

S1R72U06

Application Note

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Scope

This document applies to the S1R72U06 serial (UART/SPI) – USB Host/Device bridge LSI, which supports USB 2.0 FS/LS.

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1. Overview

This document is the Application Note for the S1R72U06 serial (UART/SPI) – USB Host/Device bridge LSI (hereinafter referred to as the “LSI”), which supports USB 2.0 FS/LS. The document describes the details needed to build a system (i.e., a product incorporating the LSI), including LSI hardware control and operating procedures.

For LSI hardware information, refer to the *S1R72U06 Data Sheet* and the *S1R72U06 Technical Manual*.

This document uses the terminology defined in the following manuals.

- *S1R72U06 Technical Manual*
- *S1R72U06 UART Interface Manual*
- *S1R72U06 SPI Interface Manual*

2. UART Control

2. UART Control

This LSI includes a UART function as an SIO. For information on control methods using UART, refer to the following sections.

For information on individual commands and protocols supporting UART, refer to the *S1R72U06 UART Interface Manual*.

2.1 UART initialization flow

Initialize the UART as shown in the flow in Figure 2.1.

Check that the SIO_READY pin is set to “High”. If the pin is not set to “High” during initialization, refer to the *S1R72U06 Development Support Manual*.

Transmitting the EI request in “SERIAL PORT (F8h) setting” switches the SIO_READY pin to “Low”, and to “High” once the setting is enabled.

“LSI SETTING (03h) setting” is not required when the default settings are used.

“EVENT INT CONTROL (FFh) setting” is not required when the XIRQ_EVENT pin is used with the “disable” setting.

For information on the flow from the point at which the power supply is switched on until the USB Class is ready to operate, refer to Appendix-B, “Initialization Flow”.

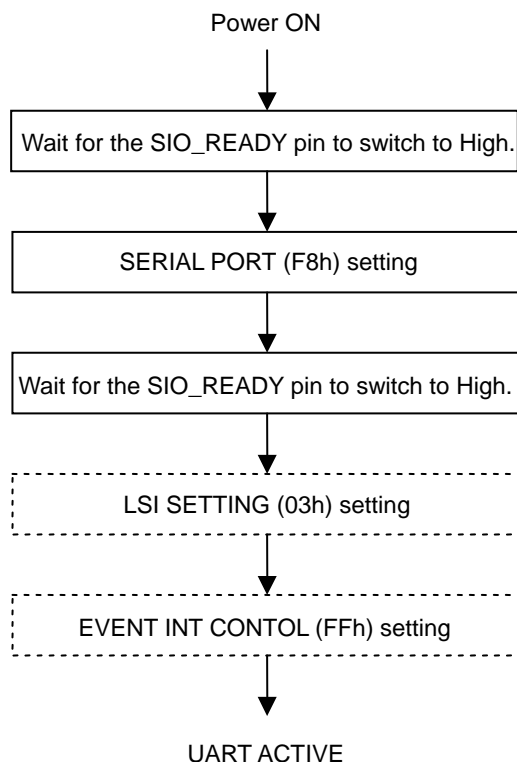


Figure 2.1 Initialization flow

2.2 UART minimum size connection configuration example

This LSI can be connected to the Main CPU in a number of different ways depending on the control method used. The optimum connection configuration should be chosen to suit the particular system.

The configuration example shown in Figure 2.2 can be used when the XIRQ_EVENT pin is set to “disable” and power management is not used with “SLEEP” (01h). The SIO_READY, XIRQ_STATUS, XIRQ_EVENT, and WAKEUP pins need not be connected.

Note that an alternative method when not connecting SIO_READY pin is to wait for a specific time. Refer to Appendix-A, “Alternative Method When SIO_READY Pin Is Left Open”.

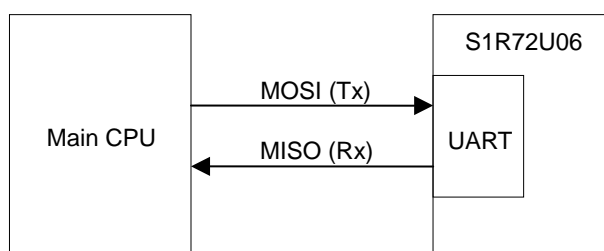


Figure 2.2 Minimum size connection configuration example

The configuration example shown in Figure 2.3 can be used when power management is used with “SLEEP” (01h) or when the XIRQ_EVENT pin is set to “enable”.

The WAKEUP pin can also be controlled from a device other than the Main CPU.

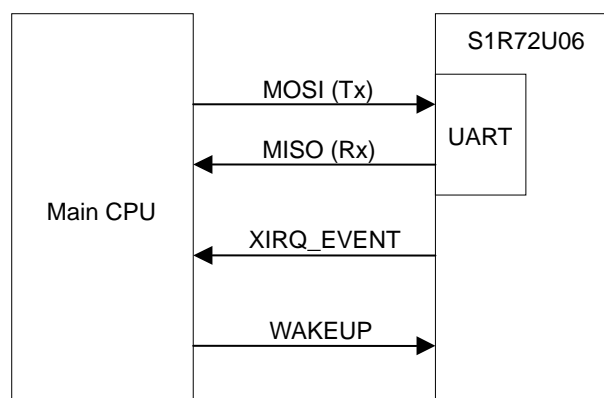


Figure 2.3 Power management configuration example

2.3 Precautions

- (1) For information on the AC characteristics (timing, etc.) for this LSI, refer to the *S1R72U06 Data Sheet*.
- (2) If initialization of this LSI fails due to an error in the initialization flow in “2.1 UART initialization flow”, there may be no response due to the inability to return an error response. For information on operation status analysis, refer to the *S1R72U06 Development Support Manual*.

3. SPI Control

3. SPI Control

This LSI includes an SPI function as an SIO. For information on control methods using SPI, refer to the following sections.

For information on commands and protocols supporting SPI, refer to the *S1R72U06 SPI Interface Manual*.

3.1 SPI initialization flow

Initialize the SPI using the procedures described in Figure 3.1.

Check that the SIO_READY pin is set to “High”. If the pin does not switch to “High” during initialization, refer to the *S1R72U06 Development Support Manual*.

“BURST SIZE (00h) setting” and “STATUS acquisition” are not required if the default settings are used.

“LSI SETTING (03h) setting” and “STATUS acquisition” are not required if the default settings are used.

For information of the flow from power on until the state in which USB Class can be operated, refer to Appendix-B, “Initialization Flow”.

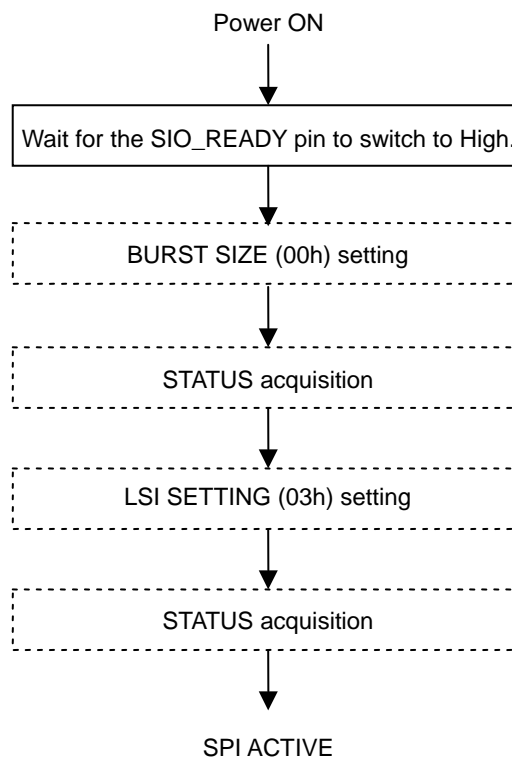


Figure 3.1 Initialization flow

3.2 SPI minimum size connection configuration example

This LSI can be connected to the Main CPU in a number of different ways depending on the control method used. The optimum connection configuration should be chosen to suit the particular system.

The configuration example shown in Figure 3.2 can be used when power management is not used with “SLEEP” (01h). The SIO_READY, XIRQ_STATUS, XIRQ_EVENT, and WAKEUP pins need not be connected.

Note that an alternative method when not connecting SIO_READY pin is to wait for a specific time. Refer to Appendix-A, “Alternative Method When SIO_READY Pin Is Left Open”.

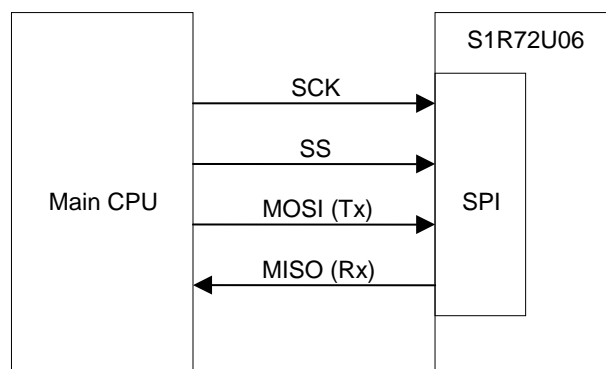


Figure 3.2 Minimum size connection configuration example

The configuration example shown in Figure 3.3 can be used when power management is used with “SLEEP” (01h).

The WAKEUP pin can also be controlled from a device other than the Main CPU.

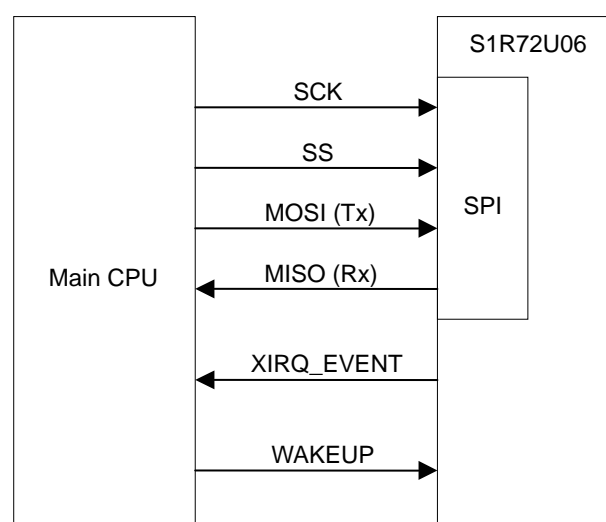


Figure 3.3 Power management configuration example

3. SPI Control

3.3 Precautions

- (1) For information on the AC characteristics (timing, etc.) for this LSI, refer to the *S1R72U06 Data Sheet*.
- (2) Care is required for SS (slave select) control if using this LSI with multi-stage connection.
- (3) The SS pin on this LSI can be fixed at “Low” if the LSI is connected to the Main CPU in a one-to-one configuration.
- (4) If initialization of this LSI fails due to an error in the initialization flow in “3.1 SPI initialization flow”, there may be no response due to the inability to return an error response. For information on operation status analysis, refer to the *S1R72U06 Development Support Manual*.

4. USB HID Class Host Control

This LSI includes an HID Class Host function as USB. For details, refer to the following sections.

4.1 HID Class Host initialization flow

Initialize the HID Class Host as shown in the flow in Figure 4.1.

For information on “SIO initialization”, refer to “2.1 UART initialization flow” or “3.1 SPI initialization flow”.

“TPL DOWNLOAD (02h) setting” is not required if the default settings are used. If “TPL” is downloaded, it must be downloaded each time Power is turned ON. The “TPL” downloaded is retained in the LSI RAM.

This LSI starts connection processing automatically when an HID Class Device is connected while in “USB ACTIVE” status. For details, refer to “4.2 HID Class Device connection”. For information on disconnection processing, refer to “4.3 HID Class Device disconnection”.

For information on the flow from power on until HID Class Device connection, refer to Appendix-B, “Initialization Flow”.

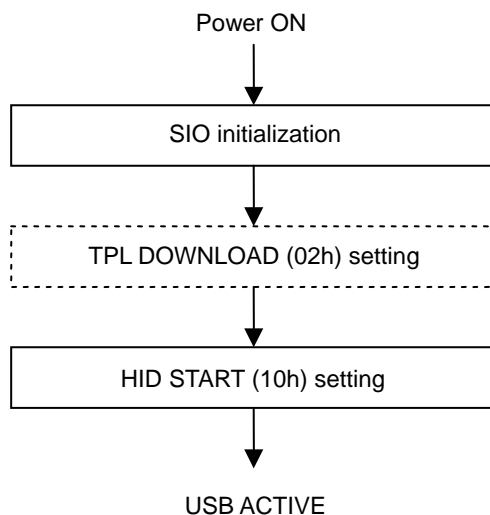


Figure 4.1 Initialization flow

4. USB HID Class Host Control

4.2 HID Class Device connection

If “HID START” (10h) is set to “Start”, the LSI automatically executes enumeration when a Device is connected. When HID Class control becomes possible, the LSI issues notification of this state to the Main CPU with an event.

For information on transfer rates when connected, refer to the *S1R72U06 Technical Manual*.

If “HID START” (10h) is set to “Stop”, the VBUS output is stopped, in which case Device connections cannot be detected.

For information on events, refer to “Host event information” in the *S1R72U06 Technical Manual*.

4.2.1 Connection flow

Set the Device operation in the Main CPU by according to the flow shown in Figure 4.2. The process shown in this flow must be performed each time a Device is connected.

“Main CPU: REPORT ID REGISTRATION (11h) setting” is required when using Report Protocol. Obtain the Report Descriptor from the Device connected and set the Report ID registration information. For information on setting examples, refer to the *S1R72U06 Technical Manual*. No settings are required when using Boot Protocol.

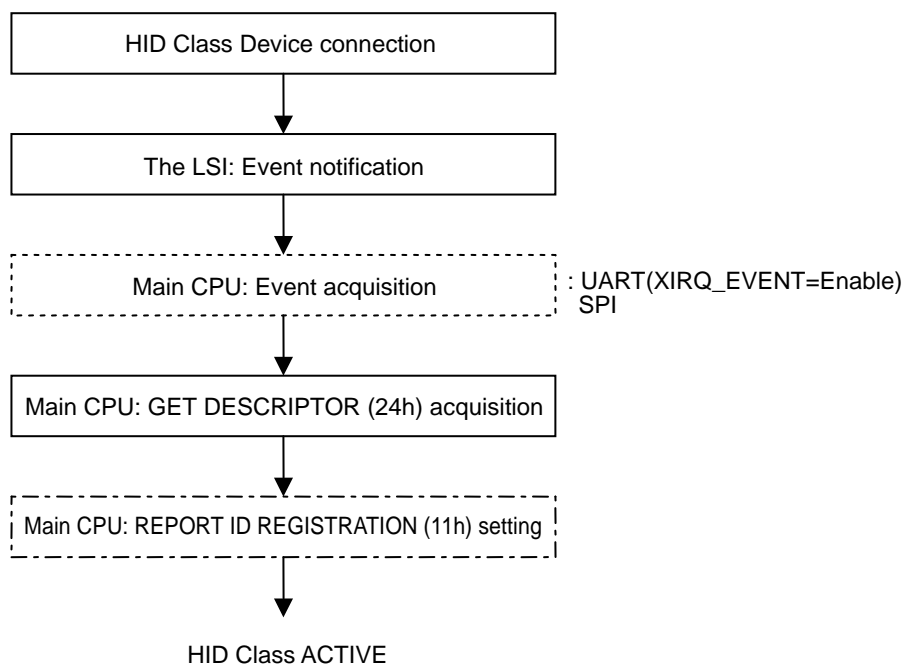


Figure 4.2 Connection flow

4.2.2 Recognition process

When multiple Devices are connected simultaneously, the LSI will recognize the Devices or Interface Descriptors in the order in which they were connected. It will recognize “supported Devices” or “unsupported Devices” from the recognized Device information. Examples of the LSI recognition process (in the case of two Interface Descriptors) are shown in Table 4.1.

The LSI can retain recognition information on up to three units. It will not recognize four or more units.

The LSI retains information on up to five Interface Descriptors. It will not recognize six or more Interface Descriptors.

Table 4.1 Recognition process

Interface 0	Interface 1	Recognition condition
HID Class Device	Video Class Device	HID Class Devices are recognized as supported Devices. Video Class Devices are recognized as unsupported Devices.
Audio Class Device	HID Class Device	Audio Class Devices are recognized as unsupported Devices. The HID Class is recognized as a supported Device.
Video Class Device	Audio Class Device	Both Classes are recognized as unsupported Devices.
HID Class Device	HID Class Device	HID Class Devices having interface 0 descriptor are recognized as supported Devices. Interface 1 descriptor is not recognized.

4. USB HID Class Host Control

4.3 HID Class Device disconnection

The disconnection processing performed when a Device is disconnected from the LSI depends on the immediately preceding state. For details, refer to the following sections. Note that the operations performed are the same as for disconnection, even when “HID START” (10h) is set to “Stop”.

For information on events, refer to “Host event information” in the *S1R72U06 Technical Manual*.

4.3.1 Disconnection flow

The LSI performs USB disconnection processing if a Device is disconnected from the LSI. The Main CPU is notified of the USB disconnect status by an event (Bit1 CD Change).

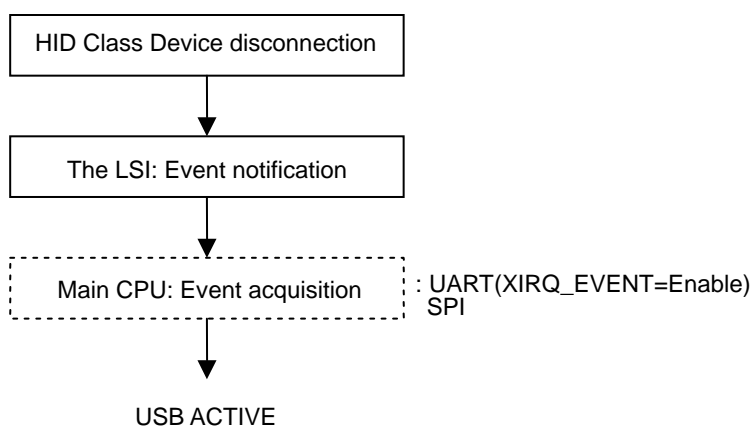


Figure 4.3 Disconnection flow

4.3.2 Disconnection flow during data reads

The LSI performs USB disconnection processing if a Device is disconnected while Report data is being read from the LSI by the Main CPU. If an event (Bit2 Rev Input Report) occurs, the Main CPU should read the remaining Report data in the LSI using “RECV REPORT (23h) acquisition”.

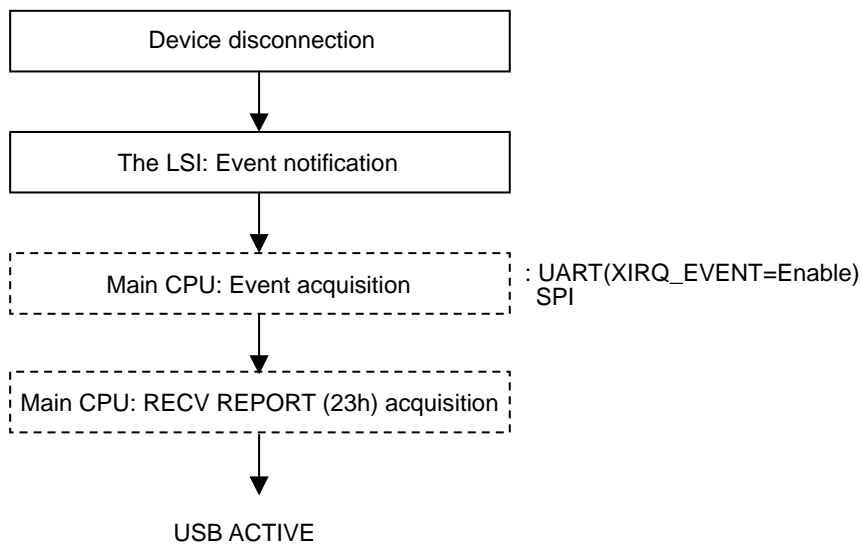


Figure 4.4 Disconnection flow during data reads

4. USB HID Class Host Control

4.3.3 Disconnection flow during sleep

If a Device is disconnected while the LSI is in the sleep status, notification is provided via the XIRQ_EVENT pin. The Main CPU should set the WAKEUP pin to “High”. The LSI performs USB disconnection processing and notifies the Main CPU that the USB has been disconnected with an event (Bit1 CD Change). For information on the WAKEUP pin, refer to “Setting Function” in the *S1R72U06 Technical Manual*.

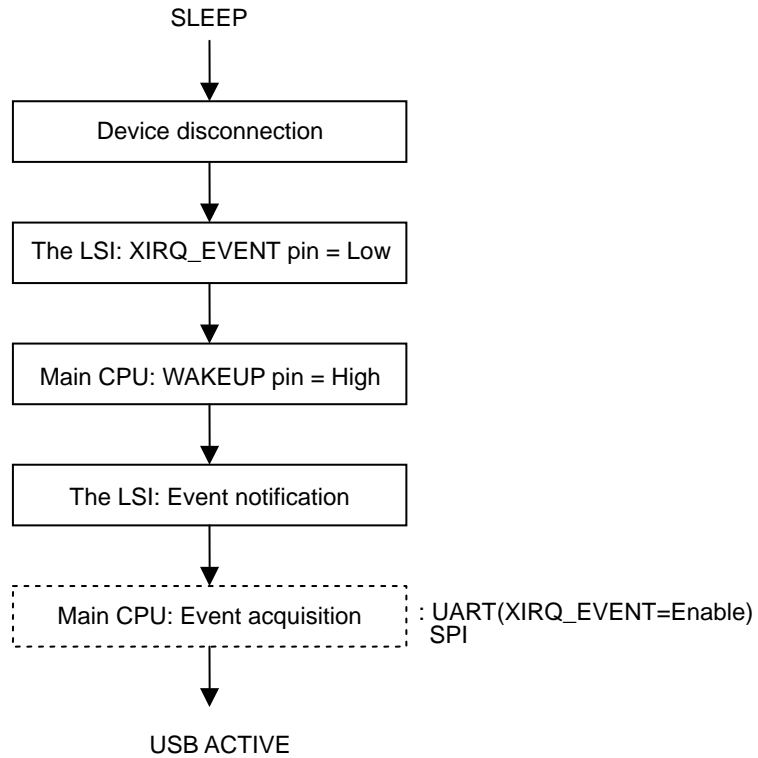


Figure 4.5 Disconnection flow in sleep

4.4 Power management

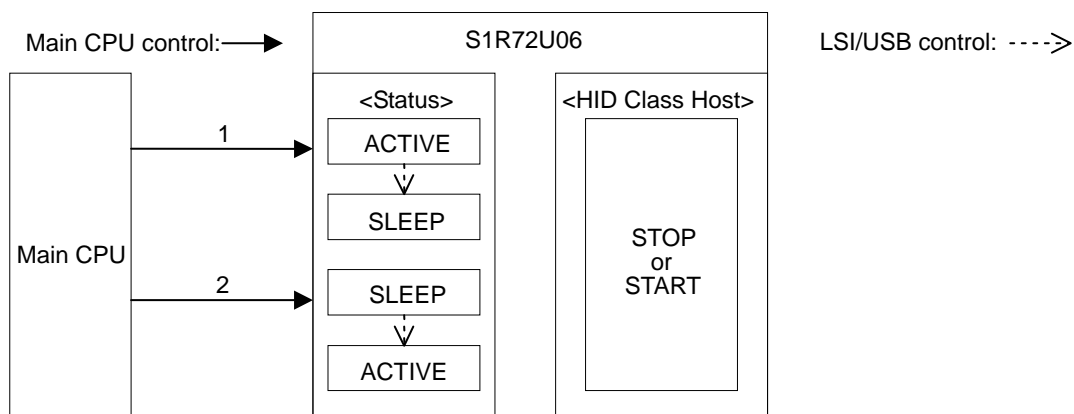
The LSI is equipped with two types of power management function. One manages the LSI using “SLEEP” control, while the other manages the USB using “Suspend” control. Note that commands cannot be written if the LSI is in “SLEEP” status, and so it should be switched to “ACTIVE” status using the WAKEUP pin. For information on control methods, refer to the following sections.

4.4.1 Control when Device is not connected

Table 4.2 shows the LSI power management method when no Device is connected. A lower power consumption state can be set with this control even if the Device is set to “Stop” or “Start” by “HID START” (10h).

Table 4.2 Control when no Device is connected

Step	Control target	Control method
1	Elreq	Execute “SLEEP” (01h). When the command is recognized, the status changes from ACTIVE to SLEEP. The SIO_READY pin changes from “High” to “Low”.
2	WAKEUP pin	Set the WAKEUP pin from “Low” to “High” and then to “Low”. The status changes from SLEEP to ACTIVE. The SIO_READY pin changes from “Low” to “High”.



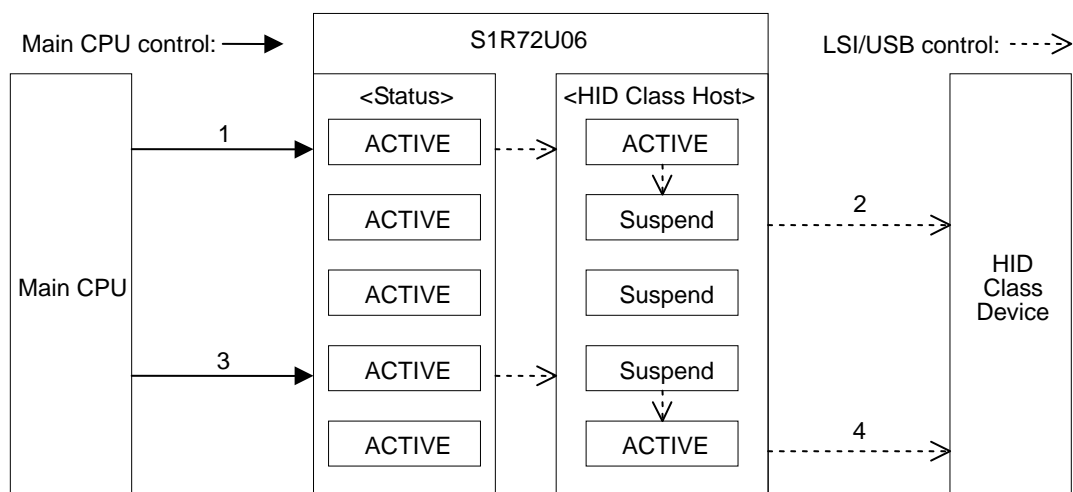
4. USB HID Class Host Control

4.4.2 Suspend control when Device is connected

Table 4.3 shows the Device power management method when a Device is connected. The LSI controls the Device with the Remote Wakeup “prohibit” setting.

Table 4.3 Suspend status control

Step	Control target	Control method
1	Elreq	Execute “DEVICE POWER MANAGEMENT” (12h). “01h: Suspend & Remote Wakeup prohibit” setting
2	Suspend	The Host (Device) status changes from ACTIVE to Suspend.
3	Elreq	Execute “DEVICE POWER MANAGEMENT” (12h). “00h: Resume” setting
4	Resume	The Host status changes from Suspend to ACTIVE. The Device is set to Resume.



4.4.3 SLEEP control when Device is connected

Table 4.4 shows the LSI power management method when a Device is connected. This control method applies when the Device does not support Remote Wakeup. The LSI controls the Device with the Remote Wakeup “prohibit” setting.

The Main CPU should determine the Device state from the following event information if a Device is disconnected or reconnected while the LSI is in the sleep status (between Steps 2 and 3).

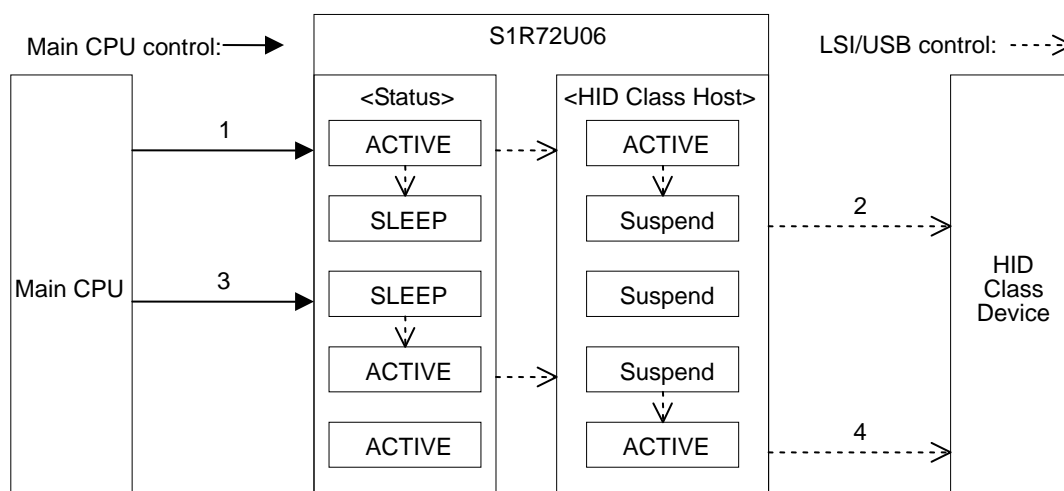
Disconnection: Event information notification is transferred when the XIRQ_EVENT pin changes and the LSI switches to the ACTIVE status. “Disconnect” can be confirmed using “CD” in the event information.

Connection: Event information notification is transferred when the XIRQ_EVENT pin changes and the LSI switches to the ACTIVE status. “Connect” can be confirmed using “CD” in the event information. Device connection processing should follow “Main CPU: GET DESCRIPTOR (24h) acquisition” in “4.2.1 Connection flow”. If error notification is given for “GET DESCRIPTOR (24h)”, this means that the Device has been disconnected and reconnected while in sleep. Execute “DEVICE RESET” (13h) and perform the Device connection processing described in “4.2.1 Connection flow”.

Note that if the Device connection (or disconnection) state is the same for the LSI before entering sleep status and after switching from sleep to ACTIVE, no event information is transferred, even if the LSI switches to ACTIVE.

Table 4.4 Sleep status control

Step	Control target	Control method
1	Elreq	Execute “SLEEP” (01h).
2	Suspend	The Host (Device) status changes from ACTIVE to Suspend. The LSI changes from ACTIVE to SLEEP. The SIO_READY pin changes from “High” to “Low”.
3	WAKEUP pin	Set the WAKEUP pin from “Low” to “High” and then to “Low”.
4	Resume	The LSI changes from SLEEP to ACTIVE. The Host status changes from Suspend to ACTIVE. The Device is set to Resume. The SIO_READY pin changes from “Low” to “High”.



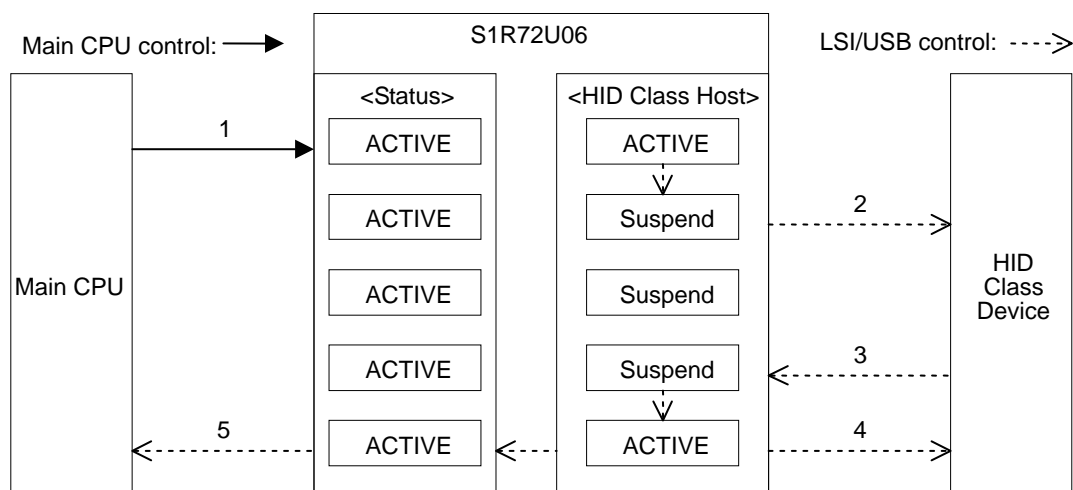
4. USB HID Class Host Control

4.4.4 Suspend (Remote Wakeup) control when Device is connected

Table 4.5 shows Device power management when a Device is connected. The LSI controls the Device with the Remote Wakeup “permit” setting.

Table 4.5 Remote Wakeup control in Suspend status

Step	Control target	Control method
1	Elreq	Execute “DEVICE POWER MANAGEMENT” (12h). “02h: Suspend & Remote Wakeup permit” setting
2	Suspend	The Host (Device) status changes from ACTIVE to Suspend.
3	Remote Wakeup	Remote Wakeup from the Device is detected.
4	Resume	The Host status changes from Suspend to ACTIVE. The Device is set to Resume.
5	Event information	Notification of event generation is issued to the Main CPU.



4.4.5 SLEEP (Remote Wakeup) control when Device is connected

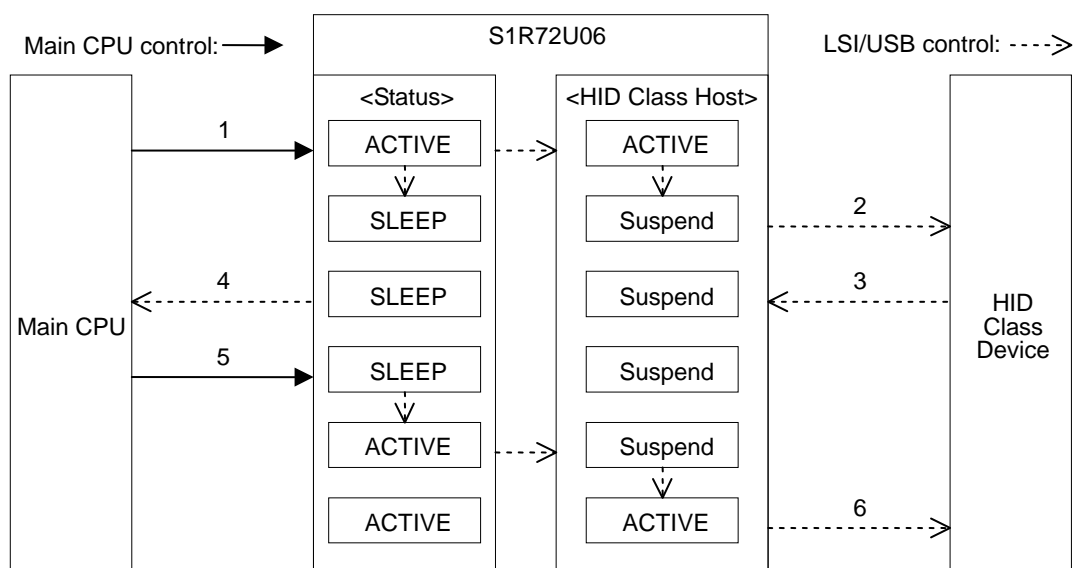
Table 4.6 shows the LSI power management method when a Device is connected. This control method applies when the Device supports Remote Wakeup. The LSI controls the Device with the Remote Wakeup “permit” setting.

If a Device is disconnected and then reconnected while the LSI is in the sleep status (Step 2 and thereafter), the LSI will not be able to detect the disconnection/reconnection. To determine if the status results from Remote Wakeup or from disconnection/reconnection occurring during the sleep status, have the Main CPU perform the following process after the SIO_READY pin changes to “High” in Step 6.

Write “GET DESCRIPTOR” (24h). If this is read properly, the status is determined to be Remote Wakeup. If error notification is sent, this means that the Device has been disconnected and reconnected while in sleep. Execute “DEVICE RESET” (13h) and perform the Device connection processing described in “4.2.1 Connection flow”.

Table 4.6 Remote Wakeup control in sleep status

Step	Control target	Control method
1	Elreq	Execute “SLEEP” (01h).
2	Suspend	The Host (Device) status changes from ACTIVE to Suspend. The LSI changes from ACTIVE to SLEEP. The SIO_READY pin changes from “High” to “Low”.
3	Remote Wakeup	Remote Wakeup is detected from the Device.
4	XIRQ_EVENT pin	The XIRQ_EVENT pin changes from “High” to “Low”.
5	WAKEUP pin	Set the WAKEUP pin from “Low” to “High” and then to “Low”.
6	Resume	The LSI changes from SLEEP to ACTIVE. The Host status changes from Suspend to ACTIVE. The Device is set to Resume. The SIO_READY pin changes from “Low” to “High”.



4. USB HID Class Host Control

4.5 Precautions

- (1) Reset the LSI using hardware reset if the Device connected causes an error and fails to respond (the Device continually gives NAK or STALL responses and the LSI does not change from Busy status).
- (2) If the connected Device is not recognized, the Device may be defective or its battery (for battery-operated Devices) may be discharged.
- (3) Some Devices do not support “Remote Wakeup”. Check the Configuration Descriptor information for the Device connected.
- (4) Devices may not be recognized depending on the number of Interface Descriptors. For details, refer to “4.2.2 Recognition process”.

5. USB MSC Host Control

This LSI includes an MSC Host function as USB. For details, refer to the following sections.

The MSC Host function includes simple control and full control. For details, refer to “5.4 Simple control” or “5.5 Full control”.

5.1 MSC Host initialization flow

Initialize the MSC Host as shown in the flow in Figure 5.1.

For information on “SIO initialization”, refer to “2.1 UART initialization flow” or “3.1 SPI initialization flow”.

“TPL DOWNLOAD (02h) setting” is not required if the default settings are used. If “TPL” is downloaded, it must be downloaded each time Power is turned ON. The “TPL” downloaded is retained in the LSI RAM.

This LSI starts connection processing automatically when an MSC Device is connected while in “USB ACTIVE” status. For details, refer to “5.2 MSC Device connection”. For information on disconnection processing, refer to “5.3 MSC Device disconnection”.

For information on the flow from power on until MSC Device connection, refer to Appendix-B, “Initialization Flow”.

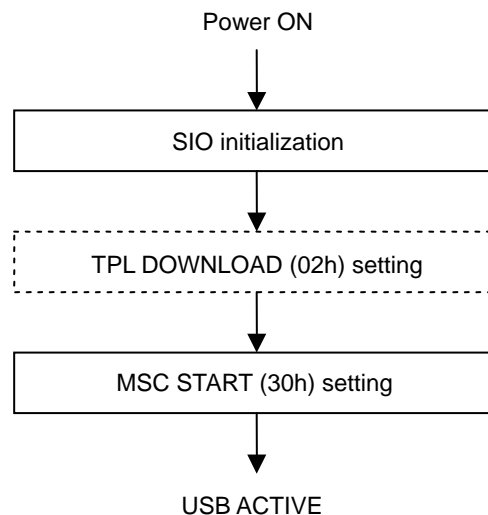


Figure 5.1 Initialization flow

5. USB MSC Host Control

5.2 MSC Device connection

If “MSC START” (30h) is set to “Start”, the LSI automatically executes enumeration when a Device is connected. When MSC control becomes possible, the LSI issues notification of this state to the Main CPU with an event.

For information on transfer rates when connected, refer to the *S1R72U06 Technical Manual*.

If “MSC START” (30h) is set to “Stop”, the VBUS output is stopped, in which case Device connections cannot be detected.

For information on events, refer to “Host event information” in the *S1R72U06 Technical Manual*.

5.2.1 Connection flow

Set the Device connection processing in the Main CPU by according to the flow shown in Figure 5.2. The process shown in this flow must be performed each time a Device is connected.

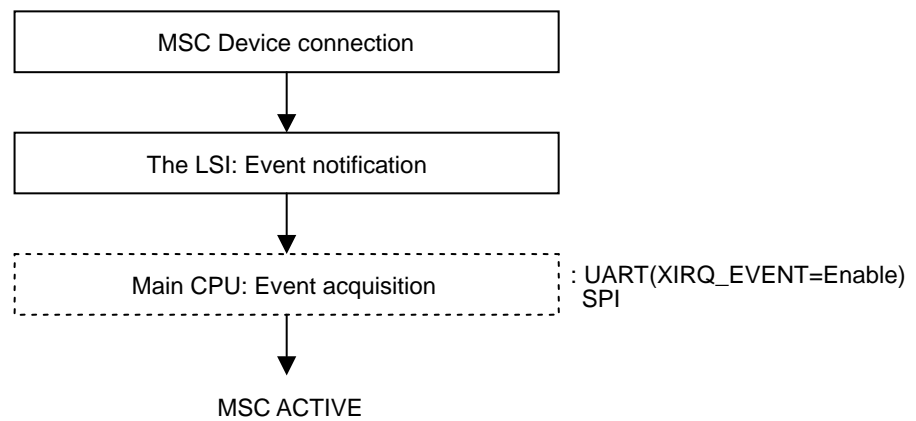


Figure 5.2 Connection flow

5.2.2 Recognition process

When multiple Devices are connected simultaneously, the LSI will recognize the Devices or Interface Descriptors in the order in which they were connected. It will recognize “supported Devices” or “unsupported Devices” from the recognized Device information. Examples of the LSI recognition process (in the case of two Interface Descriptors) are shown in Table 5.1.

The LSI can retain recognition information on up to three units. It will not recognize four or more units.

The LSI retains information on up to five Interface Descriptors. It will not recognize six or more Interface Descriptors.

Table 5.1 Recognition process

Interface 0	Interface 1	Recognition condition
MSC Device	Video Class Device	MSC Devices are recognized as supported Devices. Video Class Devices are recognized as unsupported Devices.
Audio Class Device	MSC Device	Audio Class Devices are recognized as unsupported Devices. MSC Devices are recognized as supported Devices.
Video Class Device	Audio Class Device	Both Classes are recognized as unsupported Devices.
MSC Device	MSC Device	Devices having interface 0 are recognized as supported Devices. Interface 1 is not recognized.

5. USB MSC Host Control

5.3 MSC Device disconnection

The disconnection processing performed when a Device is disconnected from the LSI depends on the immediately preceding state. For details, refer to the following sections. Note that the operations performed are the same as for disconnection, even when “MSC START” (30h) is set to “Stop”.

For information on events, refer to “Host event information” in the *S1R72U06 Technical Manual*.

5.3.1 Disconnection flow

The LSI performs USB disconnection processing if a Device is disconnected from the LSI. The Main CPU is notified of the USB disconnect status by an event (Bit1 CD Change).

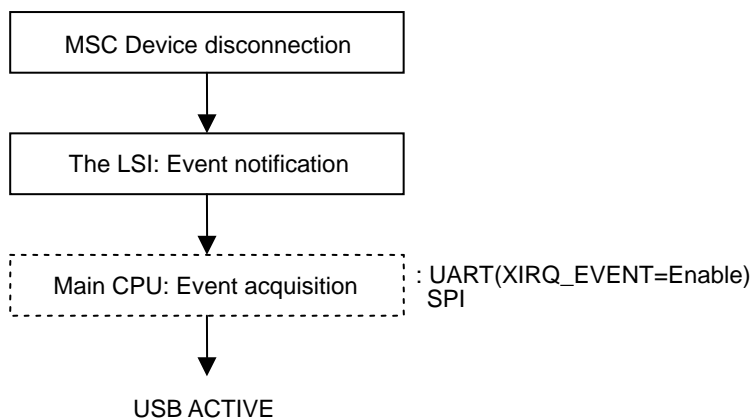


Figure 5.3 Disconnection flow

5.3.2 Disconnection flow during sleep

If a Device is disconnected while the LSI is in the sleep status, notification is provided via the XIRQ_EVENT pin. The Main CPU should set the WAKEUP pin to "High". The LSI performs USB disconnection processing and notifies the Main CPU that the USB has been disconnected with an event (Bit1 CD Change). For information on the WAKEUP pin, refer to "Setting Function" in the *S1R72U06 Technical Manual*.

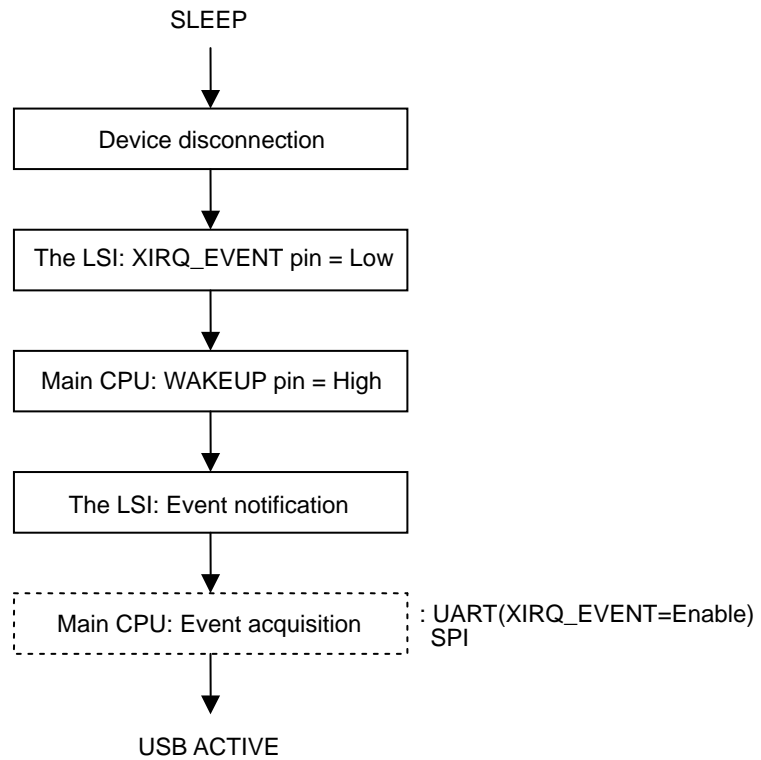


Figure 5.4 Disconnection flow in sleep

5. USB MSC Host Control

5.4 Simple control

This control method enables USB MSC Devices to be controlled easily without the need for detailed knowledge of SCSI/ATAPI standards.

5.4.1 Supported MSC Devices

This control method supports the MSC Devices listed in Table 5.2.

Table 5.2 Supported MSC Devices

MSC Device	Control	
	Read	Write
USB memory	√	√
HDD	√	√
MO	√	√

5.4.2 Simple control Elreq

The Elreqs listed in Table 5.3 should be used with this control method. For details, refer to the *S1R72U06 UART Interface Manual* or the *S1R72U06 SPI Interface Manual*.

Table 5.3 MSC EI requests

Elreq code	Elreq name	Description
40h	GET STORAGE INFORMATION	Storage information read
41h	START WRITING SECTORS	Sector write start
42h	START READING SECTORS	Sector read start
3Ah	BLK WRITE DATA	Block transfer data write
3Bh	BLK READ DATA	Block transfer data read

5.4.3 Simple control method

This section describes how to use simple control from the state in which an MSC Device is connected to the LSI.

The Main CPU should perform block transfer processing as shown in the read simple control flow in Figure 5.5.

For information on “Access size” in block transfer, refer to “MSC Access Size” in the *S1R72U06 UART*

Interface Manual or *S1R72U06 SPI Interface Manual*.

“Storage information acquisition” is required when first accessing an MSC Device.

The method used for determining when read block transfer has ended depends on SIO. For details, refer to “5.4.4 UART end determination” or “5.4.5 SPI end determination”.

“Main CPU: End determination” is omitted in the flow for write block transfer. If the “Block transfer size” is larger than the “Access size”, the Main CPU should pad invalid data areas with values as desired. This LSI automatically discards data exceeding the “Access size”.

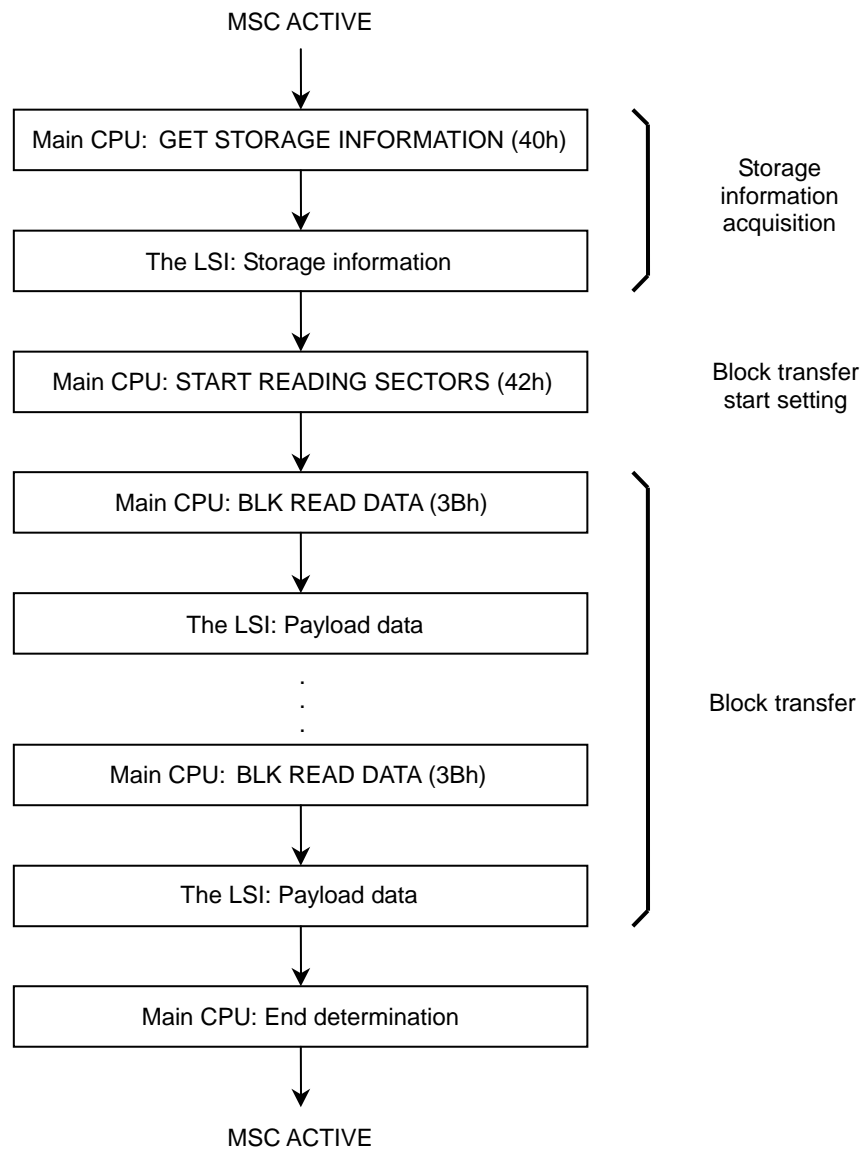


Figure 5.5 Read simple control flow

5. USB MSC Host Control

5.4.4 UART end determination

The end of UART block transfer should be determined using the sequence shown in Figure 5.6.

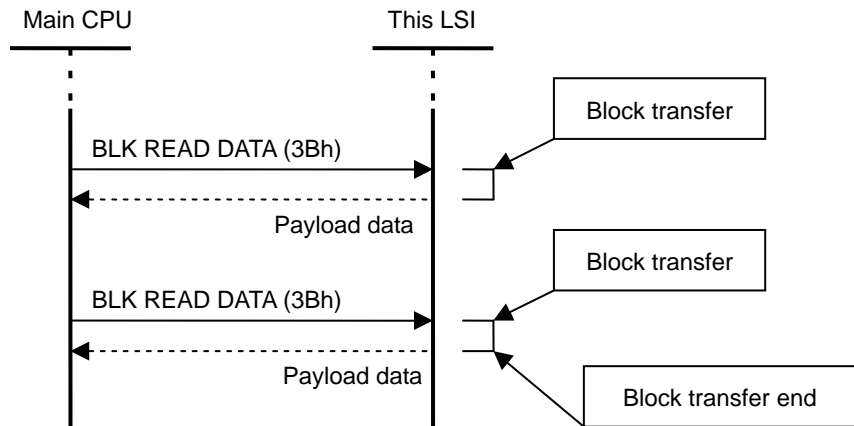


Figure 5.6 UART end sequence

There are two different end conditions, as shown in Figure 5.7 and Figure 5.8.

Figure 5.7 shows the transfer ending with the payload size matching the "Access size".

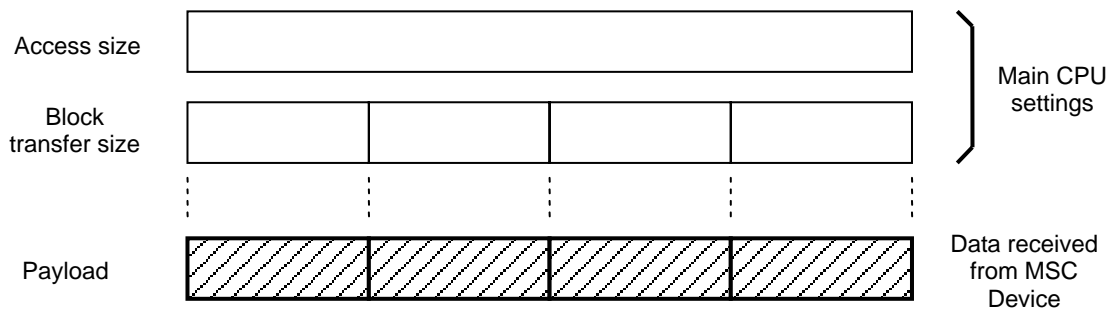


Figure 5.7 UART end conditions (1)

Figure 5.8 shows the transfer ending with the “Block transfer size” larger than the “Access size”. The LSI automatically pads with “00h” to ensure that the payload size matches the “Block transfer size”. The Main CPU should use the “Access size” as valid data.

Note that the LSI automatically pads data after disconnection with “00h” if the Device is disconnected while the Main CPU is reading data from the LSI.

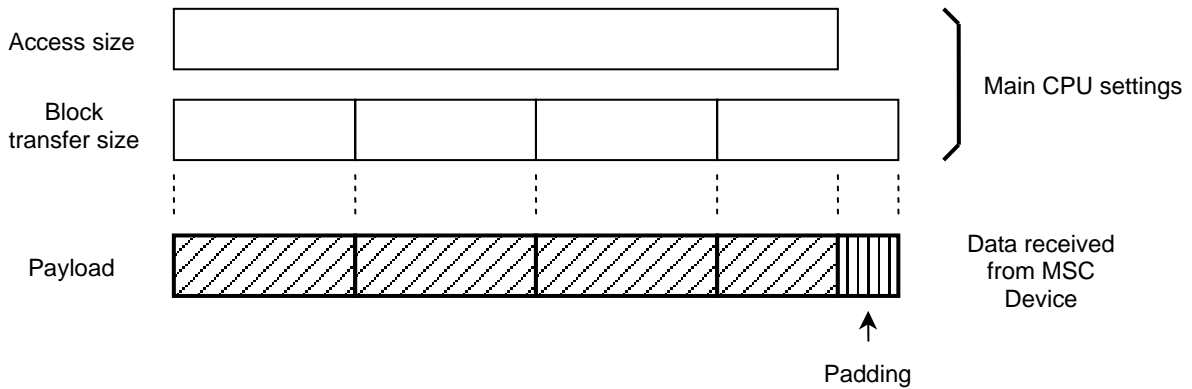


Figure 5.8 UART end conditions (2)

5.4.5 SPI end determination

Transfer end is determined when data reception from the MSC Device is complete, regardless of the “Access size” set by the Main CPU.

Status information for SPI block transfer should be checked in Burst transfer units.

The Main CPU should determine the block transfer end as soon as the status information becomes “Idle”. Figure 5.9 shows the status when transfer ends.

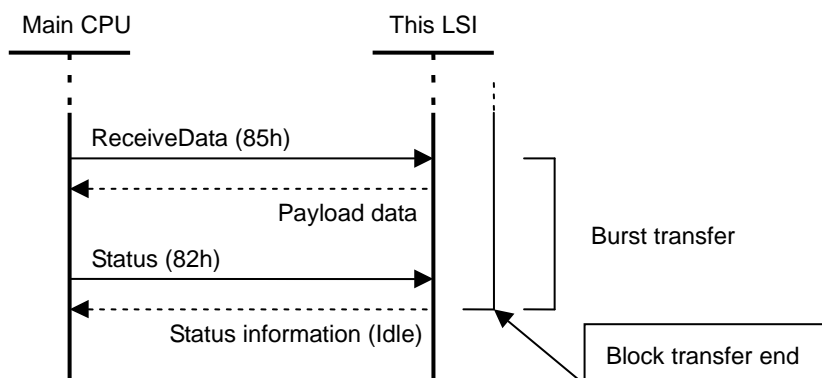


Figure 5.9 SPI end sequence

5. USB MSC Host Control

5.5 Full control

This control method allows command control in compliance with the SCSI/ATAPI standards. Users not familiar with SCSI/ATAPI are recommended to use “5.4 Simple control”.

5.5.1 Supported MSC Devices

MSC Devices described in “Compliance” in the *S1R72U06 Technical Manual* can be supported.

5.5.2 Full control Elreq

The Elreqs listed in Table 5.4 should be used for this control method. For details, refer to the *S1R72U06 UART Interface Manual* or the *S1R72U06 SPI Interface Manual*.

Table 5.4 MSC EI requests

Elreq code	Elreq name	Description
48h	STORAGE COMMAND THROUGH(6)	SCSI/ATAPI command (6 bytes)
49h	STORAGE COMMAND THROUGH(10)	SCSI/ATAPI command (10 bytes)
4Ah	STORAGE COMMAND THROUGH(12)	SCSI/ATAPI command (12 bytes)
4Bh	STORAGE COMMAND THROUGH(16)	SCSI/ATAPI command (16 bytes)
4Ch	STORAGE COMMAND RESULT	SCSI/ATAPI command execution result acquisition
3Ah	BLK WRITE DATA	Block transfer data write
3Bh	BLK READ DATA	Block transfer data read

5.5.3 Full control method

This section describes how to use full control from the state in which an MSC Device is connected to the LSI.

This control method requires that the execution results be confirmed for the THROUGH command. The “Ended” event is provided for notifying the Main CPU of the completion of THROUGH command processing. For details, refer to the *S1R72U06 UART Interface Manual* or the *S1R72U06 SPI Interface Manual*.

The Main CPU should process block transfer, referring to the read full control flow (when payload data is present) shown in Figure 5.10 (Ended permit setting) or Figure 5.11 (Ended prohibit setting). Note that “Block transfer” is omitted from the flow for “No Data” transfer.

The method used for determining when read block transfer has ended depends on SIO. For details, refer to “5.5.4 UART end determination” or “5.5.5 SPI end determination”.

“Main CPU: End determination” is omitted in the flow for write block transfer.

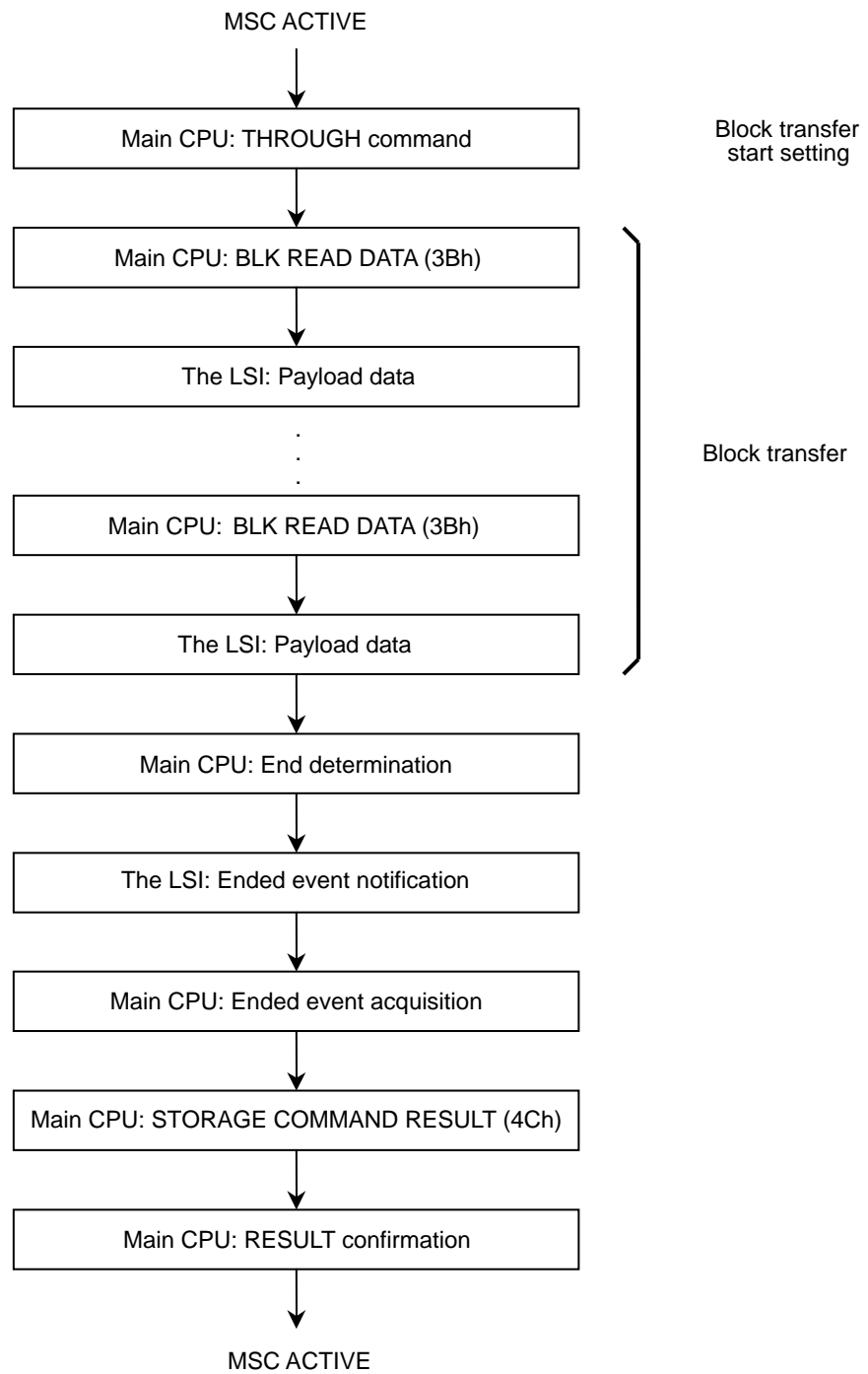


Figure 5.10 Read full control flow (Ended permit setting)

5. USB MSC Host Control

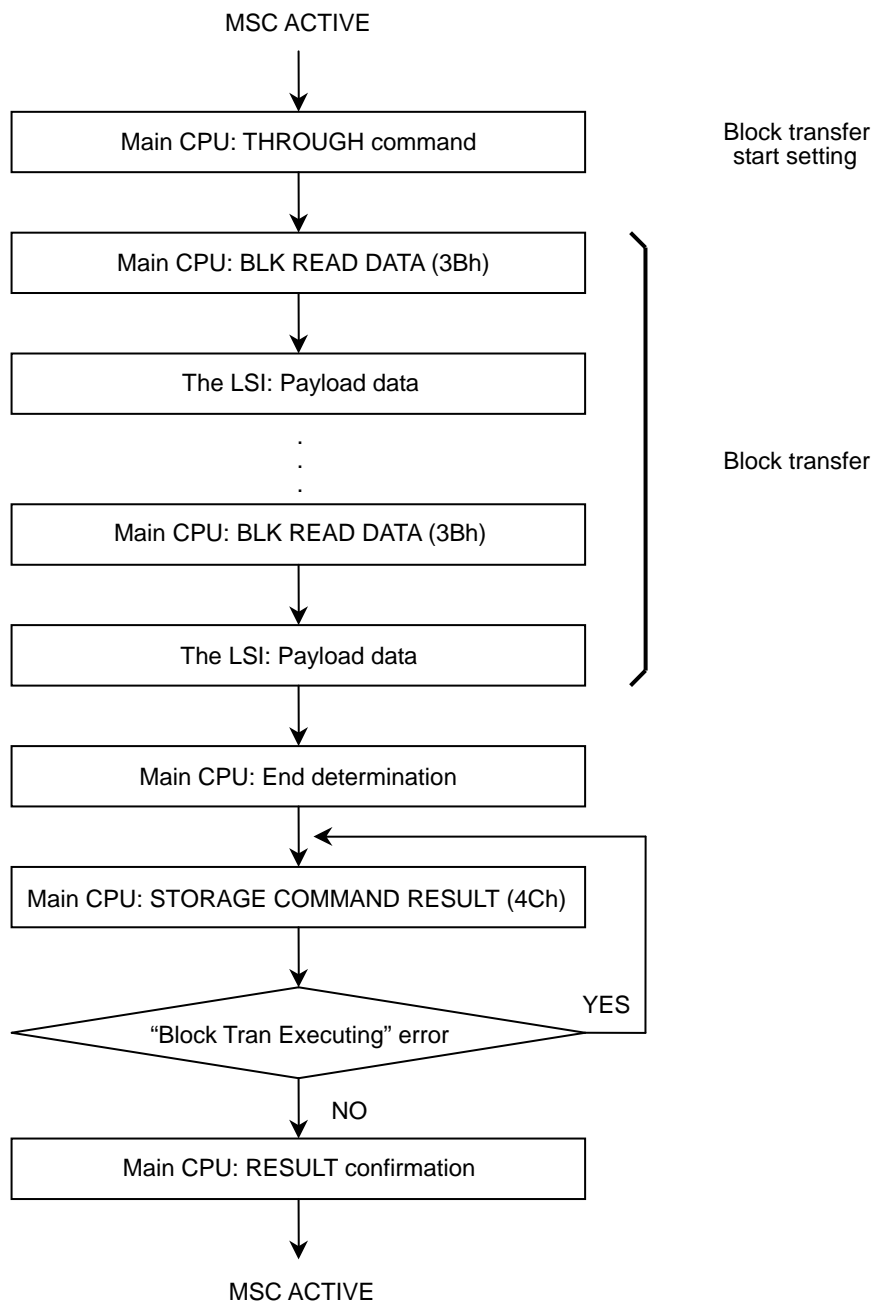


Figure 5.11 Read full control flow (Ended prohibit setting)

5.5.4 UART end determination

There are two types of UART block transfer end determination states depending on the data (payload) received from the MSC Device. For details, refer to the following sections.

5.5.4.1 Setting size read end

Figure 5.12 shows the situation in which block transfer ends with “Block transfer size” set by the Main CPU.

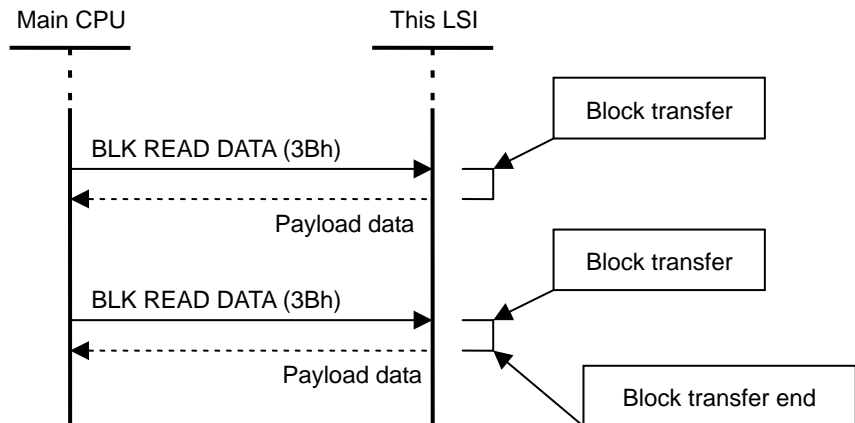


Figure 5.12 Setting size read end sequence

The end conditions may be “Payload (1)” or “Payload (2)” in Figure 5.13.

“Payload (1)” refers to transfer ending with the payload size matching the “Access size”.

“Payload (2)” refers to transfer ending with the payload size smaller than the “Access size”. The LSI automatically pads with “00h” to ensure that the payload size matches the “Block transfer size”.

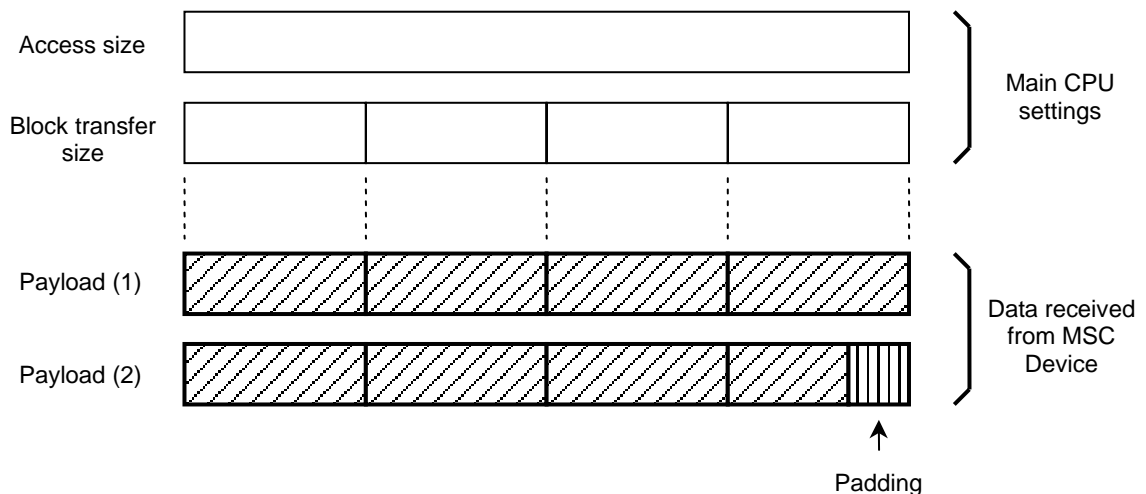


Figure 5.13 Setting size read end conditions

5. USB MSC Host Control

5.5.4.2 Elhead end

Figure 5.14 shows the situation in which block transfer ends in Elhead transfer.

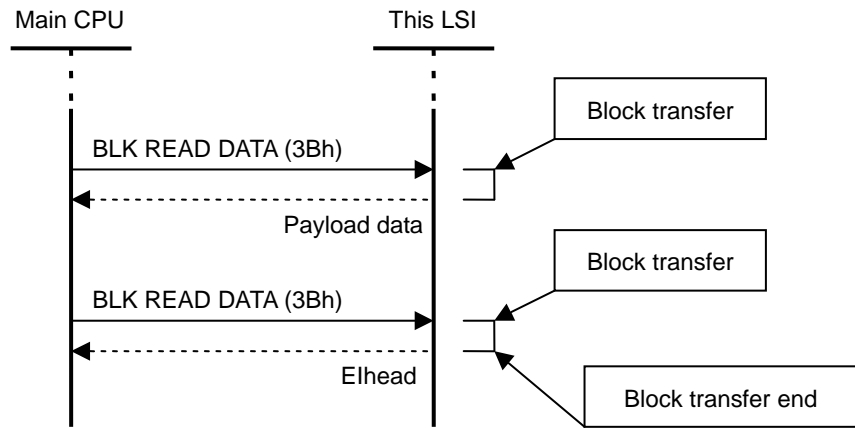


Figure 5.14 Elhead end sequence

The end conditions may be “Payload (1)” or “Payload (2)” in Figure 5.15. When transfer ends, the LSI transfers only Elhead in response to the “BLK READ DATA” (3Bh) from the Main CPU. The Main CPU should determine the end of transfer from the “Block transfer size” (0000h) indicated by Elhead.

This applies to situations in which the “Block transfer size” is at least one smaller than the “Access size”.

“Payload (1)” refers to the case in which the payload size matches the “Block transfer size”.

“Payload (2)” refers to transfer ending with the payload size smaller than the “Block transfer size”. The LSI automatically pads with “00h” to ensure that the payload size matches the “Block transfer size”.

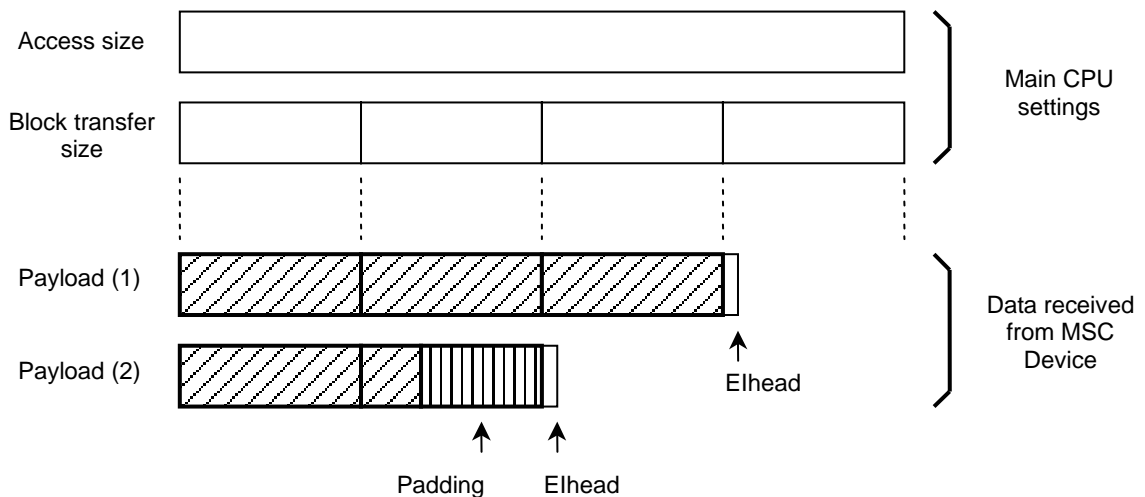


Figure 5.15 Elhead end conditions

5.5.5 SPI end determination

Transfer end is determined when data reception from the MSC Device is complete, regardless of the “Access size” set by the Main CPU.

Status information for SPI block transfer should be checked in Burst transfer units.

The Main CPU should determine the block transfer end as soon as the status information becomes “Idle”. Figure 5.16 shows the status when transfer ends.

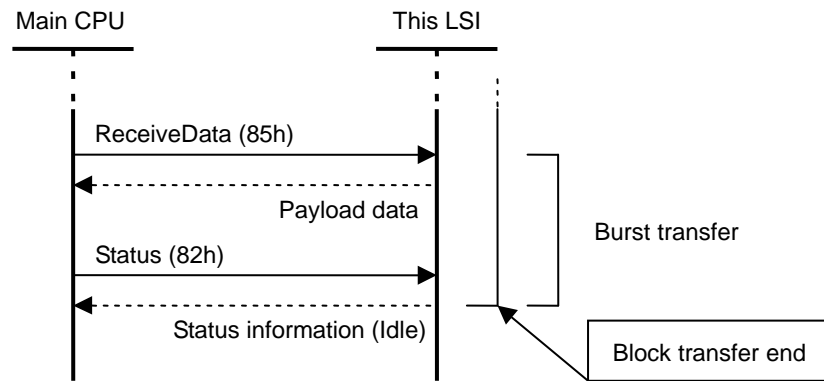


Figure 5.16 SPI end sequence

5. USB MSC Host Control

5.6 Power management

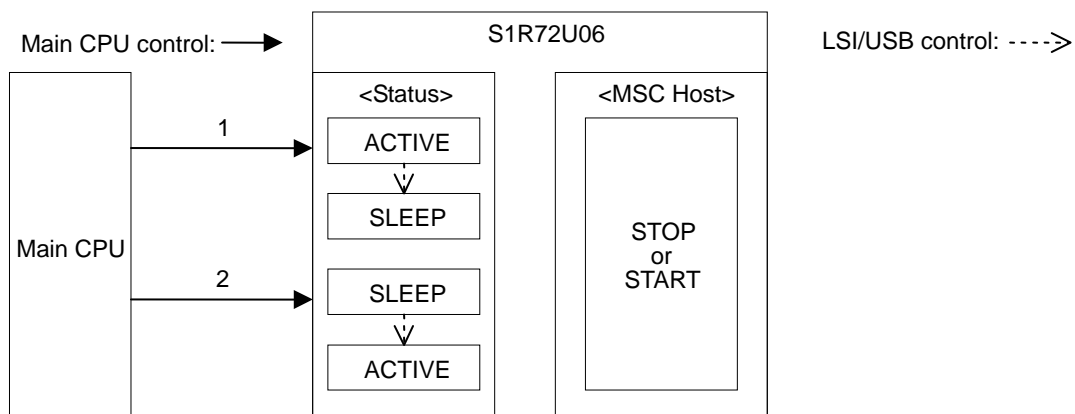
The LSI is equipped with two types of power management function. One manages the LSI using “SLEEP” control, while the other manages the USB using “Suspend” control. Note that commands cannot be written if the LSI is in “SLEEP” status, and so it should be switched to “ACTIVE” status using the WAKEUP pin. For information on control methods, refer to the following sections.

5.6.1 Control when Device is not connected

Table 5.5 shows the LSI power management method when no Device is connected. A lower power consumption state can be set with this control even if the Host is set to “Stop” or “Start” by “HID START” (10h).

Table 5.5 Control when no Device is connected

Step	Control target	Control method
1	Elreq	Execute “SLEEP” (01h). When the command is recognized, the status changes from ACTIVE to SLEEP. The SIO_READY pin changes from “High” to “Low”.
2	WAKEUP pin	Set the WAKEUP pin from “Low” to “High” and then to “Low”. The status changes from SLEEP to ACTIVE. The SIO_READY pin changes from “Low” to “High”.

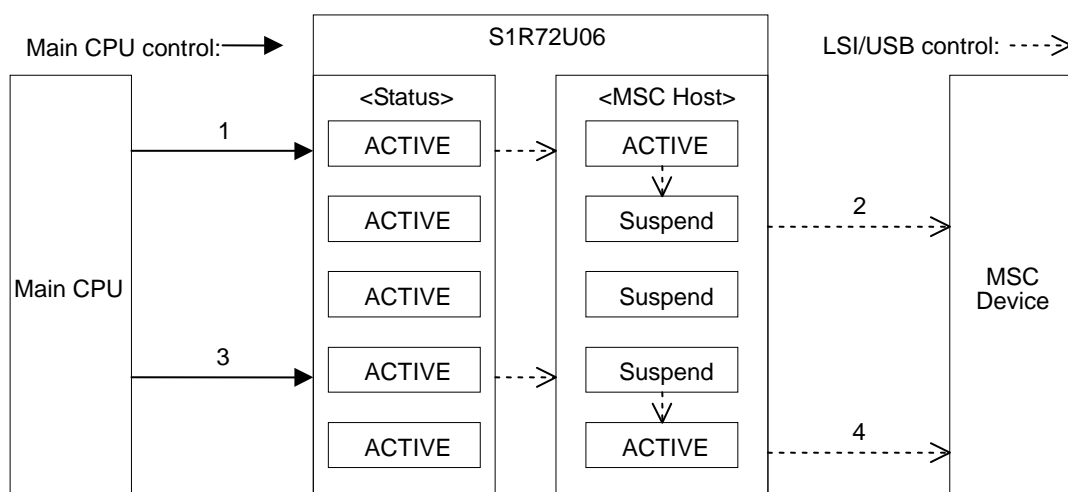


5.6.2 Suspend control when Device is connected

Table 5.6 shows the Device power management method when a Device is connected. The LSI controls the Device with the Remote Wakeup “prohibit” setting.

Table 5.6 Suspend status control

Step	Control target	Control method
1	Elreq	Execute “DEVICE POWER MANAGEMENT” (32h). “01h: Suspend & Remote Wakeup prohibit” setting
2	Suspend	The Host (Device) status changes from ACTIVE to Suspend.
3	Elreq	Execute “DEVICE POWER MANAGEMENT” (32h). “00h: Resume” setting
4	Resume	The Host status changes from Suspend to ACTIVE. The Device is set to Resume.



5. USB MSC Host Control

5.6.3 SLEEP control when Device is connected

Table 5.7 shows the LSI power management method when a Device is connected. This control method applies when the Device does not support Remote Wakeup. The LSI controls the Device with the Remote Wakeup “prohibit” setting.

The Main CPU should determine the Device state from the following event information if a Device is disconnected or reconnected while the LSI is in the sleep status (between Steps 2 and 3).

Disconnection: Event information notification is transferred when the XIRQ_EVENT pin changes and the LSI switches to the ACTIVE status. “Disconnect” can be confirmed using “CD” in the event information.

Connection: Event information notification is transferred when the XIRQ_EVENT pin changes and the LSI switches to the ACTIVE status. “Connect” can be confirmed using “CD” in the event information. Check that the Device is connected using the following commands.

Simple control: Use “GET STORAGE INFORMATION” (40h).

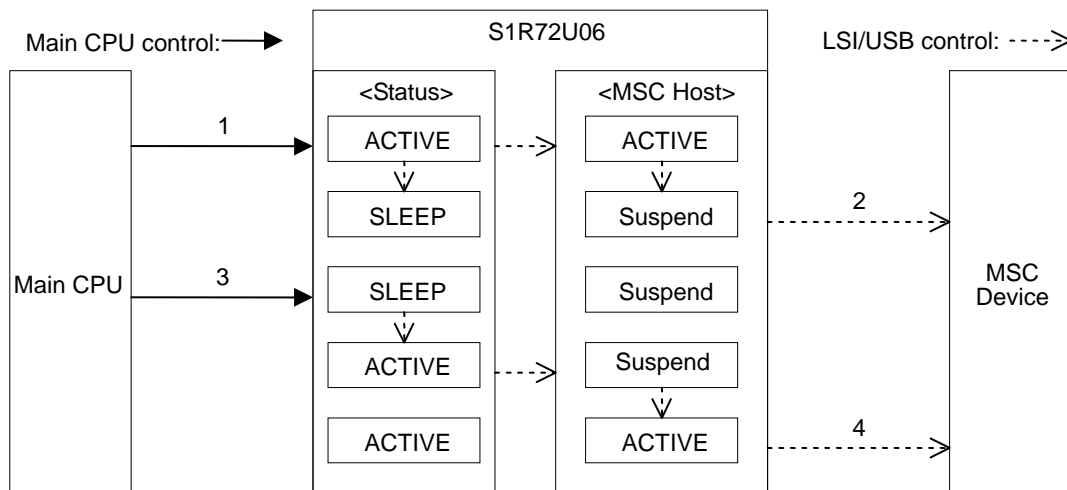
Full control: The “TEST UNIT READY” SCSI/ATAPI command is recommended.

If error notification is given for command execution, this means that the Device has been disconnected and reconnected while in sleep. Reconnection is performed automatically inside the LSI when an error occurs. This causes an event to be issued, and the Main CPU should perform the Device connection processing described in “5.2.1 Connection flow”.

Note that if the Device connection (or disconnection) state is the same for the LSI before entering sleep status and after switching from sleep to ACTIVE, no event information is transferred, even if the LSI switches to ACTIVE.

Table 5.7 Sleep status control

Step	Control target	Control method
1	Elreq	Execute “SLEEP” (01h).
2	Suspend	The Host (Device) status changes from ACTIVE to Suspend. The LSI changes from ACTIVE to SLEEP. The SIO_READY pin changes from “High” to “Low”.
3	WAKEUP pin	Set the WAKEUP pin from “Low” to “High” and then to “Low”.
4	Resume	The LSI changes from SLEEP to ACTIVE. The Host status changes from Suspend to ACTIVE. The Device is set to Resume. The SIO_READY pin changes from “Low” to “High”.

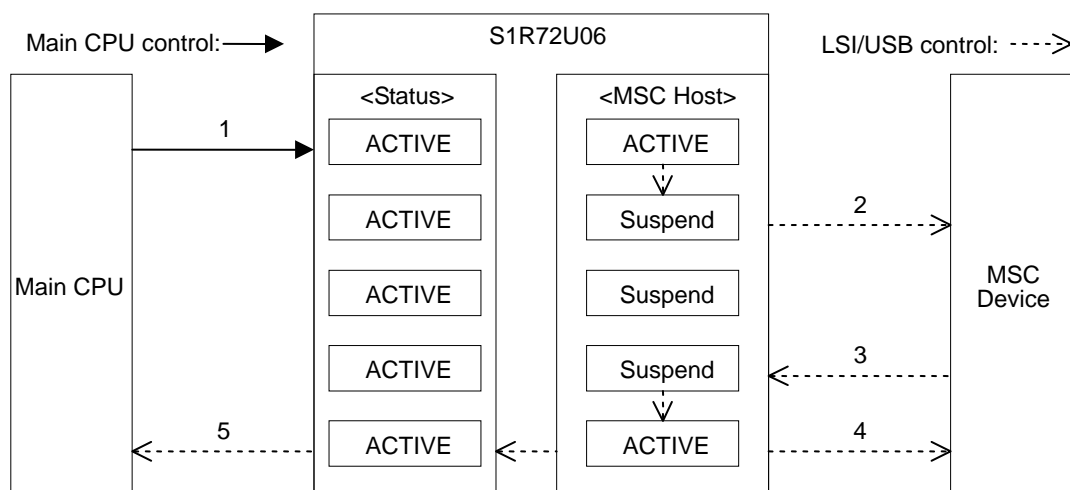


5.6.4 Suspend (Remote Wakeup) control when Device is connected

Table 5.8 shows the Device power management method when a Device is connected. The LSI controls the Device with the Remote Wakeup “permit” setting.

Table 5.8 Remote Wakeup control in Suspend status

Step	Control target	Control method
1	Elreq	Execute “DEVICE POWER MANAGEMENT” (32h). “02h: Suspend & Remote Wakeup permit” setting
2	Suspend	The Host (Device) status changes from ACTIVE to Suspend.
3	Remote Wakeup	Remote Wakeup from the Device is detected.
4	Resume	The Host status changes from Suspend to ACTIVE. The Device is set to Resume.
5	Event information	Notification of event generation is issued to the Main CPU.



5. USB MSC Host Control

5.6.5 SLEEP (Remote Wakeup) control when Device is connected

Table 5.9 shows the LSI power management method when a Device is connected. This control method applies when the Device supports Remote Wakeup. The LSI controls the Device with the Remote Wakeup “permit” setting.

If a Device is disconnected then reconnected while the LSI is in the sleep status (Step 2 and thereafter), the LSI will not be able to detect the disconnection/reconnection. To determine if the status results from Remote Wakeup or from disconnection/reconnection occurring during the sleep status, have the Main CPU perform the following process after the SIO_READY pin changes to “High” in Step 6.

Check that the Device is connected using the following commands.

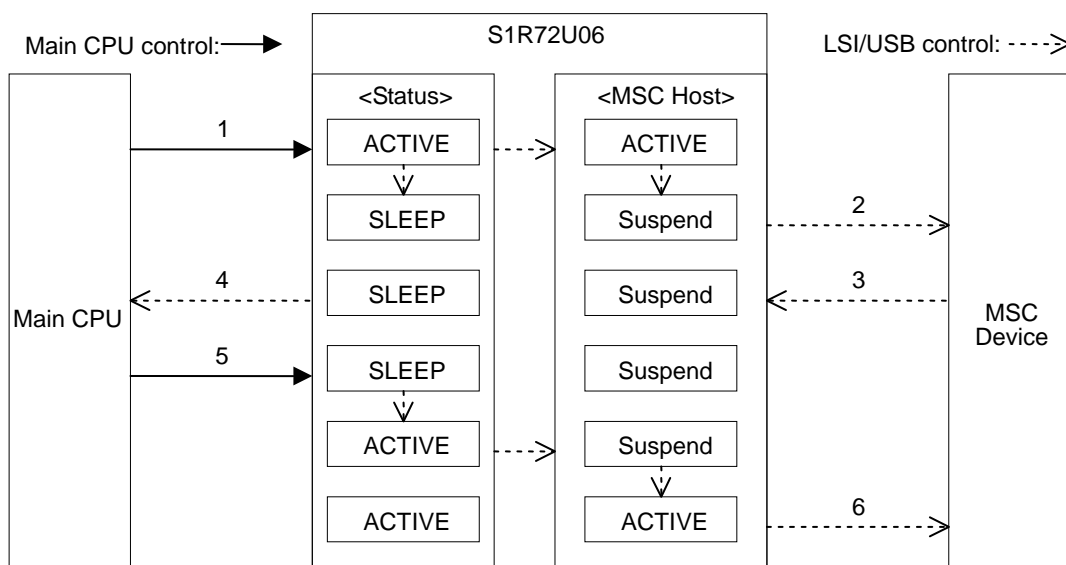
Simple control: Use “GET STORAGE INFORMATION” (40h).

Full control: The “TEST UNIT READY” SCSI/ATAPI command is recommended.

Confirmation of correct connection should be determined as Remote Wakeup. If error notification is given, this means that the Device has been disconnected and reconnected while in sleep. Reconnection is performed automatically inside the LSI when an error occurs. This causes an event to be issued, and the Main CPU should perform the Device connection processing described in “5.2.1 Connection flow”.

Table 5.9 Remote Wakeup control in sleep status

Step	Control target	Control method
1	Elreq	Execute “SLEEP” (01h).
2	Suspend	The Host (Device) status changes from ACTIVE to Suspend. The LSI changes from ACTIVE to SLEEP. The SIO_READY pin changes from “High” to “Low”.
3	Remote Wakeup	Remote Wakeup is detected from the Device.
4	XIRQ_EVENT pin	The XIRQ_EVENT pin changes from “High” to “Low”.
5	WAKEUP pin	Set the WAKEUP pin from “Low” to “High” and then to “Low”.
6	Resume	The LSI changes from SLEEP to ACTIVE. The Host status changes from Suspend to ACTIVE. The Device is set to Resume. The SIO_READY pin changes from “Low” to “High”.



5.7 Precautions

- (1) Reset the LSI using hardware reset if the Device connected causes an error and fails to respond (the Device continually gives NAK or STALL responses and the LSI does not change from Busy status).
- (2) If the connected Device is not recognized, the Device may be defective or its battery (for battery-operated Devices) may be discharged.
- (3) Some Devices do not support “Remote Wakeup”. Check the Configuration Descriptor information for the Device connected.
- (4) Devices may not be recognized depending on the number of Interface Descriptors. For details, refer to “5.2.2 Recognition process”.
- (5) If the Device is disconnected during data reading, the Main CPU must complete the block transfer currently being read. The Device disconnection processing must therefore be performed after reading is complete.
- (6) It is assumed that the MSC Device is normally connected to a PC. There may therefore be MSC Devices that cannot be recognized by the LSI or that do not operate correctly due to MSC Device internal processing (such as timeout) when transferring data.

6. USB HID Class Device Control

6. USB HID Class Device Control

This LSI includes an HID Class Device function as USB. For details, refer to the following sections.

6.1 HID Class Device initialization flow

Initialize the HID Class Device as shown in the flow in Figure 6.1.

For information on “SIO initialization”, refer to “2.1 UART initialization flow” or “3.1 SPI initialization flow”.

“Descriptor DOWNLOAD (02h) setting” must be downloaded each time Power is turned ON. The “Descriptor” downloaded is retained in the LSI RAM.

The “INITIAL FEATURE REPORT (24h) setting” is not required if Feature Report is not used.

This LSI starts connection processing automatically when connected to a Host while in “USB ACTIVE” status. For details, refer to “6.2 HID Class Host connection”. For information on disconnection processing, refer to “6.3 HID Class Host disconnection”.

If the system is configured as a “BUS-powered device”, the time elapsed from “Power ON” to “HID START (10h) setting” must be set within “70 ms” to comply with the USB standard. Similarly, the VBUS current consumption must not exceed “100 mA” from “Power ON” until “CD Change” and “CD (Connect)” events occur.

For information on the flow from power on until HID Class Host connection, refer to Appendix-B, “Initialization Flow”.

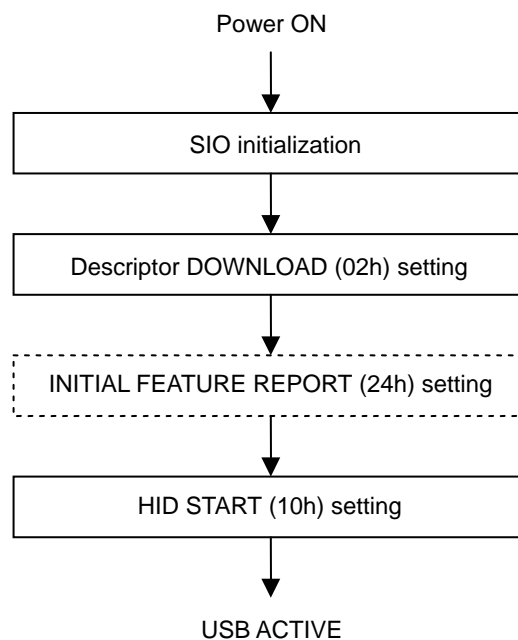


Figure 6.1 Initialization flow

6.2 HID Class Host connection

If “HID START” (10h) is set to “Start”, the LSI automatically executes enumeration as soon as it is connected to the Host. Once HID Class control is possible, the LSI issues notification of this state to the Main CPU with an event. If “HID START” (10h) is set to “Stop”, the LSI cannot connect to the Host.

The Main CPU should execute Host connection processing according to the flow shown in Figure 6.2.

“The LSI: Event notification” depends on the Host, and the “USB SuspendStatus” event may be generated several times, followed by the issuance of notification of “CD Change” event. For information on events, refer to “Device event information” in the *S1R72U06 Technical Manual*.

An event is generated when the LSI receives protocol mode settings from the Host. Change the protocol mode by making the Main CPU process the “Main CPU: GET PROTOCOL MODE (25h) acquisition”.

For information on transfer rates when connected, refer to *S1R72U06 Technical Manual*.

If the system is configured as a “BUS-powered device”, the processing described in “6.1 HID Class Device initialization flow” must be executed within the specified timeframe during the connection of the Host.

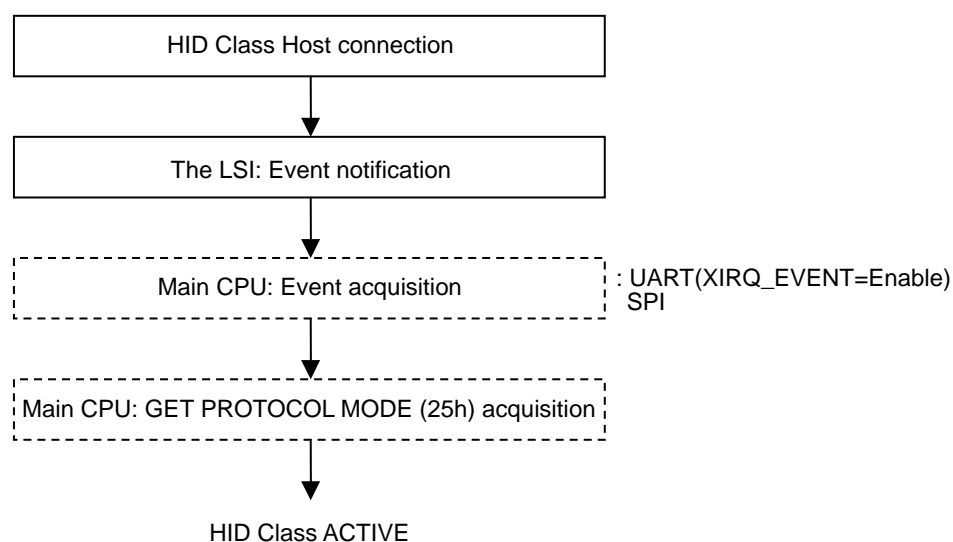


Figure 6.2 Connection flow

6. USB HID Class Device Control

6.3 HID Class Host disconnection

The disconnection processing performed when the LSI is disconnected from the Host differs depending on the immediately preceding state. For details, refer to the following sections. Note that the operations performed are the same as for disconnection, even when “HID START” (10h) is set to “Stop”.

For information on events, refer to “Device event information” in the *S1R72U06 Technical Manual*.

6.3.1 Disconnection flow

The LSI performs USB disconnection processing when disconnected from the Host. The Main CPU is notified of the USB disconnect status by an event (Bit1 CD Change).

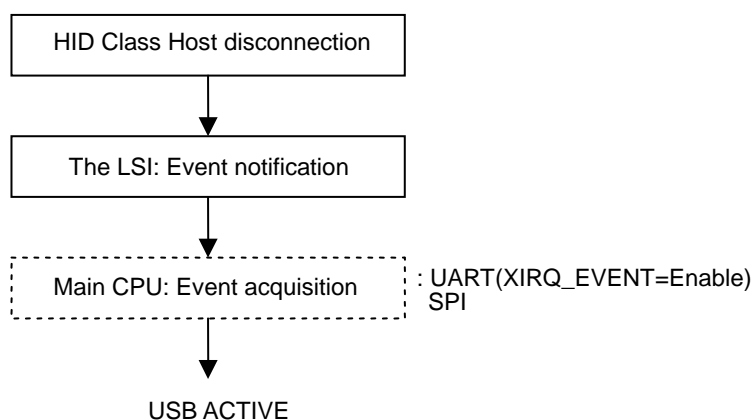


Figure 6.3 Disconnection flow

6.3.2 Disconnection flow during data reads

The LSI performs USB disconnection processing when disconnected from the Host while Report data is being read from the LSI by the Main CPU. When an event (Bit3 Rcv Feature Report or Bit2 Rcv Output Report) is generated, the Main CPU should read the remaining Report data in the LSI using “RECV FEATURE REPORT (21h) or RECV REPORT (23h) acquisition”.

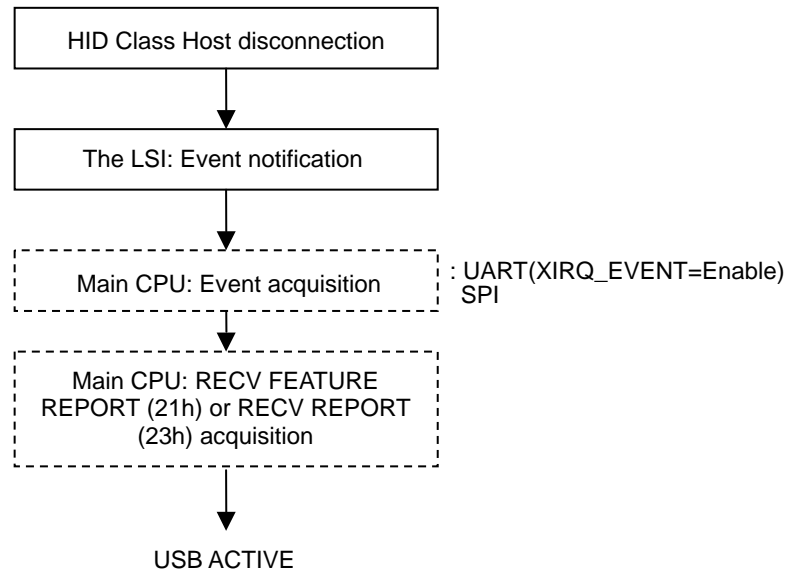


Figure 6.4 Disconnection flow during data read

6. USB HID Class Device Control

6.3.3 Disconnection flow during sleep

If the LSI is disconnected from the Host during the sleep status, notification is provided via the XIRQ_EVENT pin. The Main CPU should set the WAKEUP pin to “High”. The LSI performs USB disconnection processing and notifies the Main CPU that the USB has been disconnected with an event (Bit1 CD Change). For information on the WAKEUP pin, refer to “Setting Function” in the *S1R72U06 Technical Manual*.

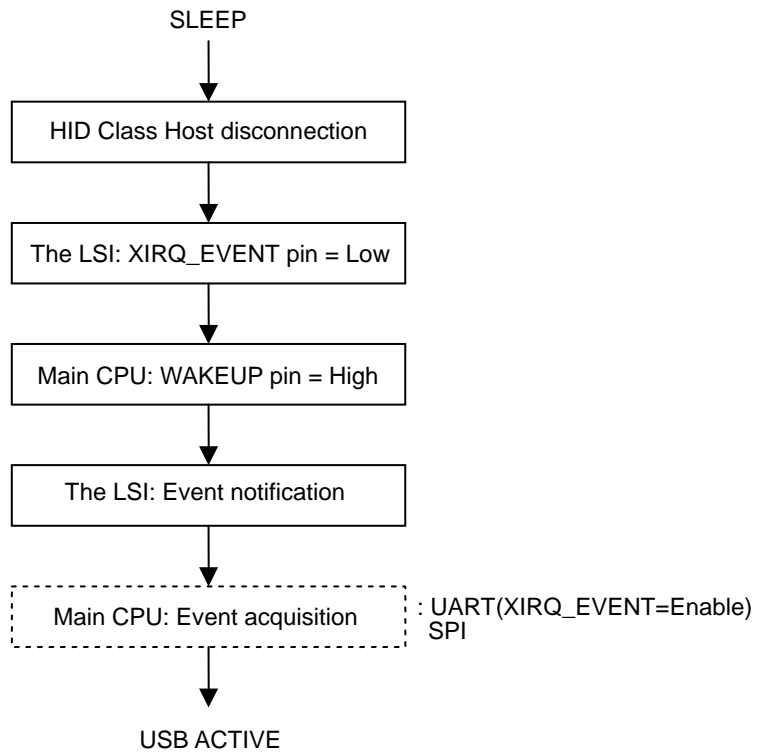


Figure 6.5 Disconnection flow in sleep

6.4 Power management

The LSI is equipped with two types of power management function. One manages the LSI using “SLEEP” control, while the other manages the USB using “Suspend” control. Note that commands cannot be written if the LSI is in “SLEEP” status, and so it should be switched to “ACTIVE” status using the WAKEUP pin. For information on control methods, refer to the following sections.

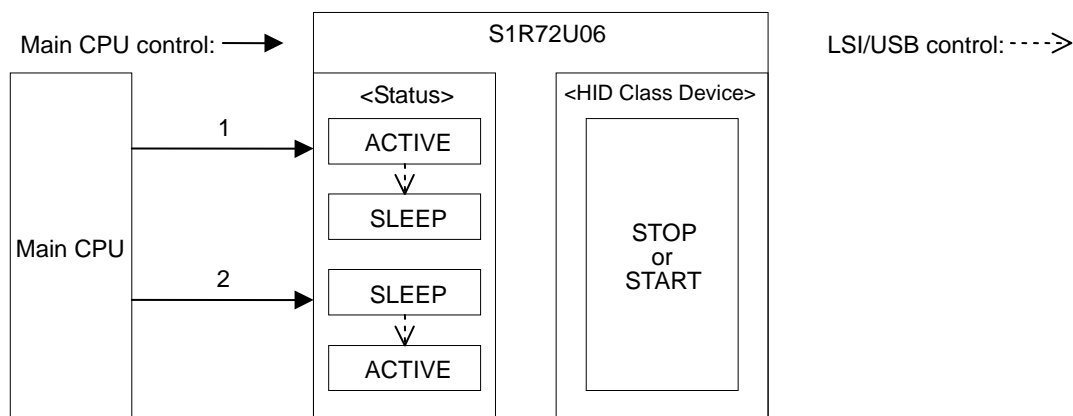
If the Main CPU requires the LSI to be in the SLEEP status while connected to the Host, “HID START” (10h) must be set to “Stop”.

6.4.1 Control when Host is not connected

Table 6.1 shows the LSI power management method with no Host connected. A lower power consumption state can be set with this control even if the Device is set to “Stop” or “Start” by “HID START” (10h).

Table 6.1 Control when no Host is connected

Step	Control target	Control method
1	Elreq	Execute “SLEEP” (01h). When the command is recognized, the status changes from ACTIVE to SLEEP. The SIO_READY pin changes from “High” to “Low”.
2	WAKEUP pin	Set the WAKEUP pin from “Low” to “High” and then to “Low”. The status changes from SLEEP to ACTIVE. The SIO_READY pin changes from “Low” to “High”.



6. USB HID Class Device Control

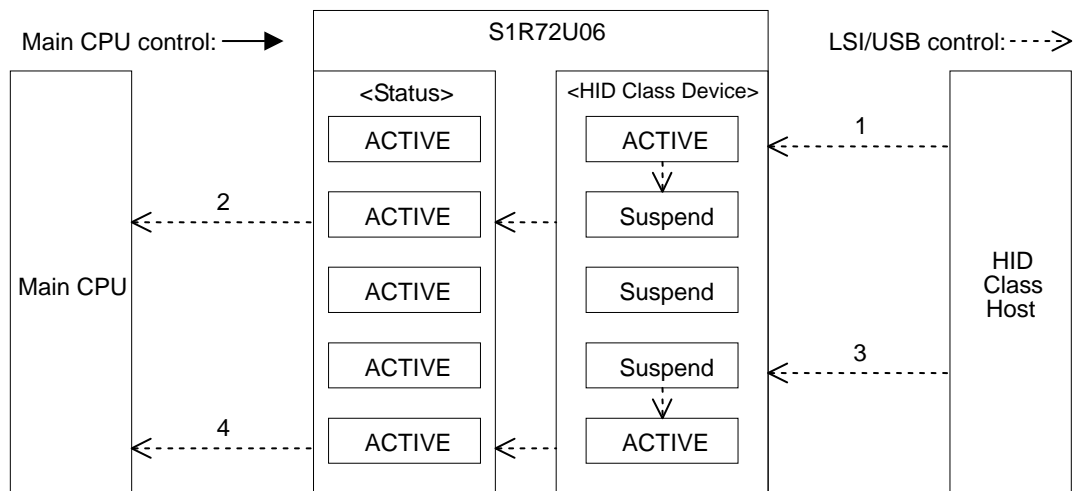
6.4.2 Suspend control when Host is connected

Table 6.2 shows the Device power management method with the Host connected. This method provides control with Remote Wakeup set to “prohibit” by the Host. If the Main CPU executes a data write during the Suspend status, the LSI discards the data and issues error notification to the Main CPU. Data transfers are not possible until the Host is set to Resume.

If the system is configured as a “BUS-powered device”, the VBUS current consumption must be set to “2.5 mA” or less within “10 ms” of the Suspend status in Step 1. Since setting the LSI to the SLEEP status to reduce the current consumed requires the processing described in “6.4.3 SLEEP control when Host is connected”, the power management described in this section cannot be used.

Table 6.2 Suspend status control

Step	Control target	Control method
1	Suspend	Suspend from the Host is detected. The Device status changes from ACTIVE to Suspend.
2	Event information	Notification of event generation is issued to the Main CPU.
3	Resume	Resume from the Host is detected.
4	Event information	The Device status changes from Suspend to ACTIVE. Notification of event generation is issued to the Main CPU.



6.4.3 SLEEP control when Host is connected

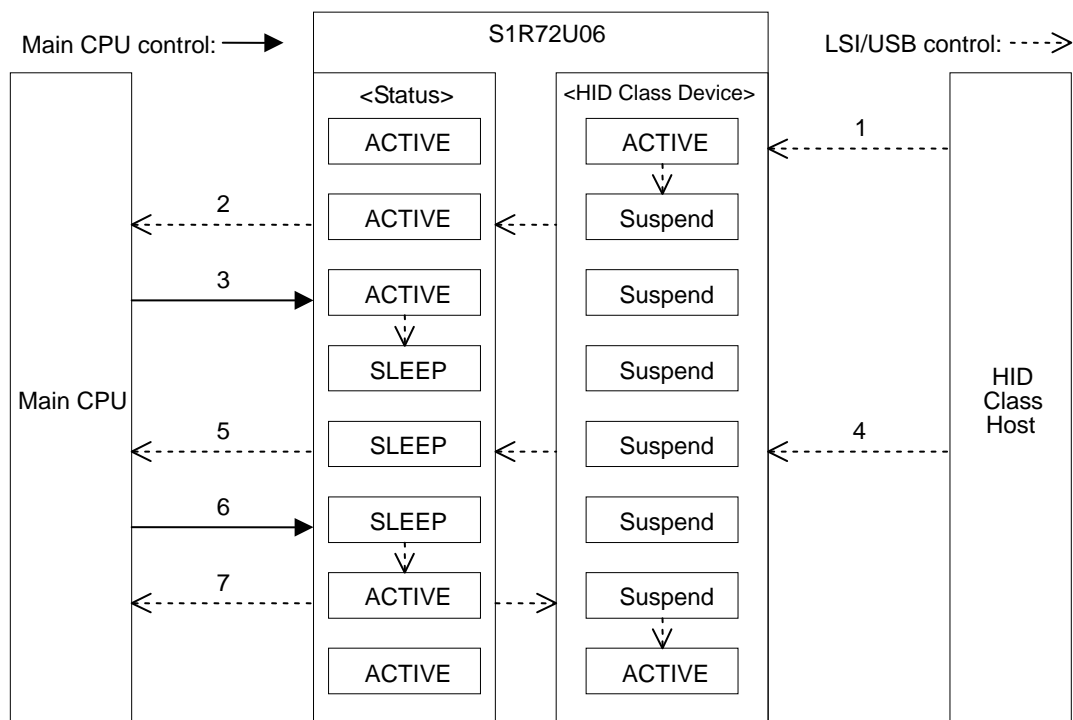
Table 6.3 shows the LSI power management method with the Host connected. This method provides control with Remote Wakeup set to “prohibit” by the Host. If a data write is executed by the Main CPU while in the Suspend status, the LSI discards the data and issues an error notification to the Main CPU. Data transfers are not possible until the Host is set to Resume.

If the system is configured as a “BUS-powered device”, execute “SLEEP” (01h) as described in Step 3 within “8 ms” of the event notification in Step 2.

Set the WAKEUP pin to “High” as described in Step 6 within “5 ms” after the XIRQ_EVENT pin is asserted in Step 5.

Table 6.3 Sleep status control

Step	Control target	Control method
1	Suspend	Suspend from the Host is detected. The Device status changes from ACTIVE to Suspend.
2	Event information	Notification of event generation is issued to the Main CPU.
3	Elreq	Execute “SLEEP” (01h). When the command is recognized, the status changes from ACTIVE to SLEEP. The SIO_READY pin changes from “High” to “Low”.
4	Resume	Resume from the Host is detected.
5	XIRQ_EVENT pin	The XIRQ_EVENT pin changes from “High” to “Low”.
6	WAKEUP pin	Set the WAKEUP pin from “Low” to “High” and then to “Low”. The status changes from SLEEP to ACTIVE. The SIO_READY pin changes from “Low” to “High”.
7	Event information	The Device status changes from Suspend to ACTIVE. Notification of event generation is issued to the Main CPU.



6. USB HID Class Device Control

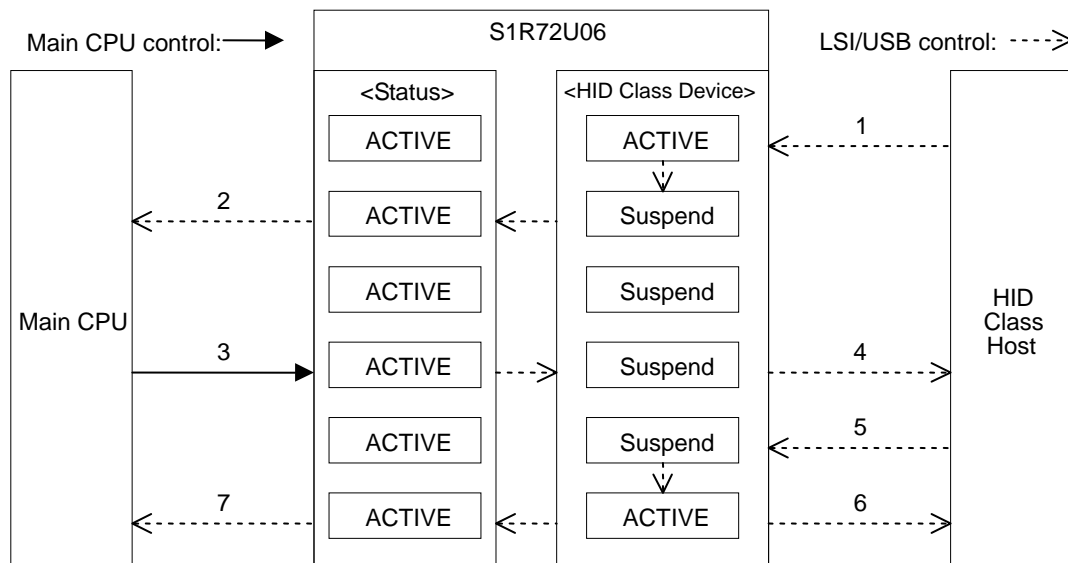
6.4.4 Suspend (Remote Wakeup) control when Host is connected

Table 6.4 shows the Device power management method with the Host connected. This method provides control with Remote Wakeup set to “permit” by the Host. Data transfers are not possible until the Host is set to Resume.

If the system is configured as a “BUS-powered device”, the VBUS current consumption must be reduced to “2.5 mA” or less within “10 ms” of the Suspend status in Step 1. Since setting the LSI to the SLEEP status to reduce the current consumption requires the processing described in “6.4.5 SLEEP (Remote Wakeup) control when Host is connected”, the power management described in this section cannot be used.

Table 6.4 Remote Wakeup control in Suspend status

Step	Control target	Control method
1	Suspend	Suspend from the Host is detected. The Device status changes from ACTIVE to Suspend.
2	Event information	Notification of event generation is issued to the Main CPU.
3	Elreq	Execute “SEND REPORT” (22h).
4	Remote Wakeup	Notification of Remote Wakeup is issued to the Host.
5	Resume	Resume from the Host is detected.
6	Data transmission	The Device status changes from Suspend to ACTIVE. Data is transmitted to the Host.
7	Event information	Notification of event generation is issued to the Main CPU.



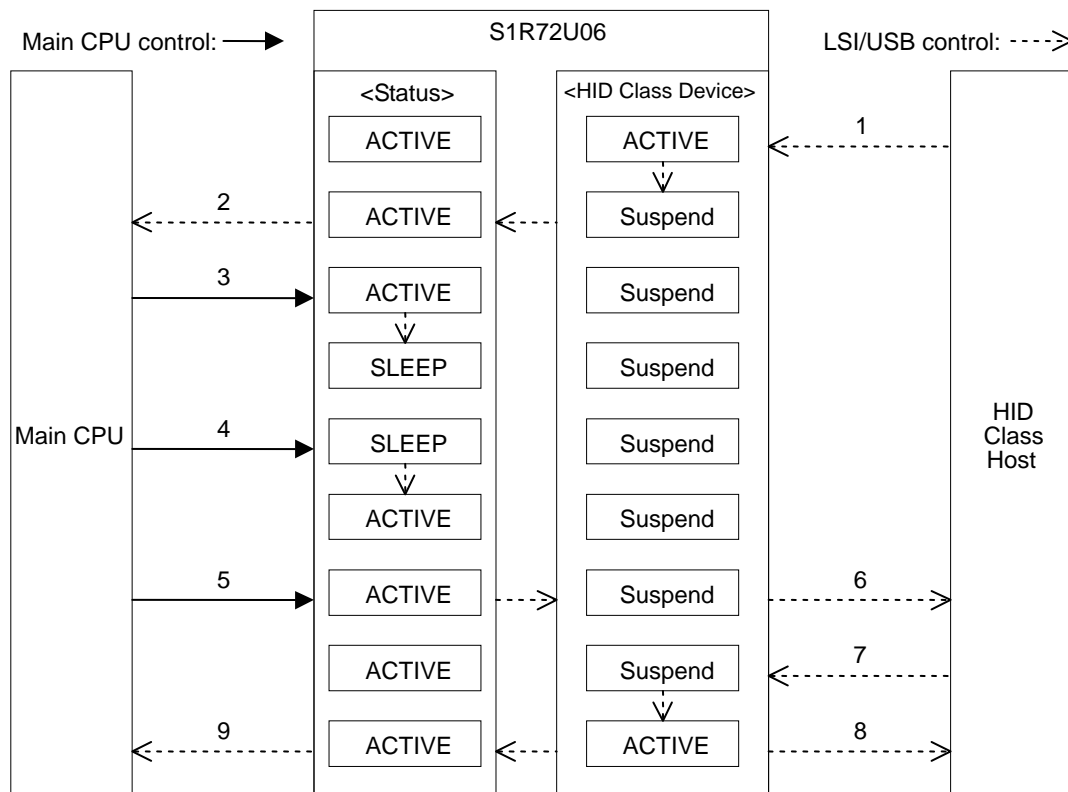
6.4.5 SLEEP (Remote Wakeup) control when Host is connected

Table 6.5 shows the LSI power management method with the Host connected. This method provides control with Remote Wakeup set to “permit” by the Host. Data transfers are not possible until the Host is set to Resume.

If the system is configured as a “BUS-powered device”, execute “SLEEP” (01h) described in Step 3 within “8 ms” of the event notification in Step 2.

Table 6.5 Remote Wakeup control in sleep status

Step	Control target	Control method
1	Suspend	Suspend from the Host is detected. The Device status changes from ACTIVE to Suspend.
2	Event information	Notification of event generation is issued to the Main CPU.
3	Elreq	Execute “SLEEP” (01h). When the command is recognized, the status changes from ACTIVE to SLEEP. The SIO_READY pin changes from “High” to “Low”.
4	WAKEUP pin	Set the WAKEUP pin from “Low” to “High” and then to “Low”. The status changes from SLEEP to ACTIVE. The SIO_READY pin changes from “Low” to “High”.
5	Elreq	Execute “SEND REPORT” (22h).
6	Remote Wakeup	Notification of Remote Wakeup is issued to the Host.
7	Resume	Resume from the Host is detected.
8	Data transmission	The Device status changes from Suspend to ACTIVE. Data is transmitted to the Host.
9	Event information	Notification of event generation is issued to the Main CPU.



6. USB HID Class Device Control

6.5 Precautions

- (1) The USB standard stipulates use of Resume processing for resetting from Suspend status, but some Hosts may use BUS resetting. To support such Hosts, disconnection and connection processing is used for reconnection.

Appendix-A. Alternative Method When SIO_READY Pin Is Left Open

This section describes the alternative method when the SIO_READY pin is left open (not connected).

A.1 UART initialization processing

The confirmation processes for the SIO_READY pin described in “2.1 UART initialization flow” can be performed by an alternative method of waiting for a specific time. These are the sections in Figure A.1 enclosed in bold boxes.

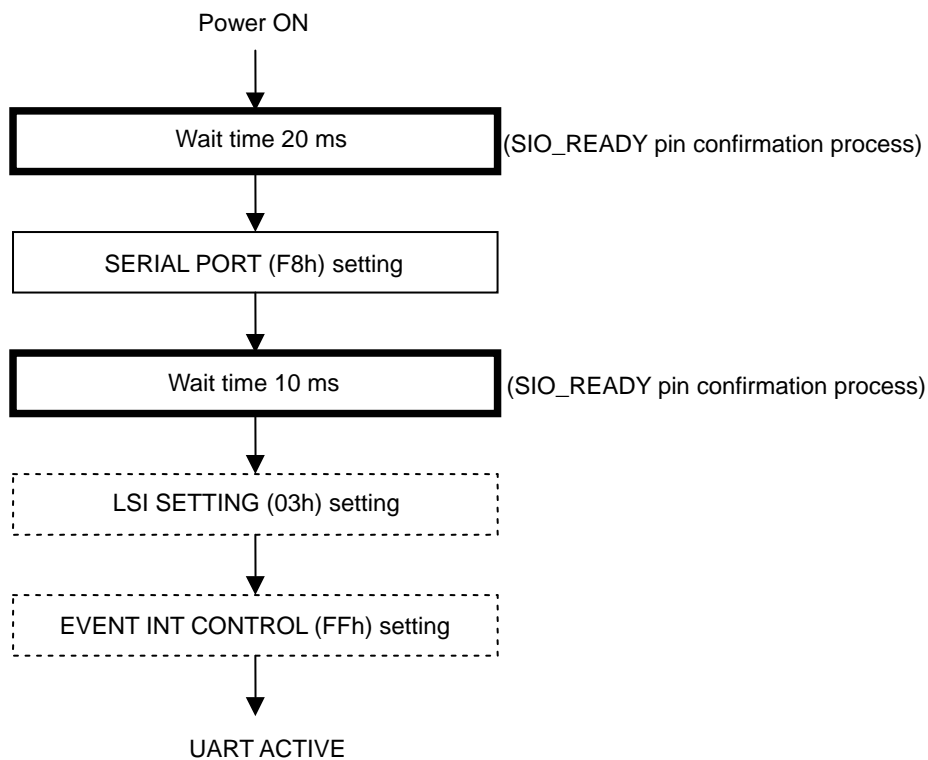


Figure A.1 UART alternative initialization flow

A.2 SPI initialization processing

The confirmation processes for the SIO_READY pin described in “3.1 SPI initialization flow” can be performed by an alternative method of waiting for a specific time. These are the sections in Figure A.2 enclosed in bold boxes.

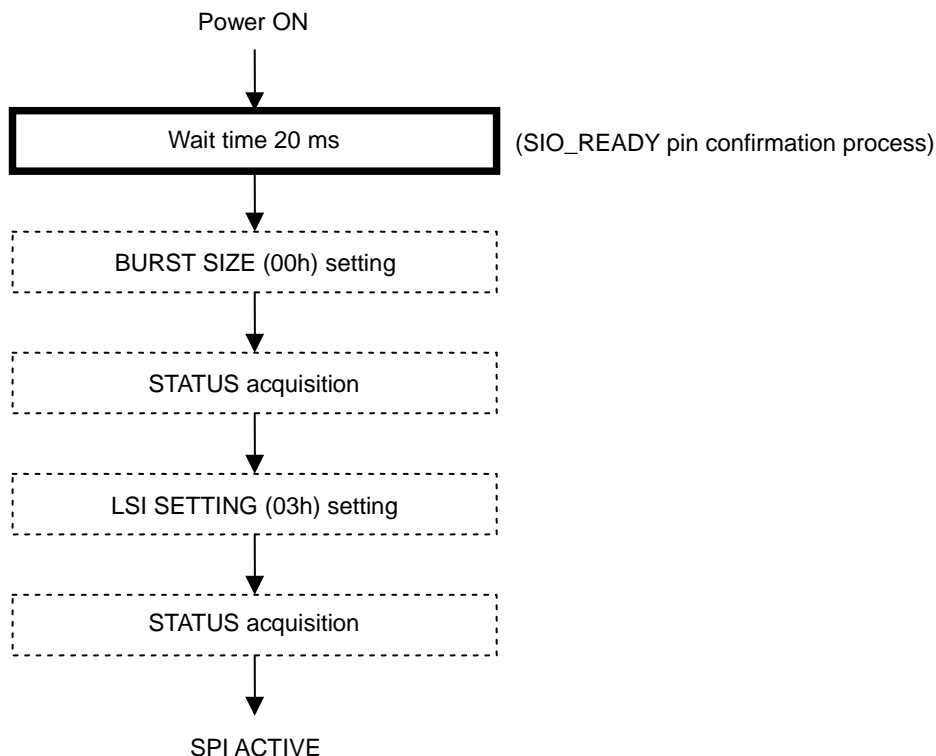


Figure A.2 SPI alternative initialization flow

A.3 Power management processing

The confirmation process for “Low” to “High” for the SIO_READY pin can be performed by an alternative method of waiting for a specific time in power management.

Table A.1 Alternative power management processing

USB	Item covered	Wait time
HID Class Host	4.4.1 Control when Device is not connected [Step 2]	20 ms
	4.4.3 SLEEP control when Device is connected [Step 4]	150 ms
	4.4.5 SLEEP (Remote Wakeup) control when Device is connected [Step 6]	150 ms
MSC Host	5.6.1 Control when Device is not connected [Step 2]	20 ms
	5.6.3 SLEEP control when Device is connected [Step 4]	150 ms
	5.6.5 SLEEP (Remote Wakeup) control when Device is connected [Step 6]	150 ms
HID Class Device	6.4.1 Control when Host is not connected [Step 2]	15 ms
	6.4.3 SLEEP control when Host is connected [Step 6]	15 ms
	6.4.5 SLEEP (Remote Wakeup) control when Host is connected [Step 4]	15 ms

Appendix-B. Initialization Flow

This describes the initialization flow from the point at which the power supply is switched on until the USB Class is ready to operate.

B.1 UART – HID Class Host flow

The UART and HID Class Host can be initialized using the procedures in “2.1 UART initialization flow” and “4.1 HID Class Host initialization flow”. If an HID Class Device is subsequently connected, it can be used as an HID Class Host by the procedural flow described in “4.2 HID Class Device connection”.

Refer to the corresponding section for detailed information on the corresponding procedural flow.

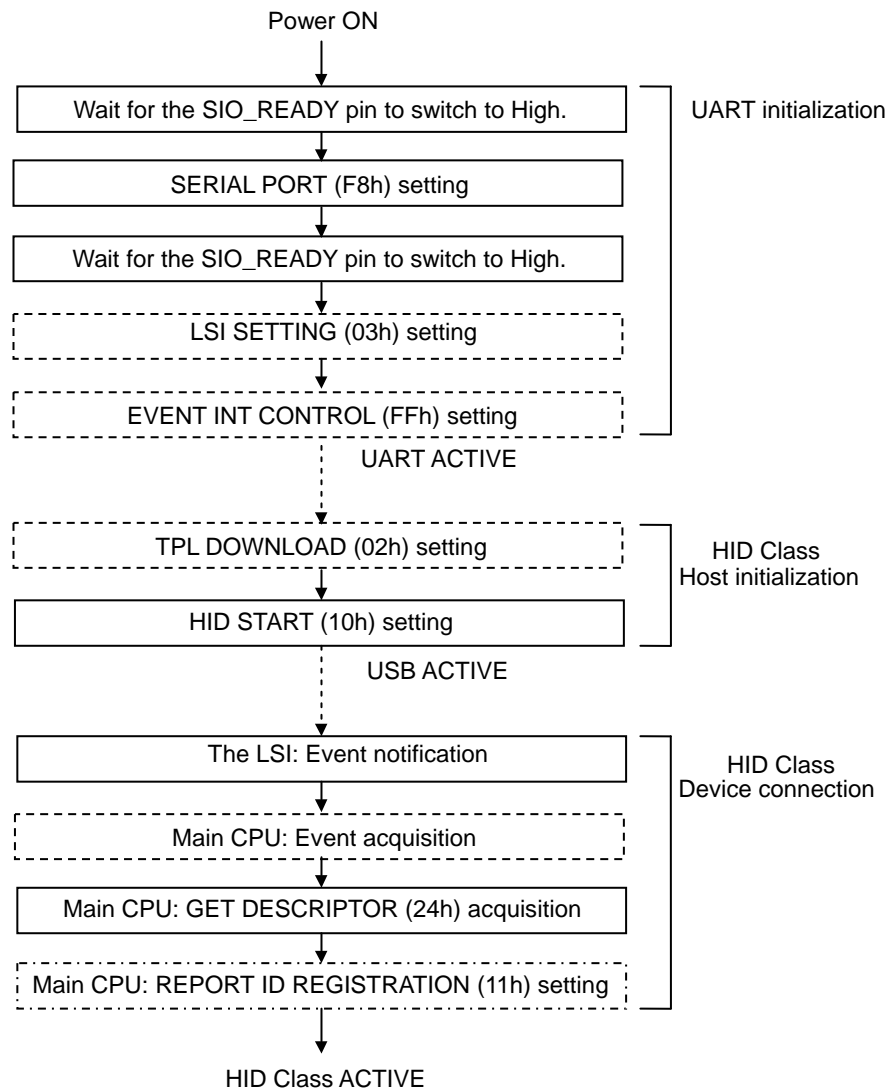


Figure B.1 UART – HID Class Host flow

Appendix-B. Initialization Flow

B.2 UART – MSC Host flow

The UART and MSC Host can be initialized using the procedures in “2.1 UART initialization flow” and “5.1 MSC Host initialization flow”. If an MSC Device is subsequently connected, it can be used as an MSC Host by the procedural flow described in “5.2 MSC Device connection”.

Refer to the corresponding section for detailed information on the corresponding procedural flow.

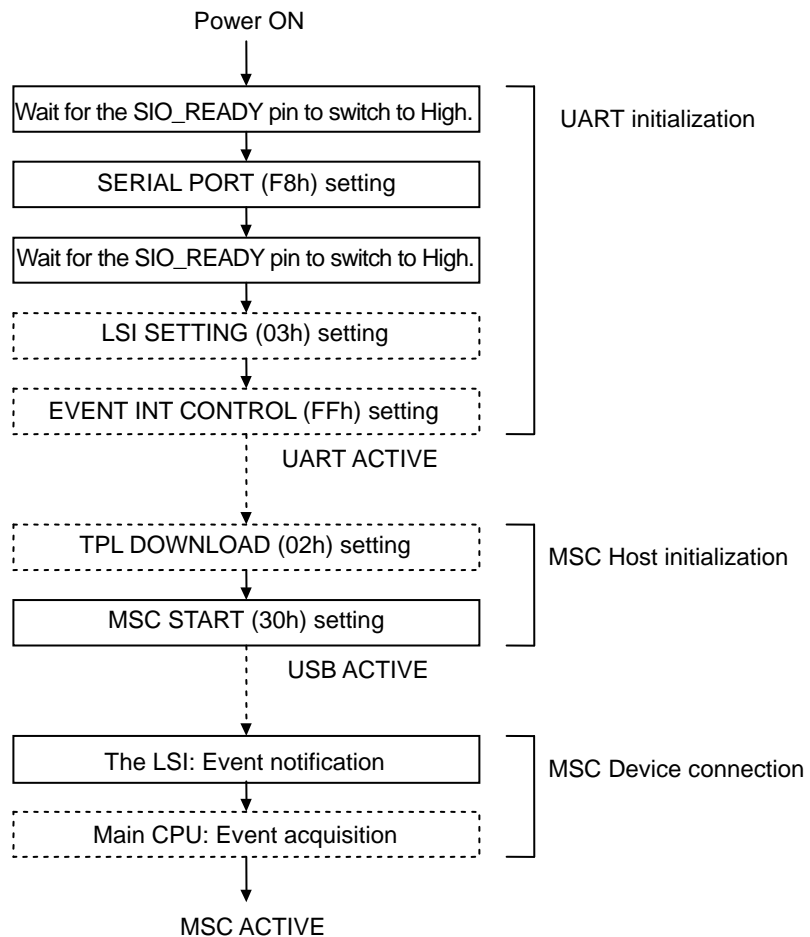


Figure B.2 UART – MSC Host flow

B.3 UART – HID Class Device flow

The UART and HID Class Device can be initialized using the procedures “2.1 UART initialization flow” and “6.1 HID Class Device initialization flow”. If an HID Class Host is subsequently connected, it can be operated as an HID Class Device using the procedural flow described in “6.2 HID Class Host connection”.

Refer to the corresponding section for detailed information on the corresponding procedural flow.

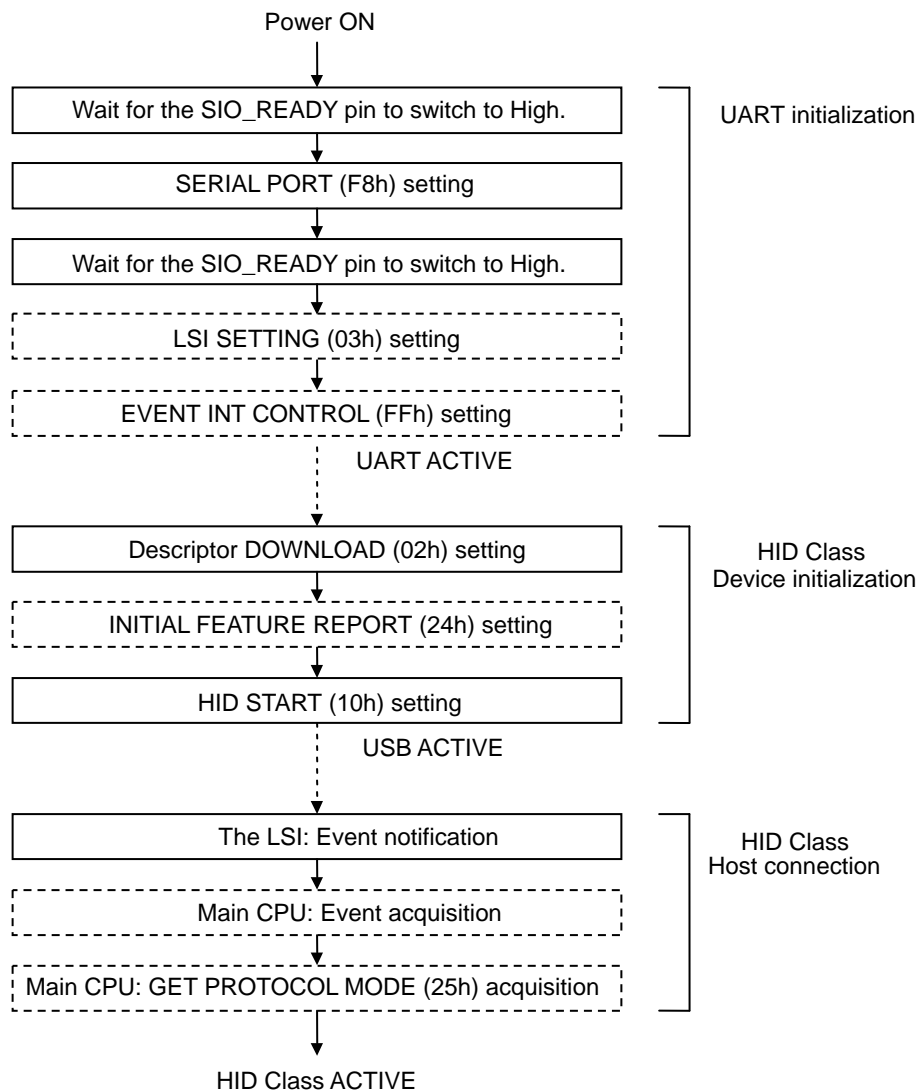


Figure B.3 UART – HID Class Device flow

Appendix-B. Initialization Flow

B.4 SPI – HID Class Host flow

The SPI and HID Class Host can be initialized using the procedures in “3.1 SPI initialization flow” and “4.1 HID Class Host initialization flow”. If an HID Class Device is subsequently connected, it can be operated as an HID Class Host using the procedural flow described in “4.2 HID Class Device connection”.

Refer to the corresponding section for detailed information on the corresponding procedural flow.

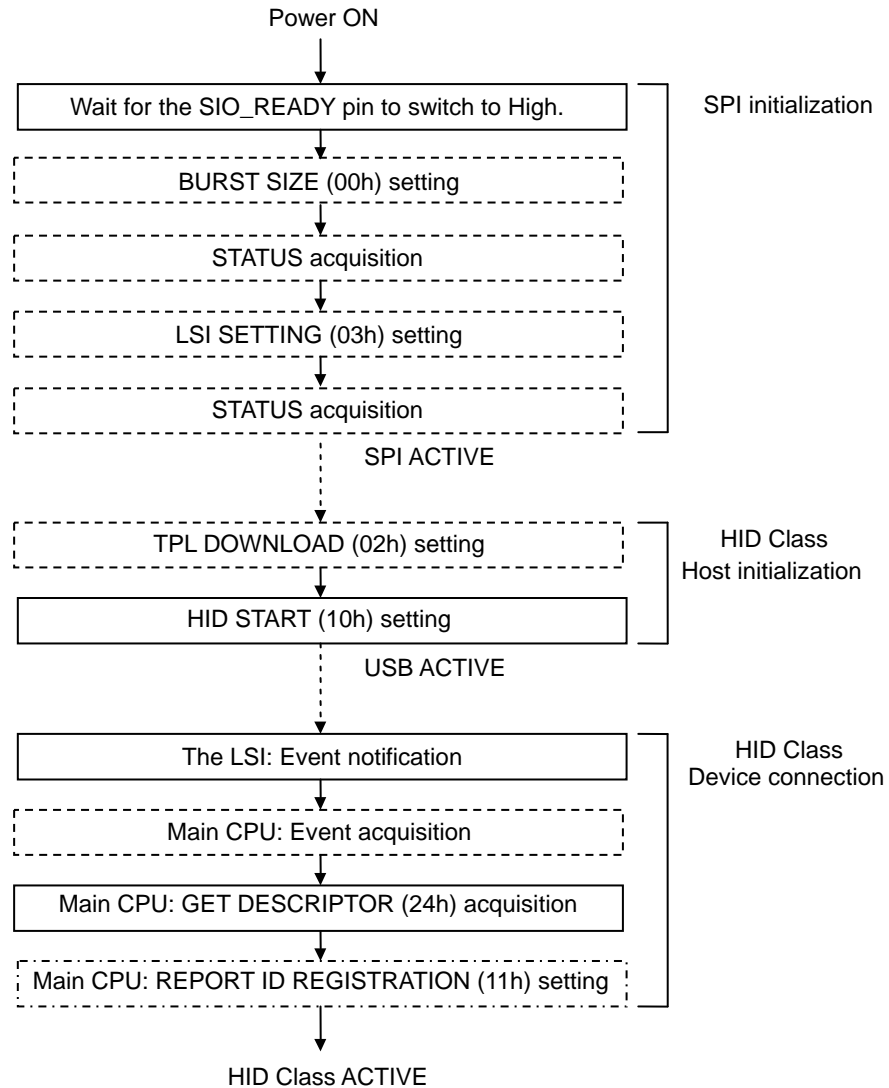


Figure B.4 SPI – HID Class Host flow

B.5 SPI – MSC Host flow

The SPI and MSC Host can be initialized using the procedures in “3.1 SPI initialization flow” and “5.1 MSC Host initialization flow”. If an MSC Device is subsequently connected, it can be operated as an MSC Host using the procedural flow described in “5.2 MSC Device connection”.

Refer to the corresponding section for detailed information on the corresponding procedural flow.

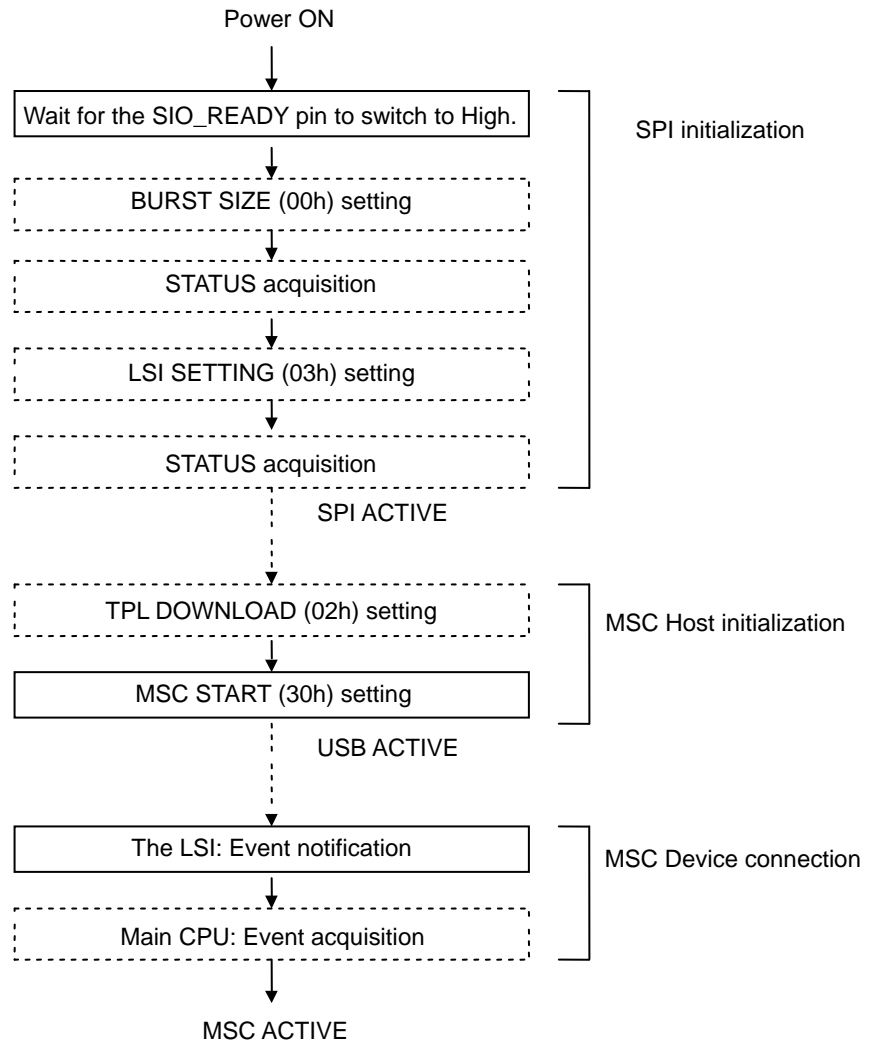


Figure B.5 SPI – MSC Host flow

Appendix-B. Initialization Flow

B.6 SPI – HID Class Device flow

The SPI and HID Class Device can be initialized using the procedures in “3.1 SPI initialization flow” and “6.1 HID Class Device initialization flow”. If an HID Class Host is subsequently connected, it can be operated as an HID Class Device using the procedural flow described in “6.2 HID Class Host connection”.

Refer to the corresponding section for detailed information on the corresponding procedural flow.

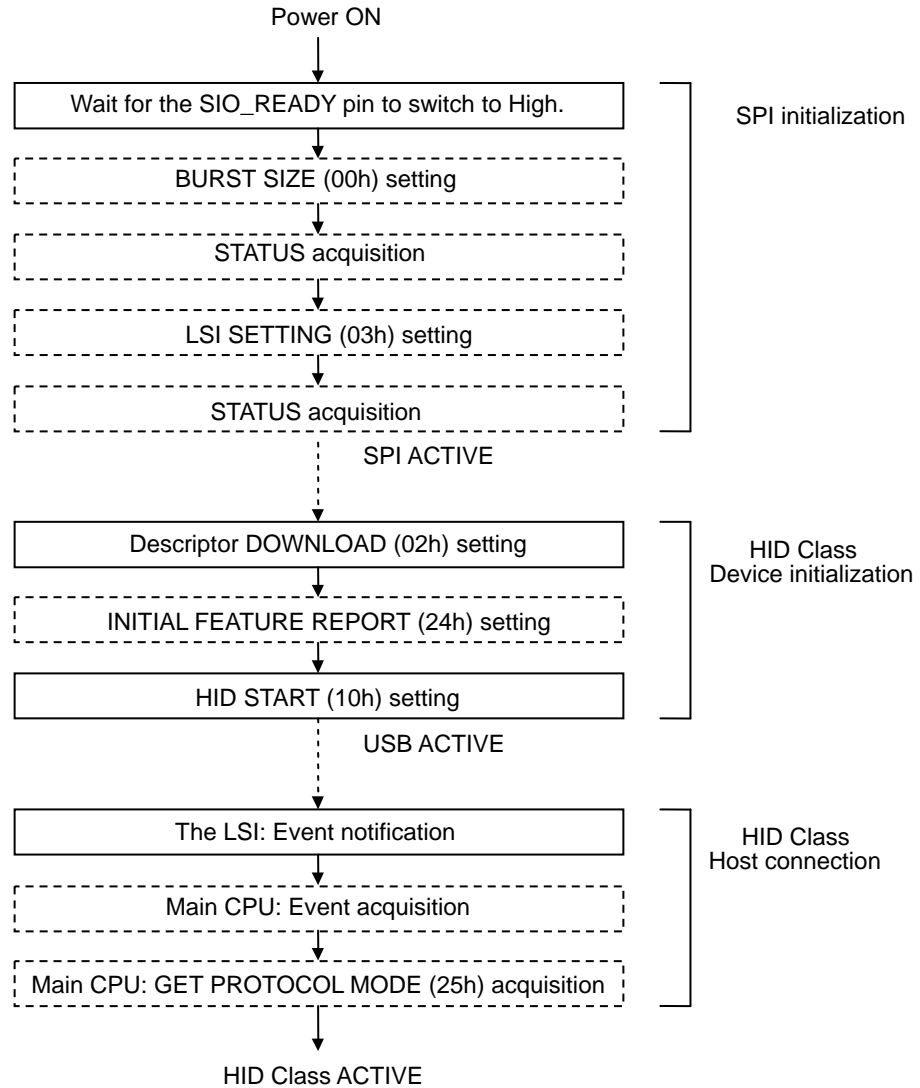


Figure B.6 SPI – HID Class Device flow

Revision History

Attachment-1

Rev. No.	Date	Page	Category	Revision details (including previous details) and reason
Rev. 1.00	4/6/2009	All	New	Newly established

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