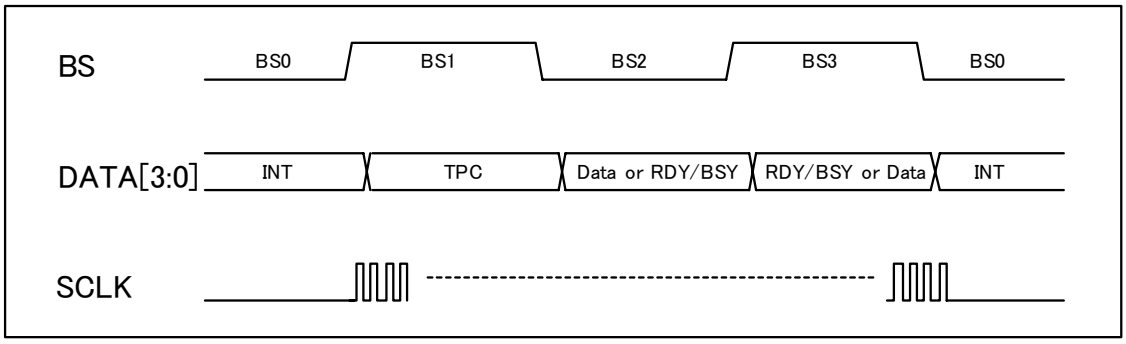

Fig. 5.2.3 Parallel I/F Signals

Table 5.2.2 Specifications of Parallel I/F Signals

Signals	Host product	Explanation
BS (Bus State)	Out	Indicates the Bus State (0 ~ 3) on the DATA[3:0] and the timing to start signal transfer. For details on Bus State, refer to "5.2.3 Bus State" .
SCLK (Serial CLocK)	Out	The host product outputs signals on BS and DATA[3:0] at a falling edge and inputs (latches) at the next falling edge. SCLK is always output during BS1 ~ BS3.
DATA [3:0]	In/Out	Four-bit-width Data Bus. Transfer direction and types of data change depending on the Bus State.

In the Parallel I/F, a TPC and data shall be transferred in a manner that the upper and lower 4 bits of 1 byte are transmitted respectively by 1SCLK. The upper 4 bits shall be transferred first. "Fig. 5.2.4 Data Transfer Order in Parallel I/F" shows data transfer order in the Parallel I/F.

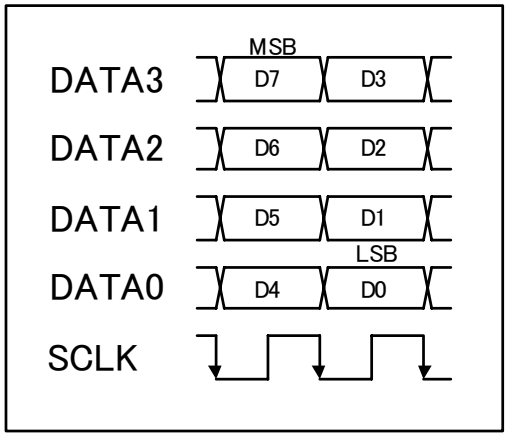

Fig. 5.2.4 Data Transfer Order in Parallel I/F

5.2.3 Bus State

The Bus State used in serial/parallel protocols is classified into four states depending on the attributes and the transfer direction of the data on SDIO/DATA[3:0]. The output timing of each data is controlled by four states: one state (BS0) with no packet communication, and the other three states (BS1, BS2, BS3) with packet communication. States BS1 to BS3 are defined as one packet, and each communication must be completed within a packet.

A Memory Stick PRO normally operates in the Four State Access Mode in which it shifts from BS0 to BS3 in one cycle. But when an error occurs on a communication channel, it automatically transits to the Two State Access Mode in which it alters from BS0 to BS1 in one cycle to avoid collision on the SDIO and DATA[3:0].

Table 5.2.3 Bus State of Four State Access Mode

<table>
<tr><th>State</th><th>BS</th><th colspan="2">Explanation</th></tr>
<tr><td>BS0</td><td>Low</td><td colspan="2">INT Transfer State :
A state in which packet communication is not done, used to transmit INT (interrupt) signals from the Memory Stick PRO to the host product.</td></tr>
<tr><td>BS1</td><td>High</td><td colspan="2">TPC Transfer State :
Packet communication starts by transferring a TPC from the host product to the Memory Stick PRO.</td></tr>
<tr><td rowspan="2">BS2</td><td rowspan="2">Low</td><td>Read Packet</td><td>Write Packet</td></tr>
<tr><td>Handshake State :
The host product waits for a RDY signal from the Memory Stick PRO.</td><td>Data Transfer State :
The host product transfers data to the Memory Stick PRO.</td></tr>
<tr><td rowspan="2">BS3</td><td rowspan="2">High</td><td>Read Packet</td><td>Write Packet</td></tr>
<tr><td>Data Transfer State :
The Memory Stick PRO transfers data to the host product.</td><td>Handshake State :
The host product waits for a RDY signal from the Memory Stick PRO.</td></tr>
</table>

Table 5.2.4 Bus State of Two State Access Mode

State	BS	Explanation
BS0	Low	High Impedance State A state in which packet communication is not done. To avoid bus collision, the data line transits to a High Impedance (Hi-Z) state.
BS1	High	TPC Transfer State Packet communication starts by transferring a TPC from the host product to the Memory Stick PRO.

5.6 Transfer Protocol Command (TPC)

5.6.1 TPC Code

The following shows the list of TPC codes.

Table 5.6.1 TPC Code Specification

Name	Code	Operation
READ_LONG_DATA	X	Transfer long length data from Data Buffer
READ_SHORT_DATA	X	Transfer short length data from Data Buffer
READ_REG	X	Read Registers
GET_INT	X	Read INT Register
WRITE_LONG_DATA	X	Transfer long length data to Data Buffer
WRITE_SHORT_DATA*	X	Transfer short length data to Data Buffer
WRITE_REG	X	Write Registers
SET_R/W_REG_ADRS	X	Address setting of READ_REG/WRITE_REG
SET_CMD	X	Set CMD
EX_SET_CMD	X	Set CMD and parameters

5.6.2 TPC Details

The following explains the operation of TPCs.

Table 5.6.2 Explanation of Each TPC

TPC	Description
READ_LONG_DATA	Transfer long length data from Data Buffer on a Memory Stick PRO to a host product.
READ_SHORT_DATA	Transfer short length data from Data Buffer on a Memory Stick PRO to a host product.
READ_REG	Transfer data from the Register of which address is set on a Memory Stick PRO to a host product. Address and data length are set by SET_R/W_REG_ADRS.
GET_INT	Transfer data from INT Register on a Memory Stick PRO to a host product.
WRITE_LONG_DATA	Transfer long length data to Data Buffer on a Memory Stick PRO from a host product.
WRITE_SHORT_DATA	Transfer short length data to Data Buffer on a Memory Stick PRO from a host product.
WRITE_REG	Transfer data to Register of which address is set on a Memory Stick PRO from a host product. Address and data length are set by SET_R/W_REG_ADRS.
SET_R/W_REG_ADRS	Transfer READ_ADRS, READ_SIZE, WRITE_ADRS and WRITE_SIZE to SET_R/W_REG_ADRS Registers.
SET_CMD	Transfer command code to CMD_REG on a Memory Stick PRO from a host product. This command is executed by a Memory Stick PRO. The result of command execution is reflected to the INT Register of a Memory Stick PRO and the INT signal(s) are output on DATA[3:0].
EX_SET_CMD	Transfer a command and parameters to a Memory Stick PRO. This command is executed by a Memory Stick PRO. The result of command execution is reflected to INT Register of a Memory Stick PRO and INT signal(s) is output on DATA[3:0].

6. Command Control

6.1 Command Overview

A Memory Stick RO executes each command defined below with issuing a SET_CMD TPC or an EX_SET_CMD TPC. The operation flow of these commands on a Memory Stick RO and a host product is shown in "Fig. 6.1.1 Operation Flow" . There are two categories of commands to be defined; Memory Access Command, Function Command.

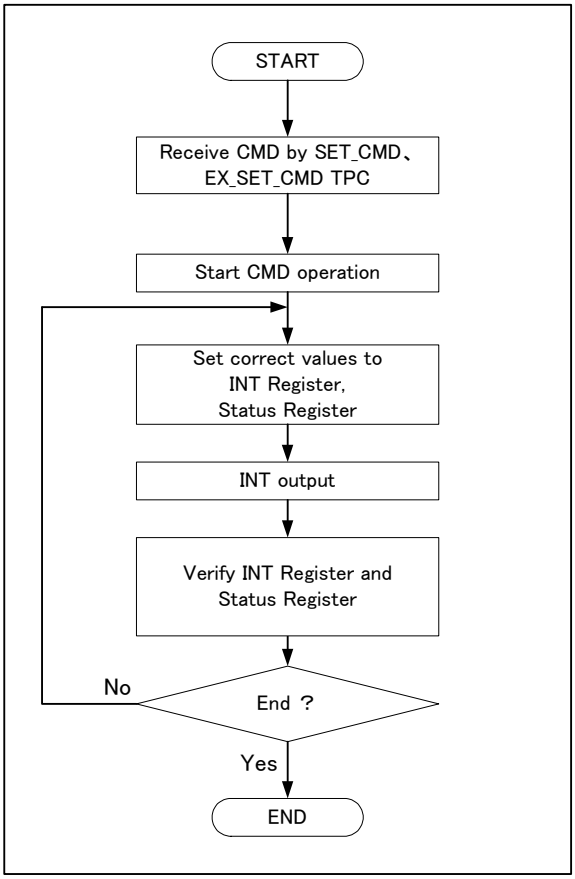

Fig. 6.1.1 Operation Flow

6.1.1 Memory Access Command

Memory Access Commands are used for accessing the memory chip on a Memory StickPRO.

Table 6.1.1 Memory Access Command

Command	Code	Description
READ_DATA	XXh	Read data continuously from the assigned address in User Area.
WRITE_DATA	XXh	Write data continuously to the assigned address in User Area.
READ_ATRB	XXh	Read data continuously from the assigned address in Attribute Information Area.
STOP	XXh	Terminate the operation by READ_DATA, WRITE_DATA, READ_ATRB, ERASE, FORMAT.
ERASE	XXh	Erase data from the assigned address in User Area.
SET_IBD	XXh	Write Information Block Data
GET_IBD	XXh	Read Information Block Data

6.1.2 Function Command

Function Commands are used for special operations.

Table 6.1.2 Function Command

Command	Code	Description
FORMAT	XXh	Self-format with unique values(Recover to factory default)
SLEEP	XXh	Shifts to low power consumption status.

7. Data Format

8. Directory Specifications