Wii Remote and Nunchuk

Hardware Overview

Version 0.33

The contents of this document are strictly confidential and the document should be handled accordingly.

RVL-06-0002-001-D
Released: September 12, 2006

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Revision History

Version	Revision Date	Revised Items	Description
0.33	9/01/2006	8	8.4 Revised description
0.32	8/31/2006	2, 11	2.2, 2.3 Corrected mistakes 11. Corrected mistakes
0.31	8/30/2006	2, 8, 11, 12, 13	2.2, 2.3 Added to sections 11. Added differences between RD3 and production version. Changed subsequent chapter numbers. 8. Additions concerning batteries 12. Corrected mistakes 13. Corrected mistakes
0.30	8/25/2006	1, 7, 9, 11, 12	Standardized terminology 9. Added Development controller types 11. Revised problem
0.29	8/23/2006	1, 2, 7, 10	Standardized terminology Revised descriptions of pairing operations Updated content of Resolved Issues
0.28	8/21/2006	1.1–3.5	Updated photographs. Changed misspelling (in Japanese, does not affect translation).
0.27	8/16/2006	All	Updated description of wireless features and reorganized. Added speaker description and all chapters from Chapter 7.
0.26	8/10/2006	All	Support for Revolution SDK 2.1. Support for Wii Remote (version RD3).
0.25	6/27/2006	All	Chapter formatting. Additions relating to Wii Remote and Nunchuk Motion Sensors.
0.24	6/21/2006	1,2,5,6,	Revised some expressions.
0.23	6/19/2006	4	Made revisions regarding changes to the acceleration sensor.
0.22	6/19/2006	1.1, 2, 5	Revised points differing from specifications regarding the wireless feature.
0.21	6/19/2006	All	Added to the description of the wireless feature.
0.20	6/16/2006	All	Support for development tool version 4.
0.16	4/18/2066		Changed and added to Motion Sensor description. Updated information on sensor bar marker interval changing to 20cm in Version 4 and production version.
0.15	3/1/2006		Updated for Revolution SDK 1.0.
0.14	11/10/2005		Modified 4 – How to Use the Motion Sensor.
0.13	11/10/2005		Modified 5 – How to Use the Rumble Motor.
0.12	11/10/2005		Changed name, added several notes.
0.06	11/5/2005		Modified for development tool version 3.
0.05	9/27/2005		Fifth draft.
0.04	9/27/2005		Fourth draft.
0.03	9/26/2005		Third draft.
0.02	7/28/2005		Second draft.
0.01	7/19/2005		First draft.

1 Introduction

The Wii controller supports the following three types of operations so that it can cover the variety of operations required by games including simple and new game playing styles while providing a feel similar to that available with conventional games:

- Operations using a Wii Remote by itself
- Operations using a Wii Remote plus Nunchuk
- Operations using a Wii Remote plus Classic Controller

Note: Hardware distribution of Classic Controllers starts beginning the end of August, 2006. Wii Remote version RD3 is shipped with NDEV Version 2.1.

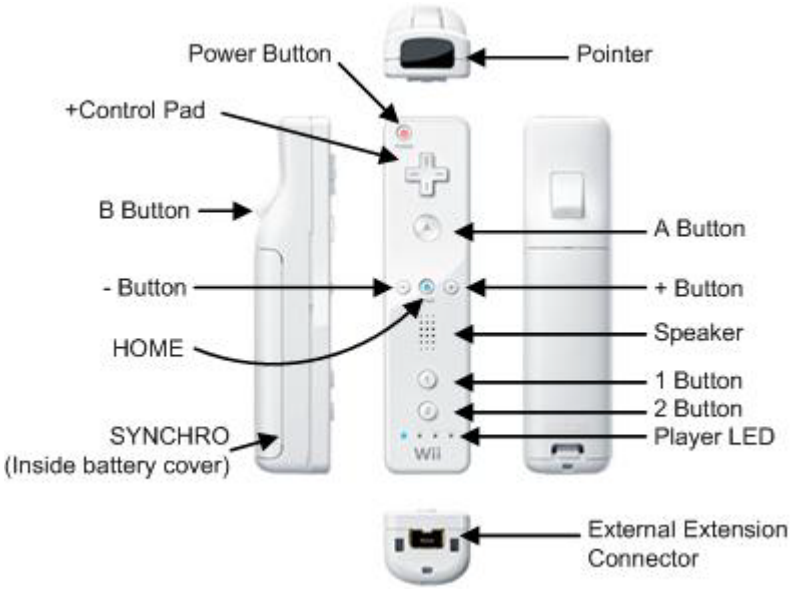
1.1 Wii Remote

The Wii Remote is suited for simple games with dynamic movement that can be controlled with one hand.

The following features are built into the Wii Remote:

- Digital input (+Control Pad, A Button and B Button, 1 Button, 2 Button, - Button, HOME, + Button, Power Button, SYNCHRO).
- Wireless communication unit (2.4GHz band).
- Pointer (sensor for screen pointing and fine movements).
- Motion sensor ±3.4G (sensor suitable for larger movements).
- Rumble Motor.
- Player LED.
- User memory area (approximately 4000 bytes in non-volatile memory)
- Speaker
- Uses two AA alkaline batteries for 30 hours of continuous operation using the Pointer and 60 hours of continuous operation when not using the Pointer.
- External Extension Connector.

The Wii Remote Power Button controls power on/off for the Wii console. SYNCHRO exchanges (or pairs) wireless ID numbers when pressed at the same time as SYNCHRO on the Wii console. Wireless communications are possible only with consoles which have been paired.

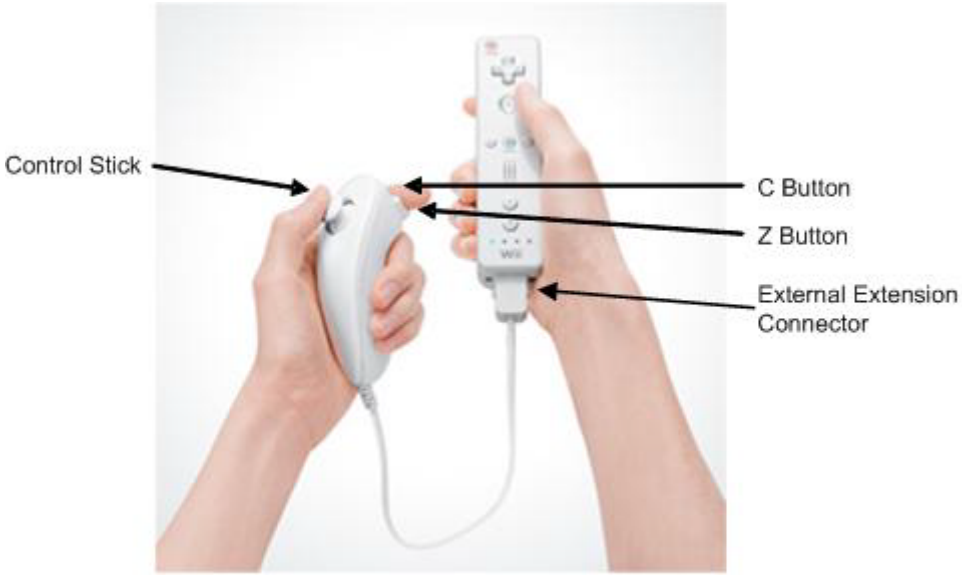


1.2 Nunchuk

The Nunchuk connects to the External Extension Connector of the Wii Remote. It is suitable for games with new operations. The features of the Nunchuk consist of the following:

- Control Stick (analog input).
- C Button, Z Button (digital input).
- Motion sensor (±2.1G).
- External Extension Connector (for plugging into the Wii Remote).

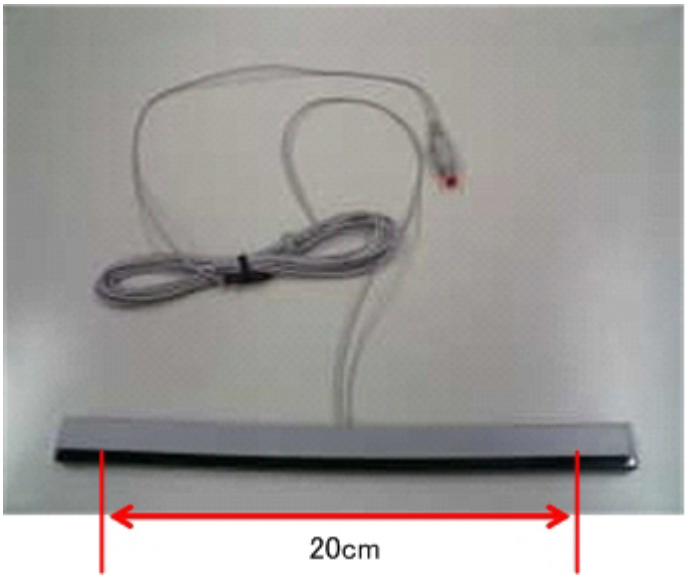
Figure 1-1 Wii Controllers



1.3 Sensor Bar

To use the Pointer, the Sensor Bar must be placed either above or below the television set. The Pointer measures the coordinates of the two ends of the Sensor Bar. The distance between both ends is 20 cm.

Figure 1-2 Sensor Bar



1.4 WPAD and KPAD Libraries

WPAD and KPAD are provided as Revolution SDK libraries. The WPAD library was developed for the purpose of obtaining values output by hardware as faithfully as possible. The KPAD library offers functions in which noise removal, clipping, and other features are pre-applied to make it easy for programmers to use. Both libraries can be used at the same time, but you should be aware that the motion sensor's XYZ coordinate axes used for the motion sensor in the two libraries do not match.

2 Wireless Feature

2.1 Normal Pairing and Simple Pairing

Communication between the Wii Remote and the Wii console is carried out using customized Bluetooth technology. This technology uses information stored in communication devices to authenticate those devices so as to allow communication only between authenticated devices.

Either a normal pairing process or a simple pairing process is required before a Wii console can communicate with a Wii Remote. Either of these pairing types can be established while an application is running.

2.1.1 Normal Pairing

If normal pairing has already been established between a Wii console and a Wii Remote, the paired status persists even if applications are switched.

If a Wii Remote pairs with another Wii console using normal pairing, the normal pairing information for the original Wii console will be deleted from the Wii Remote.

If a Wii Remote is paired using normal pairing, you can turn the paired Wii console's power on and off by pressing the power button on the Wii Remote.

If a Wii Remote is paired using normal pairing and the link is broken, you can connect to the Wii console that performed pairing by pressing any button on the Wii remote.

2.1.2 Simple Pairing

If a Wii Remote is paired with a Wii console with simple pairing, the simple pairing status persists only while the application that was in use when the simple pairing was performed continues to run.

Simple pairing status is terminated in either of two cases: the application that was running when the simple pairing was performed is reset or the power button on the Wii Remote that is paired by simple pairing is pressed.

It is not possible to turn the Wii console power off by pressing the power button on the Wii Remote if simple pairing is in effect.

2.1.3. Number of Machines and Pairing

Table 2-1 shows the limitations on machine information that can be stored on the Wii console and the Wii Remote. The information applies to both normal and simple pairing.

Table 2-1 Limitations on Storable Machine Information

Device	Normal Pairing	Simple Pairing
Wii console	10	6
Wii Remote	1	1

2.1.4. Wii Remotes Paired Using Normal and Simple Pairing

If a button is pressed on a Wii Remote whose link has been broken, the Wii Remote attempts to connect to the same Wii console that it had already been paired with. If the Wii Remote had been paired with Wii consoles using normal and simple pairing, respectively, it first attempts to connect to the last Wii console to which it had been connected. If that fails, it attempts to connect to the other Wii console.

2.1.5. Pairing Status of Production and Development Wii Remotes

Wii Remotes shipped with production Wii consoles have already been paired using normal pairing.

On the other hand, NDEV Version 2.1 and Wii Remotes shipped with NDEV Version 2.1 do not contain normal pairing information for each other. Therefore, the normal pairing operation must be executed. This is required whether or not the Wii Remote is wired or wireless.

The normal pairing procedure for NDEV Version 2.1 and the Wii Remote is as follows:

1. Run any of the demos contained in the Revolution SDK 2.1 WPAD or KPAD.
2. Press SYNCHRO located on the front of the NDEV Version 2.1.
3. Remove the battery cover from the Wii Remote (wired or wireless) and press SYNCHRO.
4. Normal pairing will complete in approximately 30 seconds.

Note: The Revolution SDK 2.1 WPAD library supports up to 10 devices. If 11 or more Wii Remotes are normal-paired to NDEV in the Revolution SDK 2.0 environment, press SYNCHRO for at least 10 seconds to delete all normal pairing information..

2.2 Procedure for Normal Pairing

To perform normal pairing, you must first set the Wii console to normal pairing status and the Wii Remote to normal pairing status. Normal pairing will fail if the Wii console is in simple pairing status and the Wii Remote is in normal pairing wait status, or if the Wii console is in normal pairing status and the Wii Remote is in simple pairing wait status.

2.2.1. Wii Console Normal Pairing

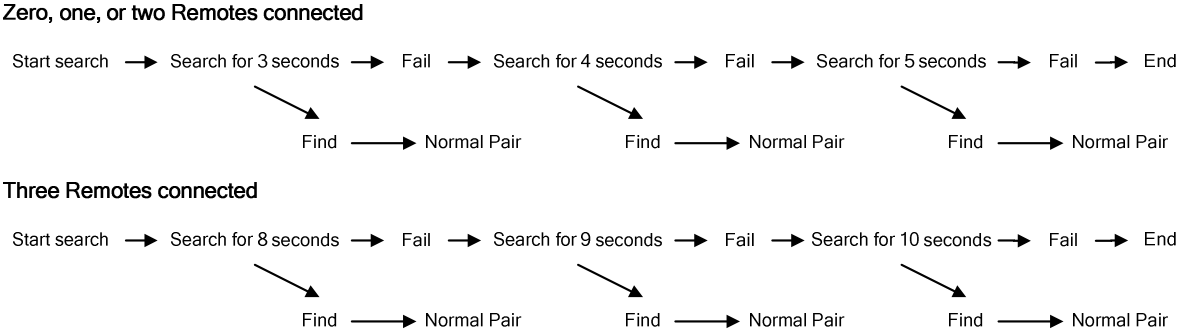
Note: The time required for normal pairing is tentative.

To set a Wii console to normal pairing status, press SYNCHRO on the front of the Wii console. When SYNCHRO on the Wii console is pressed, the Wii console begins searching for nearby Wii Remotes.

The length of time that the console searches depends on the number of Wii Remotes that are

communicating at that time. The Wii console stops searching when it finds a Bluetooth device. When it confirms that the Bluetooth device is a Wii Remote, it begins normal pairing. If normal pairing completes, searching also terminates.

If no Wii Remote, one Wii Remote, or two Wii Remotes are communicating with the Wii console, the console continues searching for 3, then 4, and then 5 seconds. If three Wii Remotes are communicating, it continues searching for 8, and then 9, and then 10 seconds. Searching terminates when no more Wii Remotes are waiting for normal pairing.



2.2.2. Wii Remote Normal Pairing

To set a Wii Remote to the normal pairing wait status, remove the battery cover and press SYNCHRO. This will put the Wii Remote in a state that is waiting for normal pairing and is searchable by a Wii console.

Status returns to unsearchable either when normal pairing completes or after approximately 20 seconds. When normal pairing completes, the Wii console stores information in a region used for normal pairing. If the entire region used for normal pairing is already in use, the new information overwrites the normal pairing information that has the oldest date for the last connection. A Wii Remote can establish a normal pairing with only one Wii console. Therefore, new normal pairing information overwrites old information. Note that pressing SYNCHRO during the pairing operation will cancel the operation and reset to normal pairing wait status.

2.3 Simple Pairing

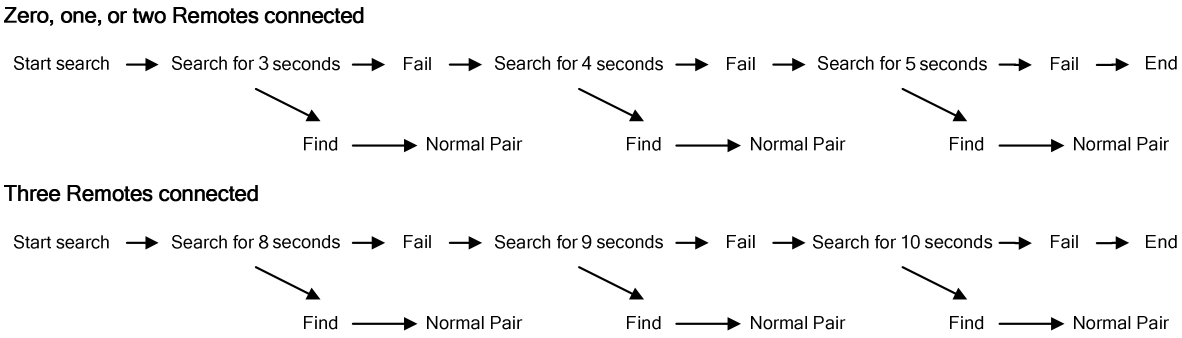
To perform simple pairing, you must first set the Wii console to simple pairing status and the Wii Remote to the simple pairing wait status. Simple pairing fails if the Wii console is in simple pairing status and the Wii Remote is in normal pairing wait status, or if the Wii console is in the normal pairing status and the Wii Remote is in simple pairing wait status.

2.3.1 Wii Console Simple Pairing

A Wii console can be set to the simple pairing status at any given time by an application. When the Wii console goes to the simple pairing status, it begins searching for nearby Wii Remotes. The Wii console stops searching when it finds a Bluetooth device. Once it confirms that the device is a Wii

Remote, it begins simple pairing.

If a function for stopping simple pairing is not called by an application during simple pairing, simple pairing status will continue to be maintained, even after simple pairing completes, If no Wii Remote, one Wii Remote, or two Wii Remotes are communicating with the Wii console, the console continues searching for 2, then 4, and then 5 seconds. If three Wii Remotes are communicating, it continues searching for 8, then 9, and then10 seconds.



2.3.2 Wii Remote Simple Pairing

To set an unlinked Wii Remote to the simple pairing wait status, press the 1 Button and the 2 Button at the same time. If the Wii Remote has been paired with a Wii console (normal or simple), it first attempts to link to the Wii console to which it was most recently paired. If the attempt fails, the Wii Remote will attempt to link to another Wii console with which it is also paired. If it fails to connect to any of the recently paired Wii consoles, the Wii Remote transitions to the simple pairing wait state, which can be searched from a Wii console. The state goes to unsearchable either when simple pairing completes or after approximately 20 seconds. Note that although simultaneously pressing the 1 and 2 Buttons during a pairing operation will not cancel it, pressing SYNCHRO will cancel the operation and cause a transition to normal pair wait status.

2.4 Setting Automatic Disconnect After No Wii Remote Input

To avoid unnecessary battery power consumption, the Wii Remote link is automatically cut if there is no Wii Remote input for a certain period of time. Initially, the time is set to 5 minutes. However, this can be changed with the `WPADSetAutoSleepTime` function

2.5 Automatic Reset for Abnormal Disconnects

If a link is terminated due to causes such as radio wave interference, the Wii Remote attempts to restore the link for about 10-20 seconds. During this time, the Wii Remote does not accept button input, and nothing will be displayed on the Player LED.

2.6 Wii Remote Status

The Wii Remote is always in one of five states.

- Disconnected
- Communicating
- Establishing Connection
- Waiting for Normal Pairing
- Waiting for Simple Pairing

Of these, the Wii console can search only on waiting for normal pairing or waiting for simple pairing.

Although other internal states do exist in the firmware and library, the user needs to know only these five. Of these, the Wii console can only search on waiting for normal pairing or waiting for simple pairing.

2.6.1 Disconnected

Nearly all functions of the Wii Remote are turned off in the Disconnected state. The sole operation performed is to await button input to the Wii Remote. The Wii Remote will change states as follows when one of its buttons is pushed.

- Pressing the SYNC button results in “Waiting for Normal Pairing”.
- Pressing the 1 and 2 Buttons at the same time results in “Establishing Connection”. However, if communication with a Wii console is impossible, this action results in “Waiting for Simple Pairing”.
- Pressing the Power Button on the Wii Remote powers on the Wii console and results in “Disconnected”.
- Pressing any other button results in “Establishing Connection”.
- Pressing a button on an External Extension Controller, such as a Nunchuk, does not change the state from “Disconnected.”

Note: At the moment the batteries are inserted, the Wii Remote is initialized for one second, after which it moves to the Disconnected state.

2.6.2 Communicating

The Wii Remote can be used by a game after it completes its connection to the Wii console. In this state, nearly all functions can be controlled by the Wii console. The state transition from Communicating status is as follows.

If `WPADDisconnect` is executed by an application, “Disconnected” results.

If `WPADDisconnect` automatically executes because the library detects that there has been no Wii Remote input for a specified period of time, “Disconnected” results.

If the batteries deplete, “Disconnected” results.

If there is no wireless signal is received for two seconds, “Disconnected” results.

If the Power Button on the Wii Remote is held down for approximately one second, the Wii console’s

power goes off and “Disconnected” results.

If SYNC is pressed, communications are stopped and “Waiting for normal pairing” results.

2.6.3 Establishing Connection

In this state, the Wii Remote attempts to establish communications with a Wii console. Pairing information must already be recorded for both pieces of hardware in order to establish a connection. The state transition from Establishing Connection is as follows.

- If connection with the Wii console is established, “Communicating” results.
- If the 1 and 2 Buttons are pressed at the same time to enter this state, and communication with the Wii console fails, “Waiting for Simple Pairing" results.
- If this state is entered while pressing any other button and communication with the Wii console fails, “Disconnected” results.
- If the batteries are depleted, “Disconnected” results.

2.6.4 Waiting for Normal Pairing

If the Wii console is in a state that allows pairing information to be recorded, both the Wii console and the Wii Remote record normal pairing information.

To save normal pairing information on the Wii console, use one of the following methods to put the Wii Remote into the Waiting for Normal Pairing state:

- Press SYNC on the Wii console (NDEV Console)
- Execute `WPADStartSyncDevice` from an application.

Transitions from the Waiting for Normal Pairing state are as follows:

- If normal pairing completes, “Communicating” results.
- If normal pairing fails, “Disconnected” results.
- If the batteries die, “Disconnected” results.

2.6.5 Waiting for Simple Pairing

If the Wii Console is in a state that allows simple pairing information to be recorded, both the Wii Console and Wii Remote record simple pairing information. To save simple pairing information, use the following method to put the Wii Remote into the Waiting for Simple Pairing state.

- Execute the `WPADStartSimpleSync` function

Transitions from the Waiting for Simple Pairing state are:

- If simple pairing completes, “Communicating” results.
- If simple pairing fails, “Disconnected” results.
- If the batteries die, “Disconnected” results.

2.7 Wii Remote Status and the Player LED

The Player LED indicates the following information responsive to Wii Remote status:

LED	Wii Remote Status	Description
Off	Battery dead Disconnected Auto reconnecting after an abnormal disconnect	*None*
One of the LEDs (1-4) is on	Communicating (normal or simple pairing)	The assigned player number
From one to four LEDs are blinking (from the left)	Establishing connection Waiting for normal pairing Waiting for simple pairing	More LEDs indicate more battery reserve.

2.8 Operations with a Wii Console and Remote That Are Already Paired

When simple pairing is attempted for a Wii console and a Wii Remote that are already normally paired, the normal pairing remains in effect. This is because a Wii Remote always connects to a normally paired console before the Wii Remote moves to the Wait for Simple Pairing state.

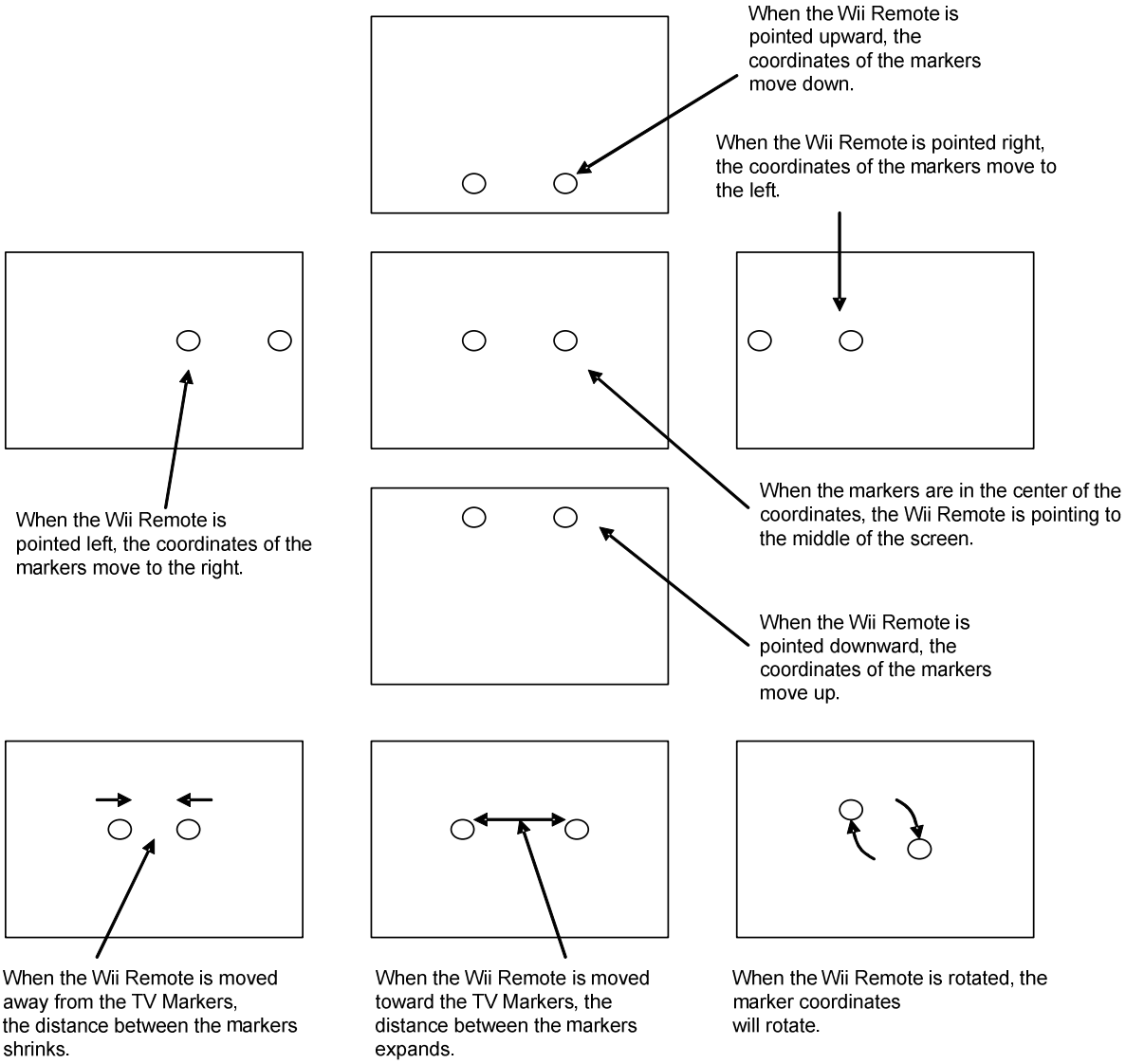
When normal pairing is attempted for a Wii console and a Wii Remote that are already simply paired, those devices shift to normal pairing. This is because normal pairing takes priority over simple pairing after the normal pairing completes for a Wii console and a Wii Remote.

3 How to Use the Pointer

3.1 Principles of Pointer Operation

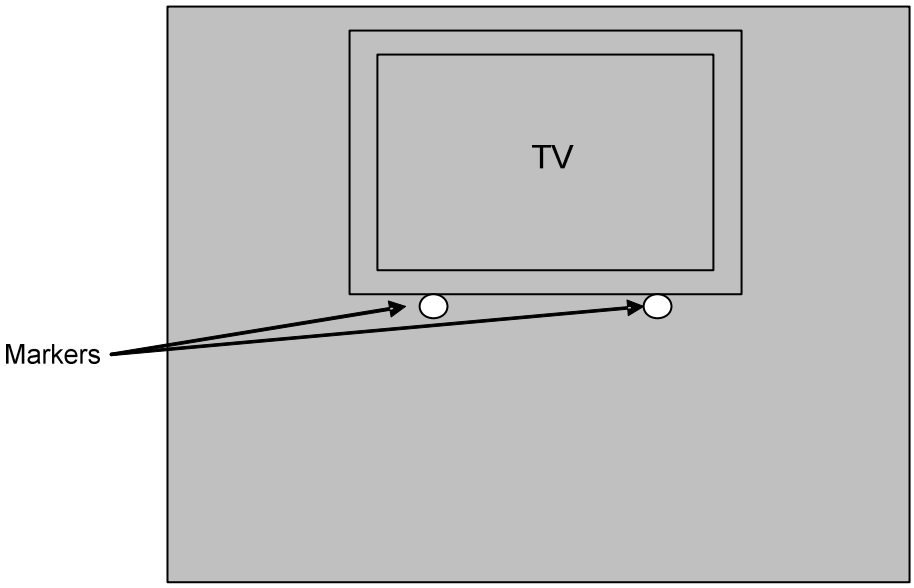
The Pointer measures the coordinates of the Sensor Bar, which is placed on the top or bottom of the television. By knowing the coordinates of the Sensor Bar, the Pointer can compute the coordinates pointed to by the Wii Remote, its rotation, and its distance.

The Pointer points to coordinates between the two points on the Sensor Bar. The Pointer coordinates are 0–1,023 on the X axis and 0–767 on the Y axis.



3.2 Range of Pointer Measurement

The Pointer can measure coordinates within the bounds of a rectangle centered on the Sensor Bar. Therefore, it can also measure points outside the television screen (see the following figure).



The Pointer also responds to strong light sources other than the Sensor Bar. Therefore, it may respond to light from windows, fluorescent lamps, halogen lamps, fireplaces/heaters, shiny tabletops, mirrors, plastic, and so forth. The Sensor Bar coordinates must be identified while eliminating these noise sources. The Pointer can measure up to four coordinates using internal calculation. The two markers on the sensor bar must be identified from the measured coordinates.

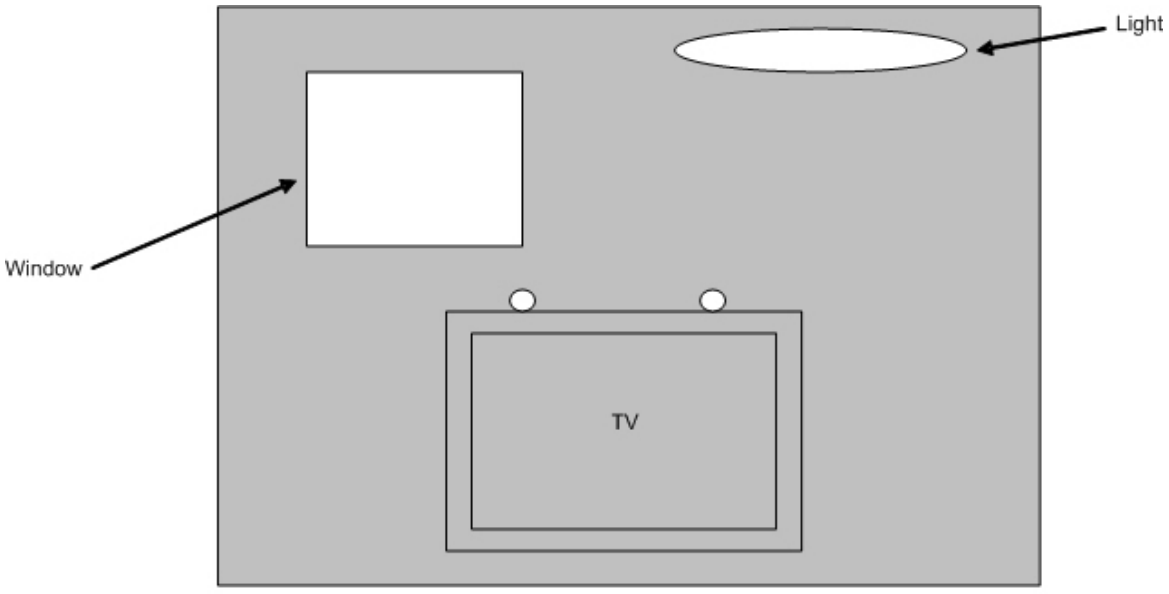
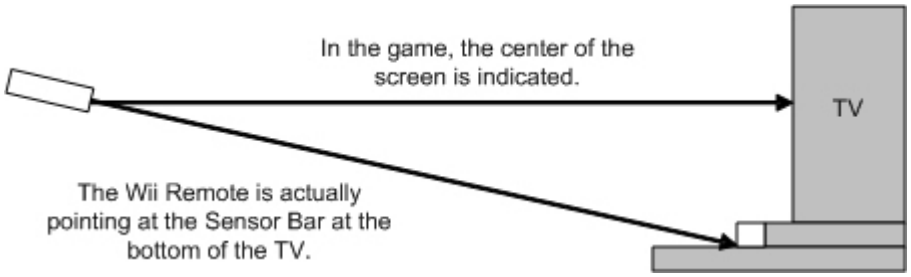


Image as seen from the Pointer
The coordinates of the Sensor Bar, the window,
and the illumination are computed from this image.

3.3 Items to Note When Using the Pointer

When the Pointer is pointing toward the Sensor Bar, it is not actually pointing at the center of the TV screen, but the program can treat this situation as if the sensor were pointing at the center of the TV screen, as shown in the following diagram. In this case, the actual coordinates and the program coordinates will differ, but when the users are a fair distance from the TV, their brain automatically corrects for the difference between the coordinates seen by the eye and the coordinates for hand movements. However, it is easier for the user to understand when the coordinates pointed to by the Pointer are displayed on the television screen.



More precise coordinate calculations can be made by knowing the size and aspect ratio (4:3 or 16:9) of the television, but there should be few operational problems even without knowing them. The human brain automatically corrects to match the coordinates and hand movements.

Precise measurement results when using the Pointer can be obtained by using a ring buffer (circular buffer) and taking the average value of several data samples. This method can also be used to reduce the effect of unsteady hands.

The KPAD library can be used to eliminate noise other than the sensor bar.

We recommend that you use the KPAD library unless you have a particular reason for not doing so.

4 How to Use the Motion Sensor

4.1 Principles of Motion Sensor Operation

The Motion Sensor measures acceleration along three axes, making it possible to detect human motion. The Wii Remote can measure in the range of +-3.4G. The Nunchuk can measure in the range of +-2.1G.

Since gravity is a type of acceleration, even when the controller is in its normal resting position, acceleration is always being applied somewhere along the three axes. By calculating this acceleration, the Wii Remote's orientation relative to gravity can be determined.

Because the game player's hand will shake while holding the Wii Remote, a precise direction can be obtained by creating a ring buffer to hold and average several acceleration samples. If 16 or more samples are averaged, hand shaking is virtually undetectable, but tracking is poorer.

Because the sensitivity of the controller movement becomes poorer when a large number of samples are used for averaging, Whether to emphasize sensitivity or the elimination of minor hand movements will depend on the application. Programmers must be careful when deciding how many samples to obtain.

Shaking the Wii Remote applies acceleration. These movements can cause momentary accelerations of 1G to 3.4Gs. Since strong accelerations can occur momentarily, obtaining a momentary value is more important than taking the average of several values.

Swinging the Wii Remote in a circular motion applies a centrifugal force. Centrifugal forces are extremely large. The end of the Wii Remote can experience a force of 3.4G and continue to output values that exceed 3.4G for a fairly long time. The time that the value exceeds 3.4G is equal to the time that the controller is being waved in a circle.

(Note that the X, Y, Z axes are different in the WPAD and KPAD libraries.)

4.2 Values output by the Motion Sensor

The diagram shows what type of values are output. Note that these are based on the WPAD library axes and therefore are offset from the KPAD library.

When the Wii Remote is placed in a horizontal position:

X: Gravity: 0G Value: 0

Y: Gravity: 0G Value: 0

Z: Gravity: 1G Value: 102

When the Wii Remote is pointed upward:

X: Gravity: 0G Value: 0

Y: Gravity: -1G Value: -102

Z: Gravity: 0G Value: 0

When the Wii Remote is turned 90 degrees to the right:

X: Gravity: 1G Value: 102

Y: Gravity: 0G Value: 0

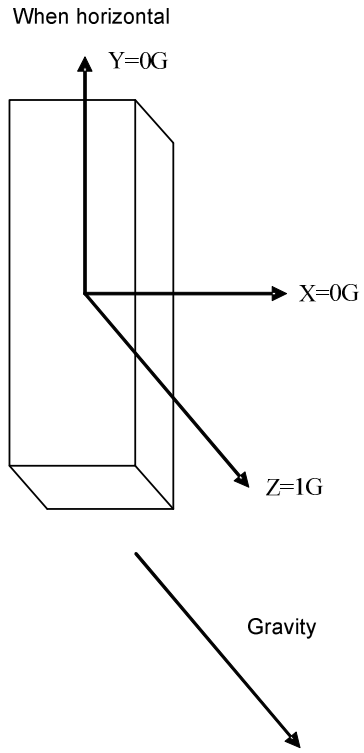
Z: Gravity: 0G Value: 0

When the Wii Remote is dropped (zero-gravity state):

X: Gravity: 0G Value: 0

Y: Gravity: 0G Value: 0

Z: Gravity: 0G Value: 0



4.3 Motion Sensor Specification

Table 4-1 Wii Remote Motion Sensor Specification

Measurement range	±3.4G	
Sensitivity	102 *Value*/G	*Value* is proportional to gravity.
0G error	0G level offset error margin	0 ±102
Sensitivity error	Sensitivity error margin	102±10% (92 *Value*/G to 112 *Value*/G)

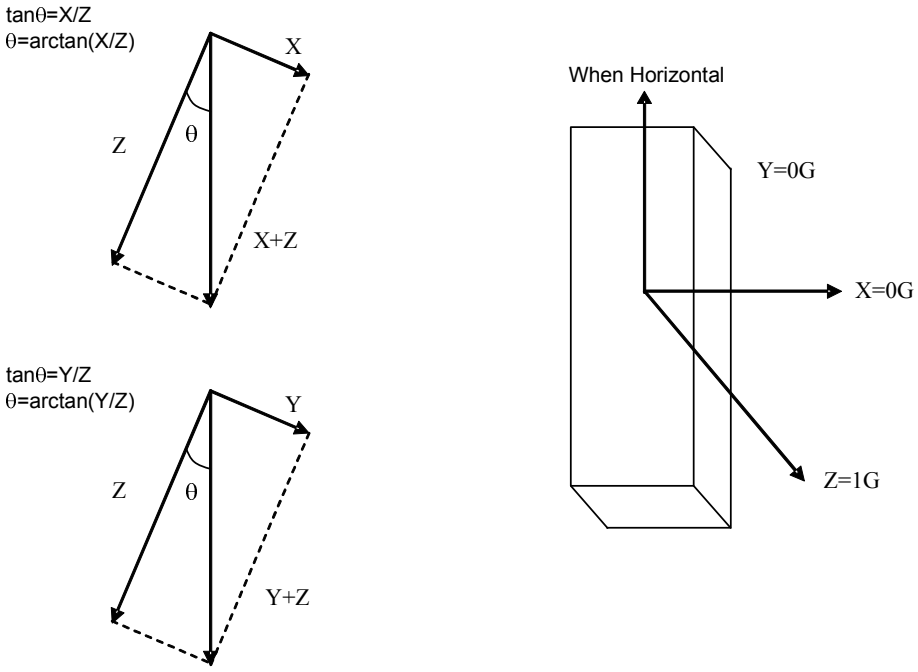
Table 4-2 Nunchuk Motion Sensor Specification

Measurement range	±2.1G	
Sensitivity	204 *Value*/G	*Value* is proportional to gravity.
0G error	0G level offset error margin	0 ±32
Sensitivity error	Sensitivity error margin	204±10% (184 *Value*/G to 224 *Value*/G)

4.4 Using the Motion Sensor to Measure Twist (Rotation)

You can measure the tilt of the Wii Remote by moving it slowly. However, if you move it quickly, accurate tilt measurement will not be possible due to the influence of acceleration.

When positioned as shown in the diagram, the rotation in the X-Z and Y-Z planes can be calculated with the following formulas.



Because gravity has no effect on the X-Y plane, it is impossible to calculate gravity and the rotation based in the vertical direction. Accordingly, it is difficult to obtain absolute coordinates in the X-Y plane from the Motion Sensor.

5 How to Use the Rumble Motor

- The Rumble Motor can only be controlled to turn on and off.
- The intensity of vibration of the Rumble Motor can be changed by turning it on and off at high speed.
- However, it cannot be turned on/off more than 100 times per second due to wireless specifications.

6 How to Use the Speaker

The Wii Remote's speaker can be used. Use the AX (AX applications), WENC, WPAD libraries to play sound from the Wii Remote speaker.

Library roles are shown below.

- The AX library synthesizes sound for the Wii Remote speaker in the same way that normal sound is played.
- The WENC library encodes data synthesized by the AX library for use by the Wii Remote speaker.
- The WPAD library controls the Wii Remote speaker, and sends data encoded by the WENC library to the Wii Remote.

Wii Remote speaker volume can be adjusted in the following two ways.

- The hardware volume set in the Wii Remote.
- The AX library volume

Hardware volume is stored in the Wii console, and is applied equally to all Wii Remotes. Hardware volume is changed by the console's setup menu, and stored in the Wii console. The library loads the hardware volume that is stored in the Wii console and applies it to Wii Remotes. There is no need for applications to take hardware volume into consideration. Applications should use the volume in the AX library to control Wii Remote speaker volume.

7 Wii Remote Memory

The memory that is incorporated in the Wii Remote provides slightly less than 4000 bytes of area for storing data. This area can only store data for one application, which will be overwritten by data from another application. The stored data can only be read by the application that created it.

Also, if an External Extension Controller is connected or disconnected while memory is being accessed, there is a danger that data may be corrupted. Therefore please note the following.

- Be careful concerning data corruption when using Wii Remote memory.
- When using data in Wii Remote memory always use one of the following error check mechanisms
  - Duplicate data and check for errors (recommended)
  - Use an error correction mechanism capable of recovery, even if 8 contiguous bytes are lost. (Currently there is no plan to provide this mechanism in the SDK.)
- When writing to Wii Remote memory, display a message such as “Do not connect or disconnect an extension controller" so that the user does not connect or disconnect an extension controller.
- Always verify after writing data to a Wii Remote. If an error occurs during verification, attempt writing up to three more times.
- If an error occurs while data is being loaded from Wii Remote memory, either try reading up to three more times, or add an error correction process.
- Make the application so that it will function normally, even if data in Wii Remote memory is corrupted.

8 Batteries

8.1 Compatible Batteries

The following batteries are compatible with the Wii Remote

Type	For Users	For Developers
Manganese Batteries	Prohibited	Can use if cautions printed on batteries are observed
Alkaline Batteries	Compatible	Compatible
Nickel-metal hydride batteries	Prohibited	Can use if cautions printed on batteries are observed
Oxyride™ batteries	Prohibited	Can use if cautions printed on batteries are observed

8.2 Remaining Battery Capacity and Behavior

Wii Remote behavior (such as pointer and acceleration sensor) is not influenced by remaining battery capacity

When remaining capacity is gone, the Wii Remote will suddenly terminate the link.

8.3 Remaining Battery Capacity

A number of methods are provided for determining remaining battery capacity.

- Press any button while the Wii Remote is in the Disconnect state. When the remote attains either establishing connection, normal pair wait, or simple pair wait status the number of blinking LEDs will indicate remaining battery capacity.
- While playing a game, pressing HOME will inform the game and the user of the remaining battery capacity. This value is linked to the number of blinking Player LEDs (four levels).
- Game software can use `WPADGetInfo` to determine remaining battery capacity. However, there is a restriction. Executing this command during sound play causes noise. When using `WPADGetInfo`, first stop sound. Do not use this function every frame, because if you do so, pointer and other normal data will be blocked, interfering with normal operations. Normally it is sufficient to use this every several seconds or several minutes. Values obtained by `WPADGetInfo` are also related to the number of blinking Player LEDs, and are in four levels.

8.4 When Remaining Battery Capacity Becomes Low

When the value obtained by `WPADGetInfo` is WPAD_BATTERY_LEVEL_LOW, there is little remaining battery capacity. However, remaining operation time will vary according to the type of

battery. Additional variences may be caused by individual differences in Wii Remotes and batteries, the type of battery, and by speaker and pointer usage. The following table contains sample values measured during development using each type of battery.

Table 8-1 Remaining Battery Capacity after WPAD_BATTERY_LEVEL_LOW

Battery Type	Minimum	Typical	Maximum
Eneloop	21 minutes	84 minutes	474 minutes
Alkaline	238 minutes	389 minutes	672 minutes

8.5 Processing When the Battery Has Been Depleted

In highly active games and the like, it is possible that sudden depletion of the battery will hinder the game. The following method is an example of a good way to allow the game to continue. Check for depleted battery status (the link with the controller is terminated), pause the game, display a message prompting the player to change the battery, and release the pause as soon as the link is reestablished (any button is pressed after the battery is changed).

9 Types of Development Controllers

Table 9-1 contains a simple list of the types of development controllers.

Table 9-1 Development Controller Types

Name	Compatible Dev Machine	Color	Supplemental
Dev Tool Version 3, 3.1	GDEV	Gray	Connect to GDEV controller port
Dev Tool WB	GDEV	Gray or White	Wireless connection to GDEV
Dev Tool Version 4	NDEV 2.00	Black	Wired connection to NDEV
Dev Tool Version 4 Wireless	NDEV 2.01	Black	Wireless connection to NDEV
Dev Tool RD3 Wired	NDEV 2.1	White	Wired connection to NDEV
Dev Tool RD3 Wireless	NDEV 2.1	White	Wireless connection to NDEV
Production Version	From NDEV 2.1	White	

10 Added and Changed Functions

For details, please refer to the function reference manuals for each library.

- Get total capacity of work memory

  Added functions that get the total area of work memory allocated when the library is initialized.
- Get signal sensitivity

  Added functions that get signal sensitivity.
- Speakers

  Added functions used to utilize the Wii Remote speaker.
- Changed Rumble Feature settings

  Added functions for changing on/off for the Wii Remote Rumble Feature.
- Time settings for Wii Remote automatic disconnect

  Added functions that set a time of allowable Wii Remote inactivity, after which it will automatically disconnect.
- Acquiring Sensor Bar position

  Added functions that obtain the controller's relationship to the Sensor Bar.
- Simple Pairing Feature

  Added functions for using the simple pairing feature.
- Storing settings for the Rumble Feature and for Speaker volume

  Whether the Rumble Feature is on or off, and Wii Remote speaker volume is stored in the Wii console. The application need not take either into consideration.
- Clamp changes and additions

  We changed the clamp values for the Nunchuk and for the analog input stick on the Classic Controller.

  Also, when the KPAD library is used, acceleration values are automatically clamped. We changed the clamp for the Wii Remote Motion Sensor to +-3.4G and the Nunchuk Motion Sensor to +-2.1G.
- Access to the Wii Remote memory

  Added functions for accessing the Wii Remote memory.
- Access to application data stored in the Wii Remote memory

  Added functions for accessing application data stored in the Wii Remote memory.

11 Wii Remote RD3 vs. Production Differences

11.1 Identifying Wii Remote RD3 and Production Versions

The number Z84M501 (for example):

- Is engraved in housing next to SYNCHRO
- 1st character Z 2006, A 2007, B 2008
- 2nd character 1, January, 2 February, 9 September, O October, N November, D December
- 3rd character 1 first, 2 second, 9 ninth, A 10th, B 11th, through Y 31st.

The production model begins August 14, so any number after Z8E will indicate a production version.

11.2 Difference Between Wii Remote RD3 and the Production Version

- Changed the wait time for normal pairing and simple pairing.

  In versions through RD3 wait time is one minute; in the production model it is 20 seconds.
- Changed the Player LED display for remaining battery capacity

  In versions through RD3, for Nickel-metal hydride batteries, only 2 or 3 would turn on, even when the battery was fully charged.

  In the production model 4 will turn on.
- Changed the lower limit for the remaining battery capacity.

  Compared to RD3, the production model cuts off the battery when there is some more remaining battery capacity.

  Although this does decrease battery life by about 4%, it improves safety with respect to leakage.
- Adjusted Motion Sensor noise and delay

  Dev Tool Version 3

  Although there is a 5.5 msec delay, it is not prone to influence from inertia or noise.

  Dev Tool Version 4 and RD3

  Although there is only a 1.6msec delay, it is prone to influence from inertia or noise.

  Production Model

  Delay time is 3.5msec. About midway between Version 3 and Version 4 / RD3

  Nunchuk production version is the same as previous ones.

  Although there is a 5.5msec delay, it is not prone to influence from inertia or noise.
- Revised issue in which there was Motion Sensor blur when the battery voltage was high.

  When using alkaline or Oxyride batteries, Motion Sensor values became blurred when remaining battery capacity was high. This has been resolved.

12 Issues Resolved in Development Tool RD3

12.1 Resolved Issues

On rare occasions, strongly shaking Version 4 of the Wii Remote Development tool disabled communications. This has been resolved with the RD3 Wii Remote.

The controller locked on Busy status when hot plug-in/removal of an External Extension Controller was done quickly and repeatedly. This has been resolved.

An exception was thrown when WPADControlMotor() was called from within a callback function that was called by the WPAD library. This has been resolved.

Pointer start timing sometimes caused the sampling rate to halve. This has been resolved.

The production version's sensor bar optical capacity is about 25% greater than that of NDEV 2.0x.

12.2 Planned Revisions

- Connection between Wii Remote and NDEV breaks unexpectedly.
- When using the Wii Remote, WPAD stops unexpectedly.
- Other minor bugs.

13 Planned Changes

The number of blinking Player LEDs now changes according to alkaline battery voltage. In the production version of the Wii Remote four LEDs will blink when the Nickel Metal Hydride batteries are fully charged. (Compared to RD3)

The influence of inertia and noise in the production version of the Motion Sensor will be decreased.

Revise pointer values using data that indicates whether the sensor bar is placed above or below the TV. (Will be able to use this when SDK 2.1 and console settings are both supported.)

Wii Remote Pointer offset from the production version will be fixed in a future SDK.

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