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# BLUETOOTH 3D SYNCHRONIZATION PROFILE

**Abstract:**

This specification provides a means for a 3D display to support one or more 3D glasses using Bluetooth technology, including mechanisms for 3D glasses to discover and associate with a 3D display, synchronization with a timing signal from the 3D display, and the format of messages between the 3D display and the 3D glasses.

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## Revision History

| Revision | Date(yy-mm-dd) | Comments |
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| V0.5 | 12-06-29 | Release to Associates |
| V0.7 | 12-09-06 | Release to Associates |
| D09r00 | 12-09-13 | Initial version |
| D09r01 | 12-10-03 | Added several clarifications suggested by the Working Group. |
| D09r02 | 12-11-07 | Added definitions, clarified Dual View Mode, and updated Profile Dependencies. |
| D09r03 | 12-11-20 | Updated the Legacy Association Notification, Core Specification Dependencies, and Reference Protocol Appendix sections. Moved the 3D Information EIR Data format section to a separate Core Spec Supplement Change Request. |
| D09r04 | 12-11-28 | Added back the 3D Information EIR Data section and corrected section references. |
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## Document Terminology

The Bluetooth SIG has adopted Section 13.1 of the IEEE Standards Style Manual, which dictates use of the words "shall", "should", "may", and "can" in the development of documentation, as follows:

- The word *shall* is used to indicate mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*).

- The use of the word *must* is deprecated and shall not be used when stating mandatory requirements; *must* is used only to describe unavoidable situations.

- The use of the word *will* is deprecated and shall not be used when stating mandatory requirements; *will* is only used in statements of fact.

- The word *should* is used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain course of action is deprecated but not prohibited (*should* equals *is recommended that*).

- The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted*).

- The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

# Table of Contents

# 1  Introduction

## 1.1  Scope

The 3D Synchronization Profile specifies the synchronization behavior of a Bluetooth 3D system consisting of a single 3D display and one or more pairs of 3D glasses that associate and synchronize with the 3D display. The user's stereoscopic 3D experience is delivered by showing different images to the left and right eyes. The 3D glasses use shutter synchronization information transmitted from the 3D display to control the shutters such that the left image is shown only to the left eye and the right image is shown only to the right eye, when 3D content is being displayed.

## 1.2  Conformance

If conformance to this Profile is claimed, all capabilities indicated as mandatory for this Profile shall be supported in the specified manner (process-mandatory). This also applies for all optional and conditional capabilities for which support is indicated. All mandatory capabilities, and optional and conditional capabilities for which support is indicated, are subject to verification as part of the Bluetooth Qualification Program.

## 1.3  Symbols, Conventions, and Definitions

The following nomenclature and abbreviations are used in this document:

- 3DD – Bluetooth 3D Display
- 3DG – Bluetooth 3D Glasses
- Bluetooth 3D Display – a display device implementing the Bluetooth 3D Synchronization Profile that is capable of signaling to Bluetooth 3D Glasses a sequence of two temporally-separated image streams that can be directed to left and right eyes to simulate a 3D stereoscopic viewing experience or optionally directed to both eyes for two different groups of viewers allowing each group to see a different 2D image stream on the same display.
- Bluetooth 3D Glasses – a pair of lens shutter glasses implementing the Bluetooth 3D Synchronization Profile that is capable of optically de-multiplexing the temporally-interleaved image streams of a Bluetooth 3D Display and either directing the image streams to left and right eyes to simulate a 3D stereoscopic viewing experience or, if optionally implemented, allowing one 2D image stream to be viewed by both eyes while the other 2D image stream is blocked.

- Frame Sync – signal used in 3D displays for video frame display timing synchronization alignment, where a frame is defined as a complete set of corresponding right and left images1.
- Legacy 3DD – a 3D display implementing the Reference Protocol defined in section 12.
- Legacy 3DG – a pair of 3D glasses implementing the Reference Protocol defined in section 12.
- Synchronization – the act by a 3DG of receiving timing information from the 3DD to adjust the shuttering of the left and right lens shutters in time with the display of a sequence of two temporally-separated image streams on the 3DD.

## 1.4  Profile Dependencies

This profile has three sub-functions. The mandatory Association function uses the General Inquiry Procedure of GAP. The mandatory 3D Broadcast function uses the Core Connectionless Slave Broadcast Feature in the Controller. The optional 3D Communications Channel uses L2CAP. Additional details on Bluetooth Core Specification [1] dependencies are described in section 10.
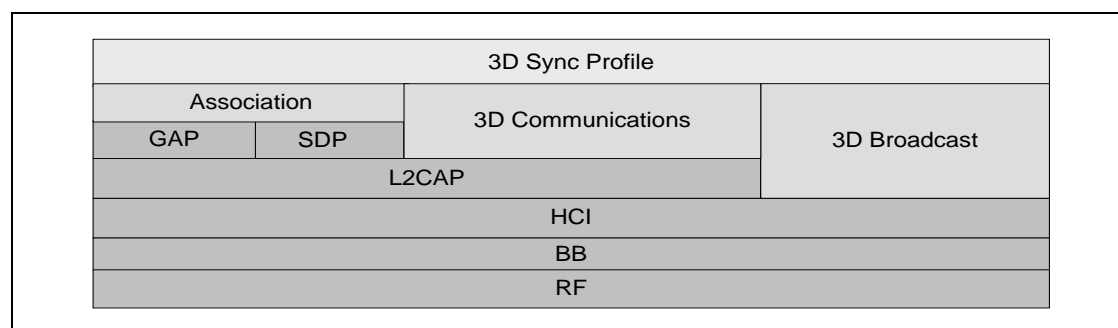


*Figure 1.1: 3D Synchronization Profile – Layers*

## 1.5  Bluetooth Specification Release Compatibility

This profile is compatible with Core Specification Addendum 4 combined with the Bluetooth Core Specification Version 3.0 + HS or the Bluetooth Core Specification 4.0.

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[1] In Dual View mode (see section 2.5) a frame is a full set of corresponding images from two distinct 2D image streams being viewed simultaneously.

# 2 Profile Overview

## 2.1 Profile Operation

The 3D Synchronization Profile supports the operation of a Bluetooth 3D System consisting of a single 3D display (3DD) and one or more 3D glasses (3DG) as shown in Figure 2.1.
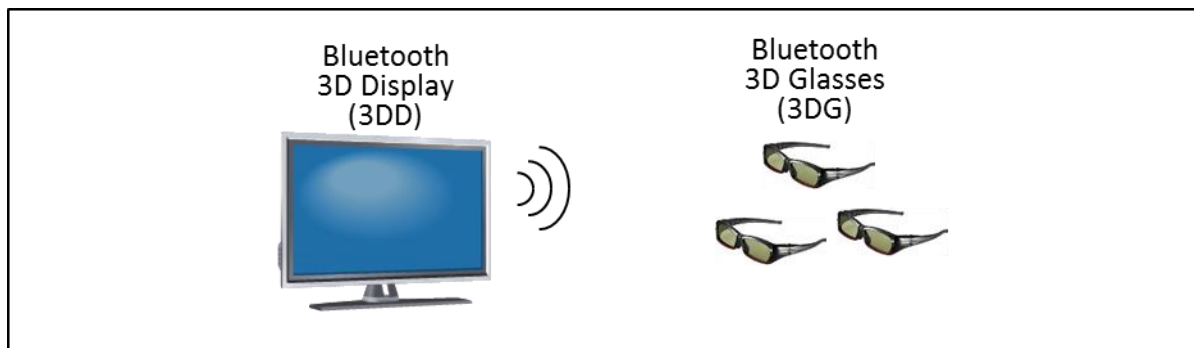


*Figure 2.1: Bluetooth 3D System*

The Bluetooth 3D Synchronization Profile operates as follows.

- The 3DG selects a 3DD on which to view 3D content through Proximity Association.

- The 3DG optionally uses the 3D Communications Channel to send Association Notification and/or its Battery Level information to the 3DD via a 3DG Connection Announcement message.

- The 3DD time stamps occurrences of its image display Frame Sync using its native Bluetooth clock. The 3DD also measures average Frame Sync period in units of 1/256 of a microsecond

- Consistent with the Bluetooth piconet definition, the 3DG's Bluetooth clock is synchronized with the 3DD's native Bluetooth clock.

- The 3DD broadcasts to the 3DG via a 3D Broadcast Message the relationship of Frame Sync timing to the 3DD's native Bluetooth clock, the frame periods, and the lens shutter control offsets relative to the Frame Sync. All timing uses the 3DD's native Bluetooth clock as the timing reference.

- The 3DD also provides periodic broadcast instants to the 3DG allowing the 3DG to limit reception to these periods.

- The 3DG receives timing information from the 3D Broadcast Message and uses this information to control the left and right lens shutters in synchronization with the 3DD left and right eye display images. If the 3DG loses reception of the 3D Broadcast the 3DG continues synchronized lens shutter operation while its lens shutter control timing error is within an acceptable range. Once lens shutter control timing error exceeds this threshold, the 3DG opens both lens shutters.

## 2.2 Profile Roles

This profile defines two roles:

- The 3DD displays the images in a 3D system. In addition to displaying the images, it performs the following additional functions:

  – represents the Frame Sync timing in terms of its native Bluetooth clock (the 3DD native Bluetooth clock serves as the reference time for all 3DGs that are synchronized to its 3D Broadcast);

  – broadcasts the Frame Sync timing, frame periods, and lens shutter control timing information in the 3D Broadcast Message;

  – is discoverable and identifiable by and synchronizable with the 3DG as a display source of 3D content; and

  – may be connectable to receive 3D Communications Channel information from the 3DG.

- The 3DG synchronizes with the sequential left eye/right eye image streams, displaying the left image to the left eye and right image to the right eye. In this profile, the 3DG performs the following additional functions:

  – discovers and synchronizes with a 3DD to associate with (Proximity Association);

  – optionally informs the associated 3DD of such association over the 3D Communications Channel (Association Notification) or via Legacy Association Notification;

  – optionally informs the associated 3DD of the 3DG battery level over the 3D Communications Channel (Battery Level Reporting);

  – receives and decodes timing information contained in the 3D Broadcast Message from the 3DD; and

  – uses timing information from the 3D Broadcast Message to control the left and right eye lens shutters.

## 2.3 System Block Diagram
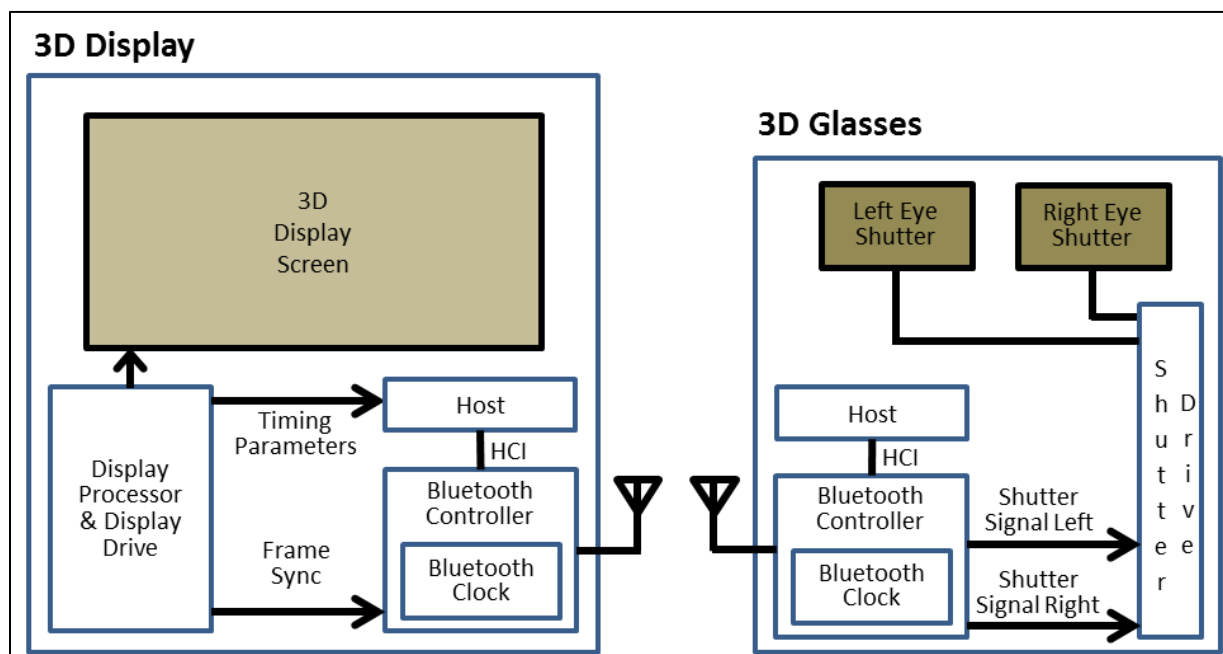


*Figure 2.2: Bluetooth 3D Synchronization Profile System Diagram*

## 2.4 System Timing

The 3DD sequentially presents two distinct images, one for the left eye and one for the right eye, separated in time. The 3DD broadcasts timing information related to its native Bluetooth clock as follows:

- the Frame Sync Instant, transmitted in units of the 3DD native Bluetooth clock (this may correspond to the rising edge of a Frame Sync signal);
- the frame period, transmitted in units of 1/256 microseconds; and
- the left and right image display timings, transmitted as time offsets to the Frame Sync Instant.

Each 3DG, worn by the viewer, synchronizes with the 3DD and only allows light to pass through the viewer's left or right eye when the corresponding image is being displayed.

Figure 2.3 provides a sample timeline of the above operations. Note: This is a simplified figure; actual implementations will vary in timing, may have black screen periods when no image is displayed, etc. Such details are outside the scope of this document.
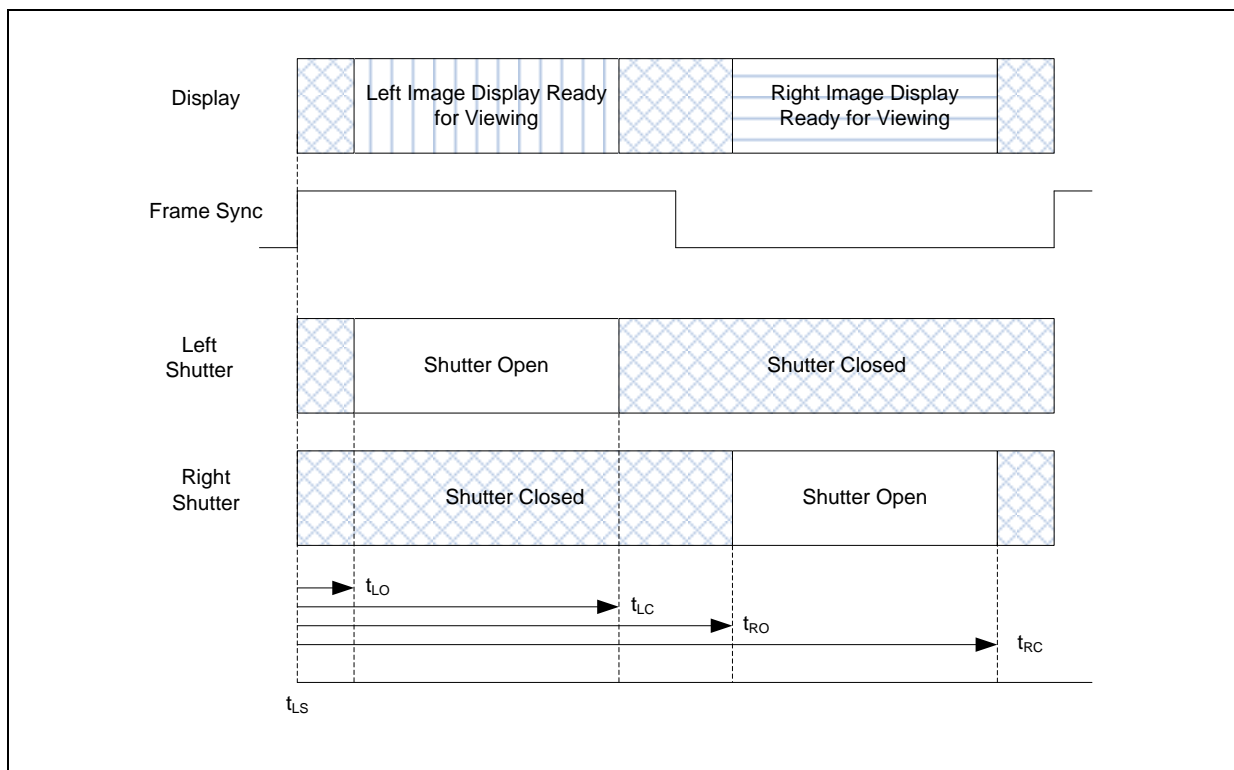
*Figure 2.3: 3D System Timing*

- $t_{LS}$ – 3DD starts displaying the left image
- $t_{LO}$ – the left lens shutter opens
- $t_{LC}$ – the left lens shutter closes
- $t_{RO}$ – the right lens shutter opens
- $t_{RC}$ – the right lens shutter closes

## 2.5  Dual View Mode

Instead of displaying two image streams intended for the left and right eyes, the 3DD can display two distinct 2D image streams to two different 3DGs or two different sets of 3DGs. Possible uses of such a method include the following examples.

- Two people (or groups) watching two different shows on the same 3DD.
- Two people playing a video game with each player having a different 2D view of the game world.

The lens shutter offset parameters transmitted by the 3DD are interpreted by the 3DG in Dual View mode as shown in Figure 2.4.
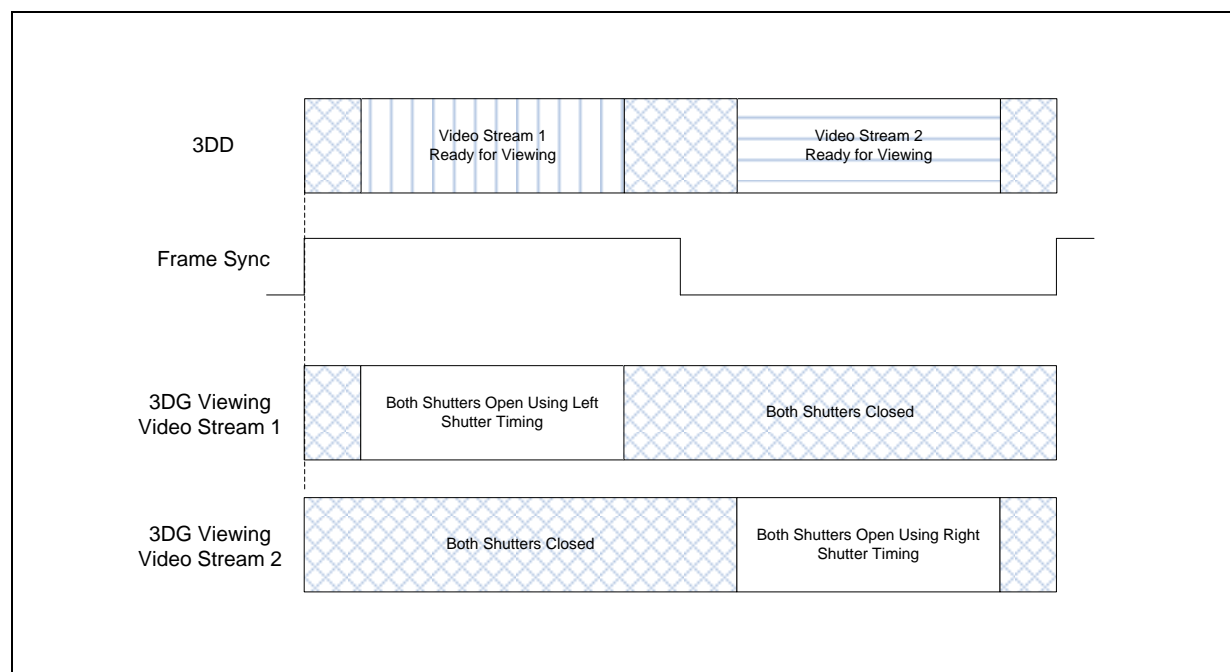
*Figure 2.4: Dual Video Stream (2D) System Timing*

## 2.6  Profile Operations

This profile defines a number of operations that are summarized below. These operations are described in more detail in latter sections of this document.

### 2.6.1  Frame Sync Capture

The 3DD captures specific occurrences of the Frame Sync Instant in units of its native Bluetooth clock.

### 2.6.2  Proximity Association

Proximity Association is used by the 3DG to discover nearby 3DDs and select a 3DD for synchronized operation.

### 2.6.3  3DG Connection Announcement

The 3DG Connection Announcement is a message sent by the 3DG to a 3DD containing information concerning Association Notification and Battery Level Reporting.

### 2.6.4  Association Notification Transmission and Reception

Association Notification is used by the 3DG to notify the 3DD (selected via Proximity Association) that the 3DG will synchronize to the 3DD's 3D Broadcast. The 3DG delivers this information as part of the 3DG Connection Announcement message sent over the 3D Communications Channel.

### 2.6.5  Legacy Association Notification Transmission

Legacy Association Notification Transmission is used by the 3DG to send the Legacy Association Notification message to notify a Legacy 3DD (selected via Proximity Association) that the 3DG will synchronize to a Legacy 3DD's 3D Broadcast. The 3DG delivers this information using the Legacy Association Notification feature.

### 2.6.6  Reference Protocol Association Notification Reception

Reference Protocol Association Notification Reception is used by the 3DD to receive the Reference Protocol Association Notification message that is sent by a Legacy 3DG to notify a Legacy 3DD (or in this case a 3DD) that it has successfully completed Proximity Association with it and will synchronize to its 3D Broadcast.

### 2.6.7  Battery Level Reporting

Battery Level Reporting may be used by the 3DG to deliver its current battery level information to the 3DD to which it is associated. The 3DG delivers this information as part of the 3DG Connection Announcement message sent over the 3D Communications Channel.

### 2.6.8  3D Broadcast Message

The 3DD transmits a set of parameters that define the Frame Sync timing, frame rate, and lens shutter control offsets to the 3DGs via a 3D Broadcast Message. The 3D Broadcast Message also conveys reference time (i.e., 3DD native Bluetooth clock) synchronization in the system.

### 2.6.9  Shutter Control

The 3DG uses information from the 3D Broadcast Message to control the opening and closing of the left and right lens shutters.

### 2.6.10 Profile Operations Summary

Table 2.1 summarizes the profile operations, their applicability to the 3DD or 3DG roles, and whether they are optional, mandatory, or not applicable for each role.

| Operation | 3DD | 3DG |
|---|---|---|
| Frame Sync Capture | M | X |
| Proximity Association Initiation | X | M |
| Proximity Association Response | M | X |
| Legacy Association Notification Transmission | X | O |
| Reference Protocol Association Notification Reception | O | X |
| 3DG Connection Announcement Transmission | X | C.1 |
| 3DG Connection Announcement Reception | C.2 | X |
| Battery Level Reporting Transmission | X | C.3 |
| Battery Level Reporting Reception | C.4 | X |
| Association Notification Transmission | X | C.5 |

| Operation | 3DD | 3DG |
|---|---|---|
| Association Notification Reception | C.6 | X |
| 3D Broadcast Message Transmission | M | X |
| 3D Broadcast Message Reception | X | M |
| Shutter Control | X | M |

*Table 2.1: 3D System Roles And Operations*

- M – Mandatory
- O – Optional
- X – Excluded
- C.1: Mandatory if Legacy Association Notification Transmission is supported, otherwise optional
- C.2: Mandatory if Reference Protocol Association Notification Reception is supported, otherwise optional
- C.3: Optional if 3DG Connection Announcement Transmission is supported, otherwise excluded
- C.4: Optional if 3DG Connection Announcement Reception is supported, otherwise excluded
- C.5: Mandatory if Legacy Association Notification Transmission or Battery Level Reporting Transmission is supported, otherwise optional if 3DG Connection Announcement Transmission is supported, otherwise excluded
- C.6 Mandatory if Reference Protocol Association Notification Reception or Battery Level Reporting Reception is supported, otherwise optional if 3DG Connection Announcement Reception is supported, otherwise excluded

# 3   Use Case Scenarios

This section describes some typical use case scenarios for 3D products implementing the Bluetooth 3D Synchronization Profile, including products that optionally support backward compatibility with Legacy 3DD and 3DG products. The Bluetooth 3D products illustrated in this section, along with the description of their optional features and user interfaces, may differ from actual Bluetooth 3D products.

## 3.1   Use Case 1: Using new Bluetooth 3D display with new Bluetooth 3D glasses

In this use case, the user buys a new Bluetooth 3DD and a new pair of Bluetooth 3DG as shown in Figure 3.1.
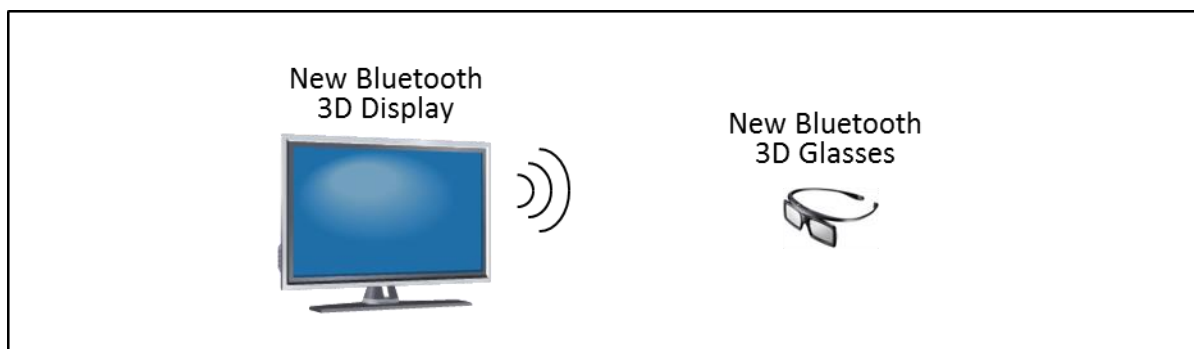


*Figure 3.1: New Bluetooth 3D Display used with New Bluetooth 3D Glasses*

The user unboxes, sets up, and powers on the new Bluetooth 3DD and unboxes and powers on the new Bluetooth 3DG. The user then holds the 3DG near the 3DD and presses the power button on the 3DG for 3 seconds. This causes the 3DG to begin searching for nearby 3DDs. The 3DG finds the 3DD and successfully completes Proximity Association with this 3DD. The 3DG then sends a 3DG Connection Announcement Message that includes the Association Notification and its Battery Level Report indicating 85% battery level remaining. Once the 3DD receives and decodes this 3DG Connection Announcement Message, it generates a user advisory on its 3D display screen stating, "3D glasses are now associated and have 85% battery capacity remaining".

The user then begins playing a 3D program on the 3DD and the 3DD begins transmitting its 3D Broadcast Message that contains the lens shutter synchronization timing information for the displayed 3D video images. The 3DG begins receiving these 3D Broadcast Messages and uses the timing information in the message to control the opening and closing of the left eye and right eye lens shutters, which allows the user to watch the 3D stereoscopic program.

The lens shutters on the 3DG stay synchronized with the 3DD as long as 3D content is being displayed and the 3DG are in range of the 3DD's 3D Broadcasts. If the user walks out of range of the 3DD's 3D Broadcast or the user switches to watching a 2D program

on the 3DD, the 3DG lens shutters for both eyes will open (2D Mode). After some period of time in the 2D Mode, the 3DG will automatically power off.

## 3.2 Use Case 2: Using new Bluetooth 3D display with Legacy 3D glasses

In this use case, the user buys a new Bluetooth 3DD that supports backward compatibility with Legacy 3DGs. The user wants to use his new 3DD with his Legacy 3DG as shown in Figure 3.2.



*Figure 3.2: New Bluetooth 3D Display used with Legacy 3D Glasses*

The user goes through the same steps to associate his Legacy 3DG with his new Bluetooth 3DD as described in Use Case 1 above. Upon successful Proximity Association, the Legacy 3DG sends Reference Protocol Association Notification, which the new Bluetooth 3DD receives and then generates a user advisory on its 3D display screen stating "3D glasses are now associated". Upon playing a 3D program on the 3DD, the Legacy 3DG receive the 3D Broadcast Message and use the information contained in it to synchronize to the 3DD as described in Use Case 1 above.

## 3.3 Use Case 3: Using a Legacy 3D display with new Bluetooth 3D glasses

In this use case, the user buys a new pair of Bluetooth 3DG that supports backward compatibility with Legacy 3DDs. The user wants to use these new 3DG with his Legacy 3DD as shown in Figure 3.3.
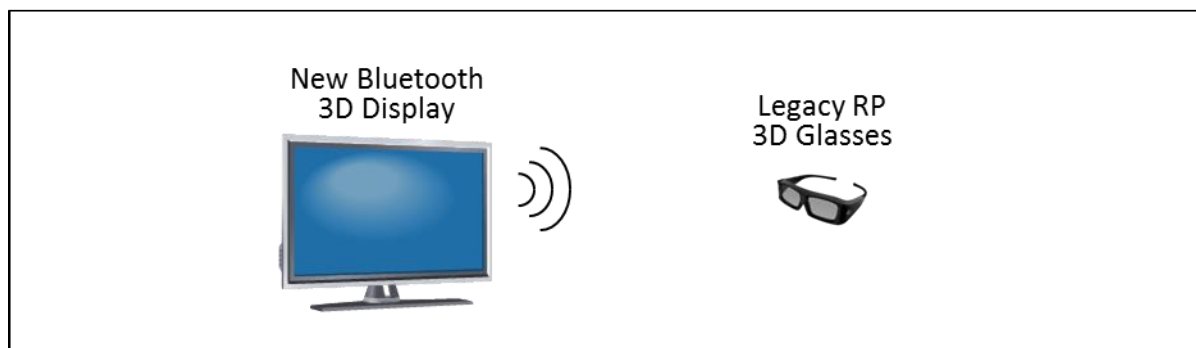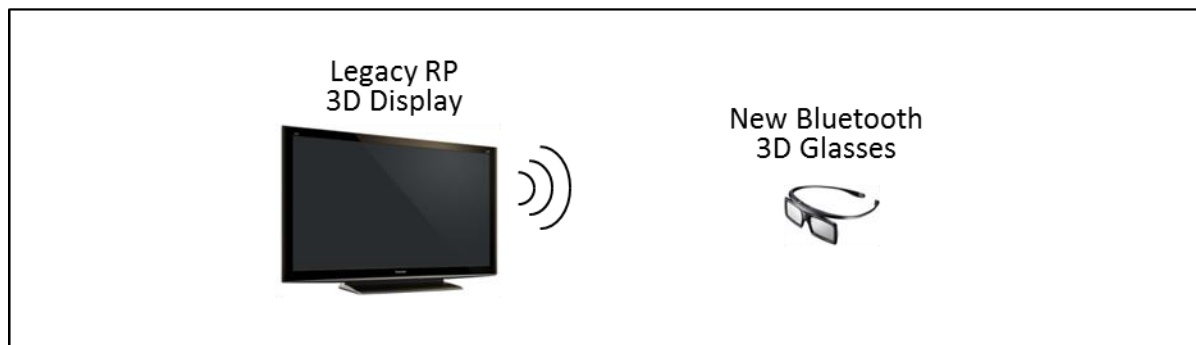


*Figure 3.3: Legacy 3D Display used with New Bluetooth 3D Glasses*

The user goes through the same steps to associate his new Bluetooth 3DG with his Legacy 3DD as described in Use Case 1 above. Upon successful Proximity Association, the new 3DG sends Legacy Association Notification, which the Legacy 3DD receives, recognizes as Reference Protocol Association Notification, and then generates a user advisory on its 3D display screen stating "3D glasses are now associated". Upon playing a 3D program on the Legacy 3DD, the new 3DG receive the 3D Broadcast Message and use the information contained in it to synchronize to the 3DD as described in Use Case 1 above.

## 3.4 Use Case 4: Using new Bluetooth 3D display and new Bluetooth 3D glasses from different manufacturers

In this use case, the user buys a new Bluetooth 3DD and a pair of Bluetooth 3DG from Manufacturer A and an additional pair of Bluetooth 3DG from Manufacturer B, as shown in Figure 3.4.
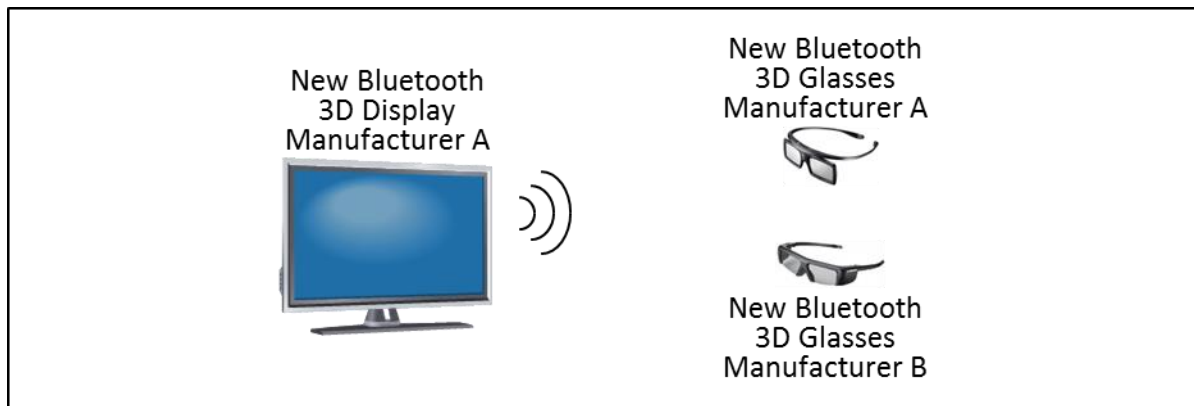


*Figure 3.4: New Bluetooth 3D Display used with New Bluetooth 3D Glasses from different Manufacturers*

The user goes through the same steps to associate each pair of new Bluetooth 3DG with his new Bluetooth 3DD as described in Use Case 1 above. After each pair of 3DG successfully complete Proximity Association with the 3DD, each 3DG sends its Association Notification, which the 3DD receives and then generates a user advisory on its 3D display screen stating "3D glasses are now associated". Upon playing a 3D program on the 3DD, both 3DGs receive the 3D Broadcast Message and use the information contained in it to synchronize to the 3DD as described in Use Case 1 above.

## 3.5 Use Case 5: Using Bluetooth 3D display with unlimited number of Bluetooth 3D glasses

In this use case, a multiplex theater operates a Bluetooth 3D digital cinema projection system with 500 pairs of Bluetooth 3DGs. Since the system uses the Bluetooth 3D Synchronization Profile, the theater allows movie audiences to bring their own Bluetooth 3DG from home to use in the 3D digital cinema as shown in Figure 3.5.
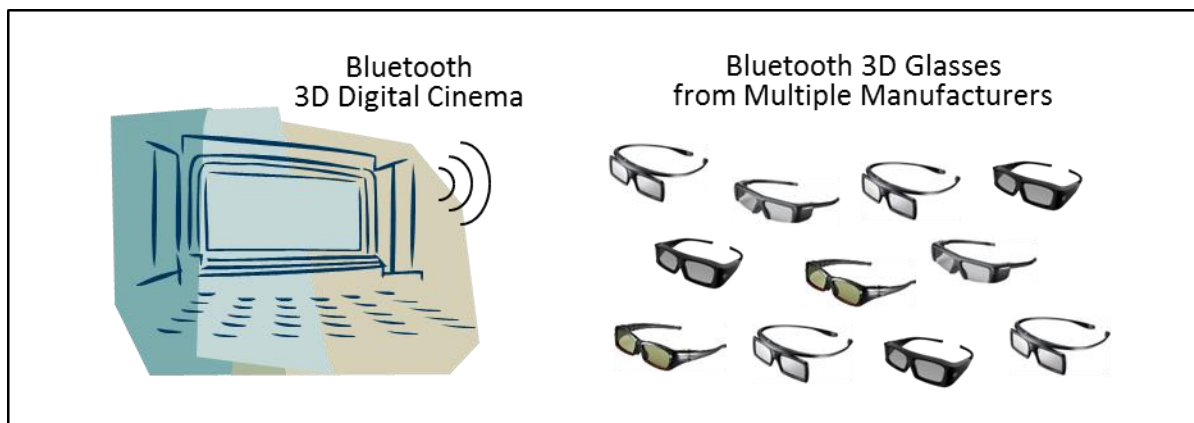
*Figure 3.5: New Bluetooth 3D Digital Cinema System used with large number of Bluetooth 3D Glasses*

The multiplex theater owner purchases and has installed a new Bluetooth 3D digital cinema projection system in Theater 1, which was ordered with 500 pairs of Bluetooth 3DG that were associated with this Bluetooth 3D projection system at the factory. These Bluetooth 3DGs are powered on and provided to moviegoers entering Theater 1. Moviegoers who want to use and have brought their own Bluetooth 3DG from home are directed to a special area in Theater 1 where they are instructed to power on and associate their Bluetooth 3DG with Theater 1's Bluetooth 3D projection system.

When the 3D movie begins playing in Theater 1, the Bluetooth 3DGs worn by moviegoers in Theater 1 begin receiving and synchronizing to the 3D Broadcast Message from the Bluetooth 3D projection system in Theater 1. These 3DGs disregard 3D Broadcast Message transmissions from other Bluetooth 3D projection systems in the multiplex.

When moviegoers who brought their own Bluetooth 3DG to the cinema return home, they can associate their 3DG again with their home 3DD in the same manner as described in Use Case 1 above.

## 3.6  Use Case 6: Multi-profile Bluetooth-enabled Living Room

In this use case, the user buys a new Bluetooth 3DD, a new pair of Bluetooth 3DG, a new Bluetooth universal remote control, and some new Bluetooth stereo headphones for use in his Living Room as shown in Figure 3.6.
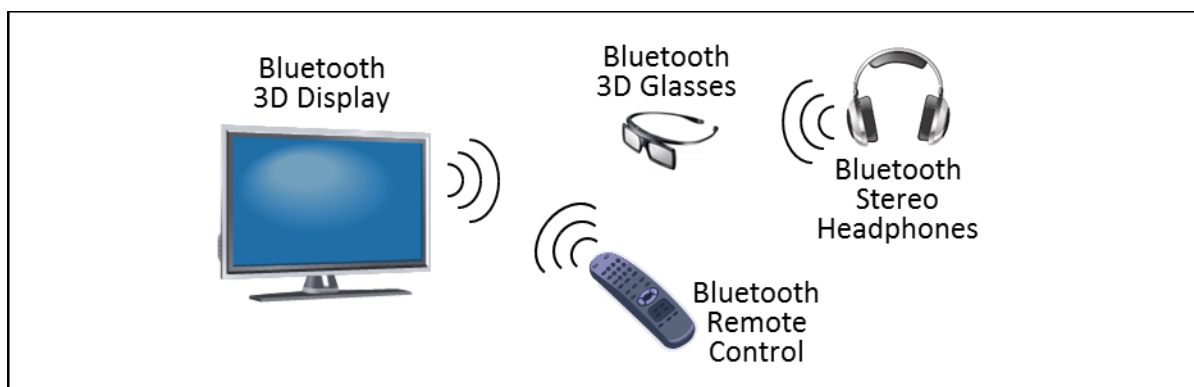


*Figure 3.6: Multi-profile Bluetooth-enabled Living Room*

The user successfully associates his Bluetooth 3DG with his Bluetooth 3DD as described in Use Case 1. The user then follows the instructions to pair his Bluetooth 3DD with both his Bluetooth Remote Control, which in this example implements the A/V Remote Control Profile (AVRCP), and his Bluetooth Stereo Headphones, which in this example implements the Advanced Audio Distribution Profile (A2DP).

The user then uses his Bluetooth Remote Control that has connected with the 3DD to select and play a 3D concert video program. The Bluetooth 3DG synchronize with the 3D Broadcast being transmitted from the Bluetooth 3DD. The user then powers up and puts on his Bluetooth Stereo Headphones, which discover and connect to the previously-paired Bluetooth 3DD thus allowing the user to watch and listen to the 3D concert video program.

## 3.7 Use Case 7: Using Bluetooth 3D glasses with a Bluetooth 3D display in a Multi-dwelling unit environment

In this use case, the tenant in Apartment 4 buys a new Bluetooth 3DD and 3DG for use in his apartment located in a multi-dwelling housing unit where neighbors in surrounding apartments also use Bluetooth 3DDs and 3DGs as shown in Figure 3.7.
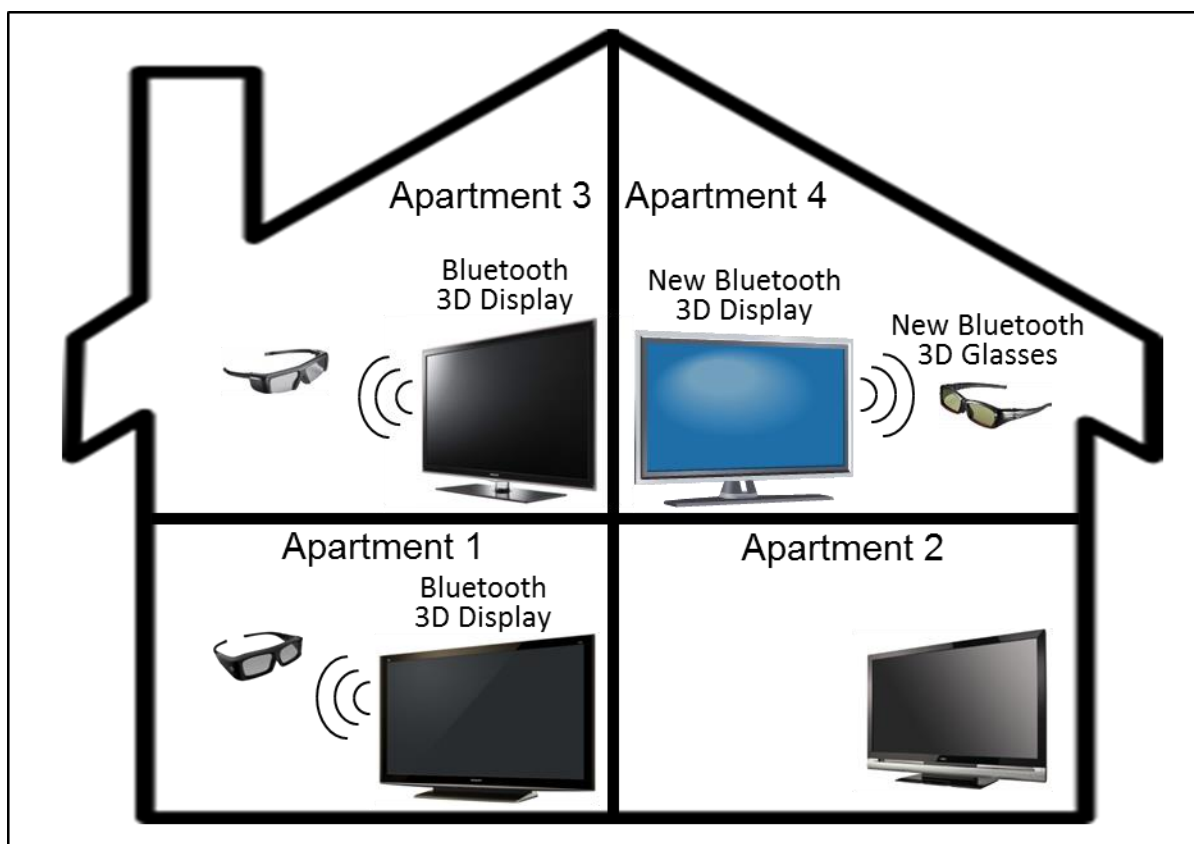


*Figure 3.7: Using Bluetooth 3D Glasses and 3D Display in a Multi-Dwelling Unit*

The user in Apartment 4 unboxes, sets up, and powers on his new Bluetooth 3DD and Bluetooth 3DG. The user then holds his 3DG near his 3DD and presses the power button on the 3DG for 3 seconds. This causes the 3DG to begin searching for nearby 3DDs. The 3DG discovers the user's 3DD along with other operating 3DDs in his

neighbors' apartments. However, the 3DG successfully completes Proximity Association with the user's 3DD, and ignores his neighbors' 3DDs, since the user's 3DD has the strongest Bluetooth transmission.

Upon playing a 3D program, the user's 3DD begins transmitting its 3D Broadcast Message, which the user's 3DG receives and synchronizes to. Because the user's 3DG are only associated to his 3DD, his 3DG ignore 3D Broadcast Messages being transmitted by his neighbors' 3DDs.

## 3.8  Use Case 8: Using Bluetooth 3D display and 3D glasses to view two different 2D images on the same display (Dual View Mode)

In this use case, a user buys a new Bluetooth 3DD and two pairs of Bluetooth 3DG to use with a 3D game console to play a 3D interactive game with a friend where the 3DD is used to provide two different 2D views of the game play instead of a single 3D view as shown in Figure 3.8.
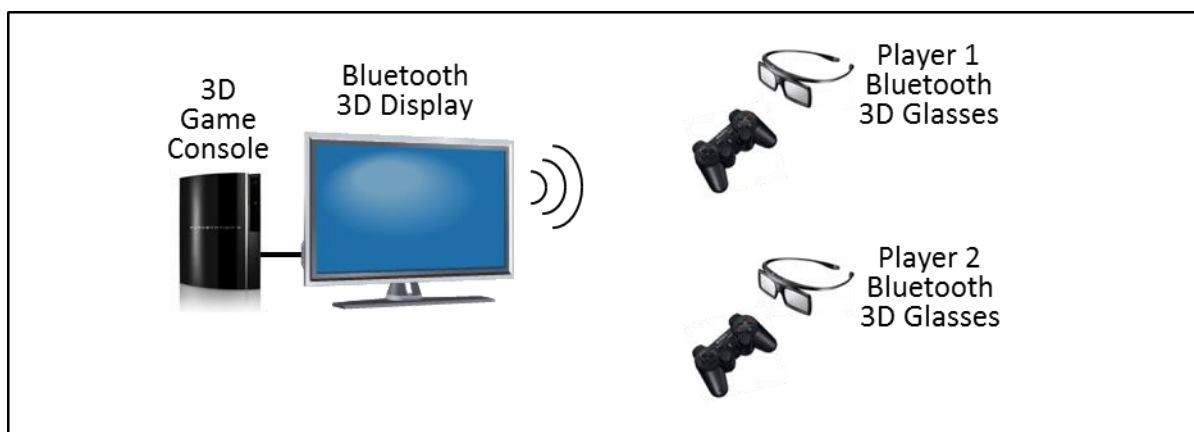


*Figure 3.8: Using Bluetooth 3D Display and 3D Glasses for Dual View Mode Interactive Gaming*

The user unboxes, sets up, powers on, and associates his new Bluetooth 3DD with two pairs of Bluetooth 3DG. He then launches a 3D interactive game on his 3D game console. In the game setup menu, he places the 3D game in the Dual View Mode where the game renders two different 2D video streams ("Player 1 View" & "Player 2 View") instead of the normal 3D stereoscopic video streams ("Left Eye View" & "Right Eye View").

The user moves the 3D/2D Dual View Mode switch on his 3DG from the "3D" position to the "2D-View 1" position. On his friend's 3DG, he moves the 3D/2D Dual View Mode switch from the "3D" position to the "2D-View 2" position.

Once the Dual View interactive game starts playing, the 3DD sends 3D Broadcast Messages causing the both left and right lens shutters on Player 1's 3DG to open during the normal "Left Eye" view and to close on the normal "Right Eye" view. This allows Player 1 to only see the 2D "Player 1 View" being displayed on the 3DD during the normal "Left Eye" display time. On Player 2's 3DG, both the left and right lens shutters open during the normal "Right Eye" view and to close on the normal "Left Eye" view. This allows Player 2 to only see the 2D "Player 2 View" being displayed on the 3DD during the normal "Right Eye" display time.

When the Dual View interactive gaming session ends, the user moves the 3D/2D Dual View Mode switch back to the "3D" Mode on both pairs of 3DGs so they are ready again to be used for viewing normal 3D stereoscopic content.

# 4  Frame Sync Capture

## 4.1  Frame Sync Capture Overview

The 3DD Frame Sync signal provides timing information about the displayed image. This section will discuss the capture and conversion of the Frame Sync timing to the system reference time, i.e., the 3DD native Bluetooth Clock.

### 4.1.1  Frame Sync Timing – An Example

A possible implementation of the Frame Sync signal is shown in Figure 4.1. In this implementation, the rising edge of Frame Sync occurs at the start of the left image display and the falling edge of Frame Sync occurs at the start of the right image display. The images are displayed for the same amount of time, i.e., the Frame Sync signal is a square wave. Other implementations of Frame Sync are possible, e.g., a pulse when the left image is drawn, separate sync signals for left and right images, etc. but it is assumed that the 3DD is able to effectively access or emulate a periodic Frame Sync signal which indicates when a specific phase occurs within each frame.
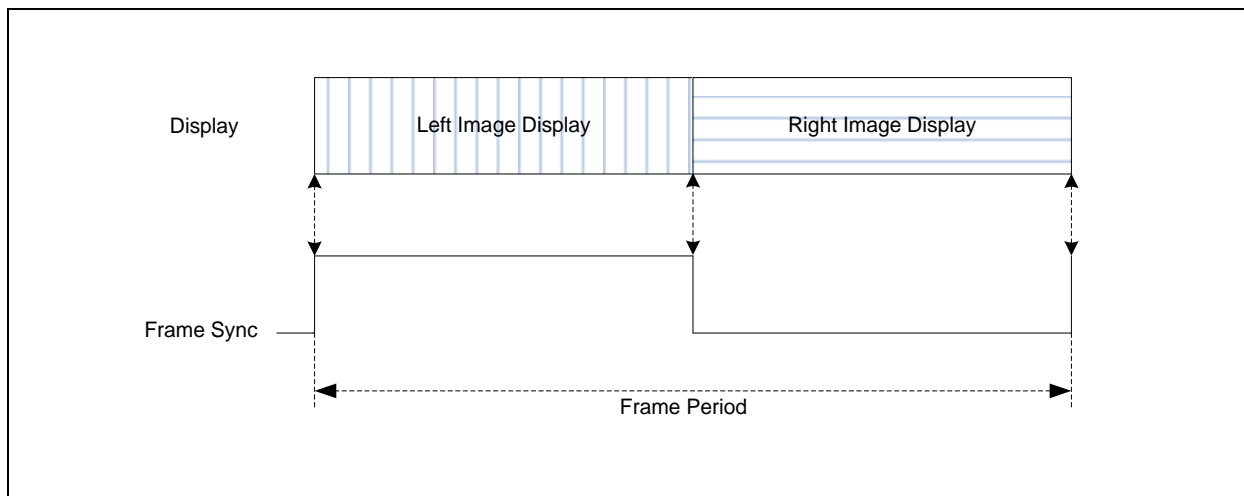


*Figure 4.1: Frame Sync Timing*

### 4.1.2  Frame Sync Timing Conversion to Native Bluetooth Clock

The 3DD shall measure Frame Sync timing with respect to its native Bluetooth clock. Timing conversion may be performed using the rising or falling edge of Frame Sync or any convenient signal that provides the same timing conversion result. Depending on the measured signal, some offset may need to be added to determine the start of Left/Right Image Displays; such an adjustment is left to the implementation.
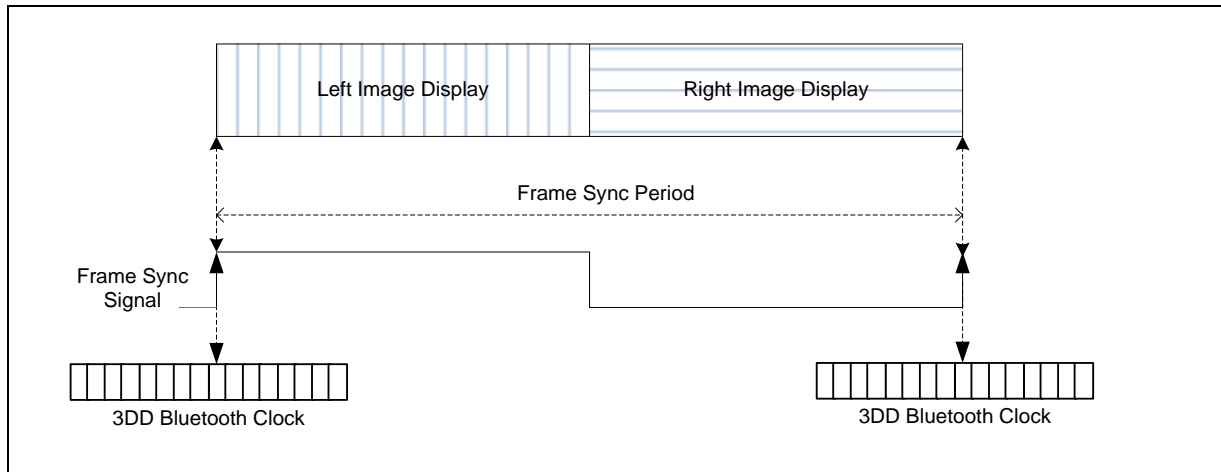
*Figure 4.2: Frame Sync Conversion to Native Bluetooth Clock*

Figure 4.2 is an example of how the conversion works. This figure assumes that the rising edge of the Frame Sync signal indicates the start of the Left Image Display frame and the falling edge indicates the start of the Right Image Display frame. When the rising edge of Frame Sync occurs, the 3DD captures and stores the current value of its native Bluetooth clock (CLK[27:0]) and also the microsecond phase.

The action of capturing the native Bluetooth clock value may be performed by hardware (HW), interrupt-driven firmware (FW), or some combination of HW and FW, and is up to the implementation. A Bluetooth device with support for the Triggered Clock Capture Core feature may also be used; see section 4.1.2.2 for more information.

### 4.1.2.1   Frame Sync Instant – Resolution and Accuracy

The measurement of the Frame Sync Instant in relation to the 3DD native Bluetooth clock shall be performed with a minimum resolution of 1 µs. The accuracy, which is defined to be the maximum error between the native Bluetooth clock value at the time of the rising edge of Frame Sync and the reported Bluetooth clock value, shall be ±5 µs.

### 4.1.2.2   Use of Triggered Clock Capture Core Feature

The Triggered Clock Capture Core feature [2] may be used to measure the Frame Sync timing in relation to the native Bluetooth clock. In such an implementation a Bluetooth Controller supporting the Triggered Clock Capture feature with the required accuracy shall be used. The Bluetooth Controller will convert the external Frame Sync to its native Bluetooth clock and provide this information to the Bluetooth Host.

## 4.1.3  Frame Sync Period Calculation

The 3DD shall also calculate the period of the Frame Sync in terms of the native Bluetooth clock. Single period measurement may be used for this purpose, in which case the period is simply the difference in the observed native Bluetooth clock values between two consecutive Frame Sync instants. Another approach is to average over a number of Frame Sync periods, as follows:

*Bluetooth 3D Synchronization Profile*

$$F_{avg} = (B_n - B_m)/(n-m)$$

Where:

- $F_{avg}$ is the average Frame Period
- m, n are the m$^{th}$ and n$^{th}$ Frame Sync instants, n > m
- $B_n$ ,$B_m$ are the 3DD native Bluetooth clock values (plus phase) at times m and n respectively

A running average may also be used.

When the average Frame Sync Period is greater than 40,000 μs, the reported values for the Frame Sync Period and the Frame Sync Period Fraction in the 3D Broadcast Message shall be set to 0.

### 4.1.3.1    Frame Sync Period – Resolution and Accuracy

Frame Sync Period shall be calculated with a minimum resolution of 1/256 μs and an accuracy of ±1 μs. The accuracy shall be defined as the maximum Frame Sync Period timing error. Note: The Bluetooth clock reference in the 3DD must have an accuracy of ±20 parts per million (ppm) or better, as specified in the Bluetooth Core Specification [1] in order to achieve end-to-end 3D system synchronization timing accuracy.

The Frame Sync Period is used by the 3DG to continue lens shutter operation in between receptions of the 3D Broadcasts and to estimate the Frame Sync timing when the 3DG misses one or more 3D Broadcasts. The resolution and accuracy of the calculated Frame Sync Period allows the 3DG to continue lens shutter control operations for a longer period of time reducing the need to synchronize to every 3D Broadcast.

# 5   Proximity Association

Proximity Association is the procedure by which the 3DG discovers a nearby 3DD, selects a 3DD to operate with and possibly stores this selection for future operation. The following is an overview of the Proximity Association procedure.

1. 3DD is configured for Proximity Association as specified in section 5.2.

2. User action triggers Proximity Association on 3DG.

3. 3DG discovers nearby 3DDs using the rules specified in section 5.3.

4. 3DG selects one of the nearby 3DD to synchronize with using the rules described in section 5.3.

## 5.1   Data Format

This section describes the format and contents of the fields/data used in the Proximity Association procedure.

### 5.1.1   Class of Device

Class of Device is provided by the 3DD in an Inquiry Response. A 3DG shall not filter on Class of Device as part of Proximity Association. A 3DD shall send the Class of Device as specified in Table 5.1 and in the Bluetooth Assigned Numbers – Baseband [3] when initiating Proximity Association with Legacy 3DG.

| Field | Value | Description |
|---|---|---|
| Major Service Class | 00000000000b or 00001000000b | Unspecified or Capturing[2] |
| Major Device Class | 00100b | Audio/Video |
| Minor Device Class | 001111b | Video Display and Loud Speaker |

*Table 5.1: Class of Device field*

### 5.1.2   EIR Data Types

The 3DD shall include the three EIR data types specified in sections 5.1.2.1, 5.1.2.2, and 5.1.2.3 in its EIR data. These data types may be included in any order and may be interspersed with other EIR data types, except as noted in section 5.1.2.2.

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[2] Setting the Capturing service class flag is required by the A2DP specification for devices supporting the Advanced Audio Distribution Profile (A2DP) source role.  See the A2DP specification.

### 5.1.2.1    3D Information

The 3DD shall include a section in its EIR data providing 3D Synchronization Profile specific information. The data structure of this EIR data is specified in the Bluetooth Core Specification [1] and is described along with the Profile-specific 3D Information data in Table 5.2.

| Field | Position | Type | Value | Notes |
|---|---|---|---|---|
| Length | Byte 0 | UINT8 | >= 3 | Length of 3D Information EIR Data Type ID and Profile-specific data section. Current version of this Profile has a length of 3 but may be extended in a future revision. |
| 3D Information EIR Data Type ID | Byte 1 | UINT8 | TBD | Bluetooth assigned number |
| Association Notification | Byte 2, bit 0 | Bit | | 0 – Not supported<br>1 – Supported |
| Battery Level Reporting | Byte 2, bit 1 | Bit | | 0 – Not Supported<br>1 – Supported<br><br>The value shall be set to 0 if the Association Notification is set to 0. |
| Send Battery Level Report on Start-up Synchronization | Byte 2, bit 2 | Bit | | 0 – 3DD requests 3DG to not send a 3DG Connection Announcement Message with Battery Level Report on Start-up Synchronization.<br>1 – 3DD requests 3DG to send a 3DG Connection Announcement Message with Battery Level Report on Start-up Synchronization.<br><br>The value shall be set to 0 if the Battery Level Report is set to 0. |
| Reserved | Byte 2, bit 3 | Bit | 0 | |
| Reserved | Byte 2, bit 4 | Bit | 0 | |
| Reserved | Byte 2, bit 5 | Bit | 0 | |
| Reserved | Byte 2, bit 6 | Bit | 0 | |
| Factory Test Mode | Byte 2, bit 7 | Bit | 0 | 0 – normal operating mode<br>1 – vendor-defined factory test mode |
| Path Loss Threshold | Byte 3 | UINT8 | 60-100 (typical) | In dB. Maximum allowable path attenuation from 3DD to 3DG. Greater attenuation than this number will inform the 3DG that it is too far away and to look for another 3DD. |

*Table 5.2: 3D Information EIR Data*

Future versions of this EIR data may be extended to carry additional bytes in the Profile-specific 3D Information data section. Therefore, 3DG compliant with this version of the Profile specification shall ignore any additional data beyond what is specified in Table 5.2, if present.

### 5.1.2.2   Legacy 3D Information

The 3DD shall include a section in its EIR data for Legacy 3D Information that is formatted as Manufacturer Specific Data type as specified in Table 5.3. It shall be the first Manufacturer Specific Data in the EIR packet, preceding any other Manufacturer Specific Data. This is necessary for backward compatibility with the Reference Protocol as some Legacy 3DG only look at the first Manufacturer Specific Data in the EIR data. It should be noted that the requirement of the 3DD to include the Legacy 3D Information in its EIR data may become optional in a future version of the Profile specification.

The data structure of this EIR data is specified in the Bluetooth Core Specification [1] and is described along with the specific Legacy 3D Information in Table 5.3.

| Field | Position | Type | Value | Notes |
|---|---|---|---|---|
| Length-Manufacturer Specific Data | Byte 0 | UINT8 | 6 | Length of manufacturer specific section |
| Manufacturer Specific | Byte 1 | UINT8 | 0xFF | Bluetooth assigned number |
| Fixed ID | Byte 2-3 | UNIT16 | 0x000F | Fixed value (Broadcom) |
| Fixed | Byte 4 | UINT8 | 0 | Shall be set to 0. If this field is not 0, Legacy 3DG shall skip this section |
| 3D Capable TV | Byte 5, bit 0 | Bit | 1 | 1 – 3D supported<br>0 – 3D not supported |
| Ignored | Byte 5, bit 1 | Bit | 0 | |
| Ignored | Byte 5, bit 2 | Bit | 0 | |
| Ignored | Byte 5, bit 3 | Bit | 0 | |
| Fixed | Byte 5, bit 4 | Bit | 0 | Shall be set to 0. |
| Ignored | Byte 5, bit 5 | Bit | 0 | |
| Fixed | Byte 5, bit 6 | Bit | 0 | Shall be set to 0. |
| Test Mode | Byte 5, bit 7 | Bit | 0 | 0 – 3DD in normal operating mode<br>1 – 3DD is in factory Legacy 3DG test mode[Note 1] |
| Path Loss Threshold | Byte 6 | UINT8 | 60-100 (typical) | In dB. Maximum allowable path attenuation from 3DD to Legacy 3DG. Greater attenuation than this number will inform the Legacy 3DG that it is too far away and to look for another 3DD |

*Table 5.3: Legacy 3D Information*

Note 1: Factory test mode is for manufacturing convenience. Support of this mode and device behavior in this mode is up to the manufacturer and outside the scope of this document.

### 5.1.2.3   TX Power Level

The 3DD shall include a TX Power Level data type in its EIR data (see [4]). Note: For compatibility with Legacy 3DGs, the use of negative TX power values (i.e., below 0 dBm) should be avoided.

## 5.2  3DD Configuration for Proximity Association

The 3DD support of Proximity Association requires the following configuration steps:

1. inclusion of EIR data types as specified in section 5.1.2, and

2. the 3DD is in the general discoverable mode.

For an improved user experience, it is recommended that the 3DD be configured for Proximity Association as the factory default setting.

## 5.3 Proximity Association Procedure

The Proximity Association procedure is executed by the 3DG. This procedure is described below.

1. User interaction triggers Proximity Association on the 3DG.

   a. User interaction may be accomplished using a push button, a motion or touch sensor, or some other human interaction with the 3DG.

2. The 3DG performs a general inquiry with a duration of 5.12 seconds but no longer than 10 minutes.

3. While the general inquiry is ongoing, the 3DG shall create a list of nearby Bluetooth devices, ignoring their Class of Device, that satisfy the following criteria and obtain the EIR receive power for each device in the list.

   a. A correctly formatted EIR packet is received from the responder that includes the 3D Information data type and the TX Power Level data type as described in section 5.1.2, or in the case of a Legacy 3DD, the EIR packet includes the Reference Protocol 3D Information data type as specified in section 12.1.2 and the TX Power Level data type. When the EIR packet contains both the Manufacturer Specific Data data type containing Legacy 3D Information and the 3D Information EIR data type, the Manufacturer Specific Data data type containing Legacy 3D Information shall be ignored by the 3DG. If the Reference Protocol 3D Information data type is received from a Legacy 3DD, the 3DG shall verify that the "Multicast Capable" bit in this field is 1 and if not, the 3DG shall ignore the response.

   b. The calculated path loss for the EIR packet of the responder (Path Loss = TX Power – RX EIR Power) is less than or equal to the Path Loss Threshold specified in the responder's EIR data.

4. At the end of the general inquiry, the 3DG shall select and commence Proximity Association with the responder from the list of devices determined in Step 3 with the lowest path loss. If no response is received that satisfies the criteria specified in step 3, the 3DG may enter a low power state, repeat the general inquiry, or take other action. If there are multiple responders with identical path loss that satisfy the criteria specified in step 3, then it is implementation specific as to which responder to select to complete Proximity Association.

5. After successfully completing Proximity Association, the 3DG shall store the 3D Information data type or the Reference Protocol 3D Information data type may attempt to synchronize to the 3D Broadcast defined in section 8, communicate with the 3DD via the 3D Communications Channel or communicate with the Legacy 3DD via Legacy Association Notification, or enter a low power state.

The above procedure for Proximity Association between a 3DD and a 3DG is depicted in Figure 5.1:
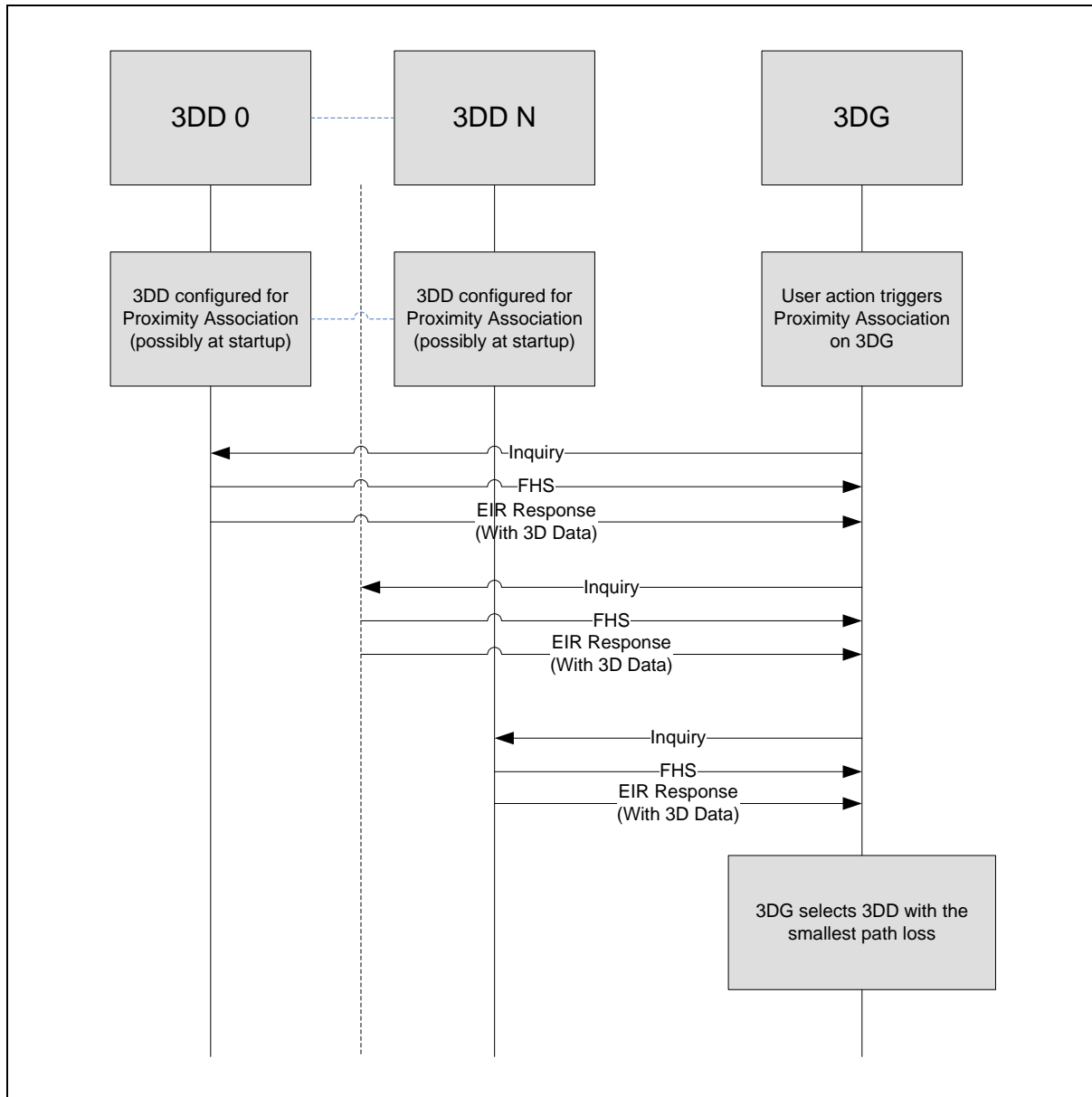


*Figure 5.1: Proximity Association*

# 6  3D Communications Channel

The 3D Communications Channel is used to send messages between the 3DD and 3DG. In this version of the profile, only a single message is defined, the 3DG Connection Announcement, which is sent from the 3DG to the 3DD and contains the Association Notification and Battery Level fields
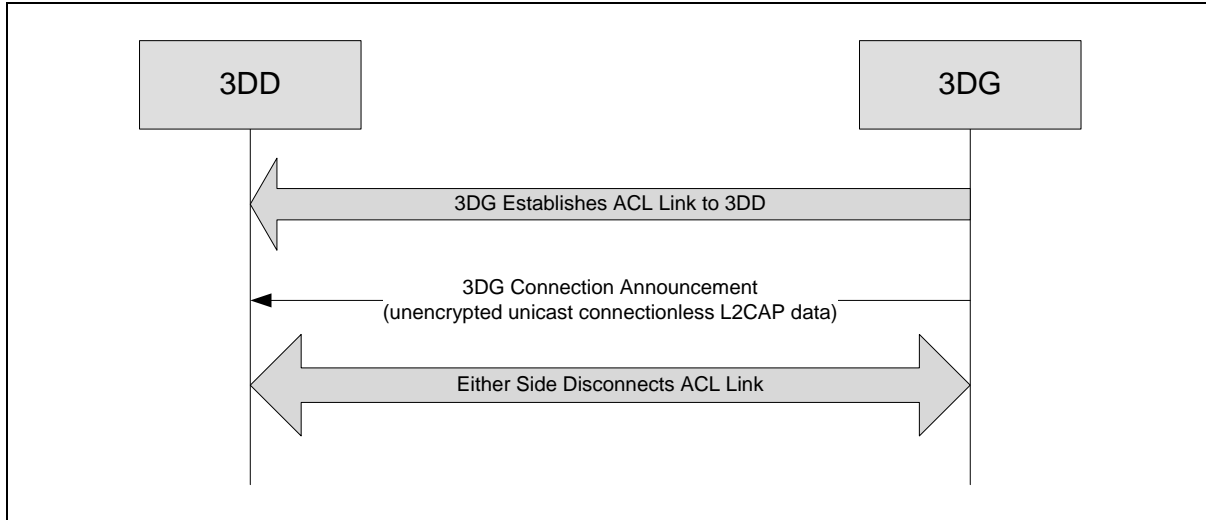


*Figure 6.1: 3DG Connection Announcement on 3D Communications Channel*

The following sequence of steps is used to send the 3DG Connection Announcement message on the 3D Communications Channel.

- The 3DG shall establish an ACL link with the 3DD.

- The 3DG shall send the 3DG Connection Announcement as unicast traffic over the connectionless L2CAP data channel. This Profile does not require encryption of the 3DG Connection Announcement message.

- After the 3DG has transmitted the 3DG Connection Announcement message, the 3DD may initiate additional transactions, e.g., service discovery or utilizing other services, which the 3DG may offer.

- Either side may disconnect the ACL link at this time.

## 6.1  3D Communications Channel Messages

Messages sent on the 3D Communications Channel shall use the G-frame format as described in Volume 3, Part A, Section 3.2 of [1] and shall consist of a 3-byte length message with first byte containing an opcode field followed by two bytes of information. The PSM field in the packet shall be set to the fixed PSM value for the 3D Synchronization Profile Communications Channel as defined in [3].

The following sections define the messages, which may be used over the 3D Communications Channel. The G-frame header is not included in the definition of each

message. The 3D Communications Channel Message Opcode field shall be the first byte in the Information payload portion of the G-frame PDU.

## 6.2  3DG Connection Announcement Message Format

Table 6.1 shows the format of the 3DG Connection Announcement message from the 3DG to the 3DD.

| Field | Position | Type | Value | Notes |
|---|---|---|---|---|
| 3D Communications Channel Message Opcode | Byte 0 | UINT8 | 0 = 3DG Connection Announcement message<br>1-255 = Reserved | |
| Association Notification | Byte 1, bit 0 | Bit | 0 = Connection not due to association<br>1 = Connection occurred due to association | Whenever the User Request for Battery Level Display bit is set to a value of 1, this field shall be set to 0. |
| User Request for Battery Level Display | Byte 1, bit 1 | Bit | 0 = User has not made a specific request to display Battery Level<br>1 = User has made a specific request to display Battery Level | Whenever the Association Notification bit is set to a value of 1, this field shall be set to 0. |
| Reserved | Byte 1, bits 2-7 | | 000000b | |
| Battery Level | Byte 2 | UINT8 | 0-100 = % of current charge level of battery<br>101-254 = reserved<br>255 = Battery Level Reporting not supported | Expresses the battery charge level in linear units of percentage points. |

*Table 6.1: 3DG Connection Announcement Message Format*

## 6.3  Use Case – Association Notification

### 6.3.1  3DG Behavior

If Association Notification is supported by the 3DG and the 3DD has indicated support in the Association Notification field in its 3D Information data type received over EIR, the 3DG shall send a 3DG Connection Announcement message to the 3DD with the Association Notification bit set to the value 1 after completing Proximity Association with the 3DD. Such 3DG Connection Announcement message may also include the Battery Level report if supported by the 3DG.

If Association Notification is supported by the 3DG but the 3DD has indicated no support for Association Notification in its 3D Information data type received over EIR, the 3DG shall not send a 3DG Connection Announcement to the 3DD.

### 6.3.2  3DD Behavior

If Association Notification is supported by the 3DD,

1) the 3DD shall parse the 3D Communications Channel Message Opcode to confirm it is a valid 3DG Connection Announcement message and

2) upon receiving a 3DG Connection Announcement message with the Association Notification bit set to a value of 1, the 3DD should display the association status of the 3DG to the user if appropriate for the 3DD user interface.

## 6.4  Use Case – Battery Level Reporting

### 6.4.1  3DG Behavior

When the 3DG sends its Battery Level report, the 3DG's current percentage of battery level remaining shall be reported in the Battery Level field of the 3DG Connection Announcement message.

If Battery Level Reporting is supported by the 3DG and the 3DD has indicated support in the Battery Level Reporting field in its 3D Information data type received over EIR, the 3DG may send its Battery Level report at any time to a 3DD.

If Battery Level Reporting is supported by the 3DG and the 3DD has indicated support in the Battery Level Reporting field in its 3D Information data type received over EIR, the 3DG shall send its Battery Level report in the following scenarios:

1) At the time of Association Notification, the 3DG shall send the Battery Level information in the 3DG Connection Announcement message with the Association Notification bit set to 1 and the User Request for Battery Level Display bit set to 0.

2) If the Send Battery Level Report on Start-up Synchronization bit specified in section 5.1.2.1 is enabled by the 3DD, at the time the 3DG transitions from a powered-off or stand-by mode to powered on and synchronized with the 3DD ("Start-up Synchronization"), the 3DG shall send the Battery Level information in the 3DG Connection Announcement with the Association Notification bit set to 0 and the User Request for Battery Level Display bit set to 0.

3) If the 3DG optionally implements the ability of a user action on the 3DG to specifically request the 3DG to send its battery level, then when such user action is initiated, the 3DG shall send the Battery Level information in the 3DG Connection Announcement with the Association Notification bit sent to 0 and the User Request for Battery Level Display bit set to 1.

If Battery Level Reporting is supported by the 3DG but the 3DD has indicated no support for Battery Level Reporting in its 3D Information data type received over EIR, the 3DG shall not send a 3DG Connection Announcement except when signaling Association Notification.

If Battery Level Reporting is not supported by the 3DG, then the Battery Level field shall be set to indicate "Battery Level Reporting not supported" whenever the 3DG Connection Announcement message is sent.

In the case where the 3DG is a multi-profile implementation with both GATT Battery Service support and Battery Level Reporting, the 3DG shall calculate the Battery Level

value reported in the 3DG Connection Announcement in the same way as used to calculate the Battery Level value reported using the GATT Battery Service.

### 6.4.2   3DD Behavior

Upon receiving the 3DG Connection Announcement message containing a Battery Level field with a value between 0 and 100, the 3DD may display the Battery Level value to the user if appropriate for the 3DD user interface. If such 3DG Connection Announcement message has the User Request for Battery Level Display bit set to 1, the 3DD should display the Battery Level value to the user.

## 6.5   3DDs without support for the 3D Communications Channel

A 3DD that does not support the 3D Communications Channel shall indicate in its 3D Information data type that it does not support Association Notification and Battery Level Reporting.

3DGs shall not send 3D Communications Channel messages to 3DDs that do not support Association Notification.

# 7  Association Notification with Legacy 3D Devices

For backward compatibility with Legacy 3DGs and Legacy 3DDs, a 3DG may optionally support the Legacy Association Notification transmission as described in this section and a 3DD may optionally support Reference Protocol Association Notification reception as described in sections 12.1.3 and 12.1.4. The Legacy Association Notification transmission shall only be used by a 3DG when Proximity Association occurs with a Legacy 3DD.

## 7.1  Identification of Legacy 3D Devices

A 3DG can identify a Legacy 3DD by inspection of the EIR data field. If the EIR data does not contain the 3D Information data type but does contain the Reference Protocol EIR Data field, the 3DD is a Legacy 3DD.

A 3DD can only identify a Legacy 3DG by reception of the 3DG's Reference Protocol Association Notification message.

## 7.2  Reference Protocol Association Notification Reception

Reference Protocol Association Notification reception (as described in sections 12.1.3 and 12.1.4) may optionally be supported by a 3DD when a Legacy 3DG sends this message to notify the 3DD that it has successfully completed Proximity Association with the 3DD. This procedure consists of the following steps.

1. Legacy 3DG completes Proximity Association with a 3DD.

2. Legacy 3DG transmits the Reference Protocol Association Notification to notify the selected 3DD that the Legacy 3DG has associated with the 3DD.

3. The 3DD receives the Reference Protocol Association Notification sent by the Legacy 3DG but does not send any acknowledgement back to the Legacy 3DG of successful reception of the Reference Protocol Association Notification.

## 7.3  Legacy Association Notification Transmission

Legacy Association Notification transmission (as described in section 7) may optionally be supported by a 3DG to notify a Legacy 3DD that it has successfully completed Proximity Association with the Legacy 3DD. This procedure consists of the following steps.

1. 3DG completes Proximity Association with a Legacy 3DD.

2. 3DG executes the Legacy Association Notification procedure to notify the selected Legacy 3DD that the 3DG has associated with the Legacy 3DD.

3. 3DG receives the Reference Protocol Association Notification Ack sent by the Legacy 3DD after successfully receiving the 3DG's Legacy Association Notification.

      a. If the 3DG does not receive the Ack from the Legacy 3DD, the 3DG continues the Legacy Association Notification procedure until the Ack is received or at least 10.24 seconds elapse.

      b. If the 3DG is not able to complete Step 3, then the Legacy Association Notification transmission procedure is terminated.

The above procedure is depicted in Figure 7.1.
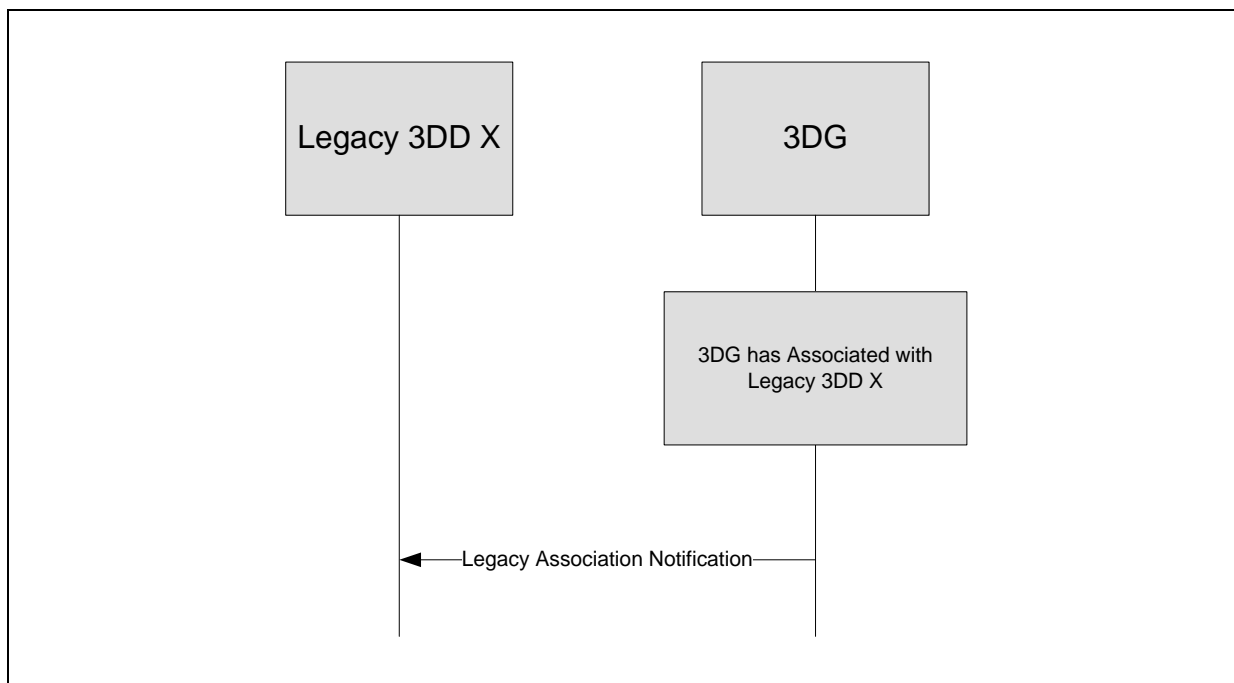


*Figure 7.1: Legacy Association Notification Transmission*

## 7.4 Data Format

This section describes the format and contents of the data fields used in the Legacy Association Notification procedure.

### 7.4.1 Legacy Association Notification Message

The format of the Legacy Association Notification message is shown in Table 7.1.

| Field | Position | Type | Value | Notes |
|---|---|---|---|---|
| 3DG ID | Bytes 0-5 | UINT48 | A pseudo-random value from 0 through ((2^48)−1) inclusive. | The value shall be refreshed after each successful completion of Proximity Association. |
| Device Type | Byte 6 | UINT8 | 0: 3DG<br>1-255: Reserved | |
| Reserved | Bytes 7-16 | | 0x00 | |

*Table 7.1: Legacy Association Notification Message Format*

## 7.5  3DD Requirements

A 3DD shall satisfy the following requirements when implementing the optional Reference Protocol Association Notification reception feature:

1. 3DD shall support the reception of the Reference Protocol Association Notification message transmitted by a Legacy 3DG as described in sections 7, 12.1.3, and 12.1.4.

2. 3DD shall support parsing of the Reference Protocol Association Notification message as described in section 12.1.3.

3. Upon receiving the Reference Protocol Association Notification message, the 3DD should display the association status of the Legacy 3DG to the user if appropriate for the 3DD user interface.

## 7.6  3DG Requirements

A 3DG shall satisfy the following requirements, when implementing the optional Legacy Association Notification transmission feature:

1. 3DG shall support the transmission of the Legacy Association Notification message to a Legacy 3DD as described in sections 7 and 12.1.4.

2. 3DG shall support the Legacy Association Notification message format described in section 7.4.

3. Upon successful completion of Proximity Association with a Legacy 3DD, the 3DG shall transmit the Legacy Association Notification message to the selected Legacy 3DD.

# 8 3D Broadcast

The 3DD broadcasts 3D timing information, including Frame Sync Instant, Frame Sync Period, and lens shutter open and close offsets, using the Connectionless Slave Broadcast Core feature [2]. The 3DG uses the Connectionless Slave Broadcast core feature to synchronize to the 3DD and receive this information for lens shutter control.

## 8.1 Connectionless Slave Broadcast Parameters

The Broadcast Period for Connectionless Slave Broadcast should be set to a value between 50-100 ms. The Broadcast LT_ADDR value 1 shall be acquired after reset and before any ACL connections are established.

## 8.2 Synchronization Train Parameters

Synchronization Train shall use GAP parameters unless noted below:

− Sync_Train_Duration should be 120 seconds or longer.

## 8.3 3D Broadcast Message Format

The format of the 3D Broadcast Message is shown in Table 8.1:

| Field | Position | Type | Value | Notes |
|---|---|---|---|---|
| Frame Sync Instant | Byte 0, bit 0 – Byte 3, bit 3 | UINT28 | Expressed in units of the 3DD Native Bluetooth Clock. | |
| Reserved | Byte 3, bits 4,5 | UINT2 | 0 | |
| Video Mode | Byte 3, bit 6 | Bit | 0 – 3D Mode 1 – Dual View Mode | In the Dual View Mode, the left lens shutter offsets are interpreted as offsets for video stream 1 and the right lens shutter offsets are interpreted as offsets for video stream 2. |
| Reserved | Byte 3, bit 7 | Bit | 0 | |
| Bluetooth clock phase at Frame Sync Instant (µs) | Bytes 4,5 | UINT16 | 0-312 | The value shall not be > 312. |
| Left lens shutter open offset (µs) | Bytes 6,7 | UINT16 | 0-65535 | Special value of 0xFFFF signals glasses are in 2D mode and both shutters shall be opened. When |

| Field | Position | Type | Value | Notes |
|---|---|---|---|---|
|  |  |  |  | the value of the Frame Sync Period is equal to 0, then this field shall be set to 0xFFFF. |
| Left lens shutter close offset (µs) | Bytes 8,9 | UINT16 | 0-65535 | |
| Right lens shutter open offset (µs) | Bytes 10,11 | UINT16 | 0-65535 | |
| Right lens shutter close offset (µs) | Bytes 12,13 | UINT16 | 0-65535 | |
| Frame Sync Period (µs) | Bytes 14,15 | UINT16 | 0-40000 | The value shall not be > 40000. |
| Frame Sync Period Fraction (1/256 µs) | Byte 16 | UINT8 | 0-255 | The fractional part of the Frame Sync Period |

*Table 8.1: 3D Broadcast Message Format*

## 8.4  3DD Requirements

1. 3DD shall start the collection of Frame Sync Instant and Frame Sync Period as described in section 4.

2. 3DD shall set up a Connectionless Slave Broadcast channel using the parameters described in section 8.1.

3. 3DD shall format the 3D Broadcast Message as described in section 8.3.

    a. The lens shutter open and close offsets shall be defined relative to the Frame Sync Instant. The lens shutter open offsets shall represent the time when the image displayed by the 3DD is ready for viewing by the 3DG. The lens shutter close offsets shall represent the time when the image displayed by the 3DD begins to transition from suitable for viewing to not suitable for viewing.

4. 3DD shall either continuously be in Synchronizable mode for the duration of the 3D Broadcast, or enter Synchronizable mode for a period equal to or greater than that specified in section 8.2 upon detecting a Slave Page Response Timeout event. 3DD should ignore Slave Page Response Timeout events if it is already in Synchronizable mode or if the 3D Broadcast is inactive.

## 8.5  3DG Requirements

1. 3DG shall perform Synchronization establishment with the 3DD with which it has completed Proximity Association.

2. If Synchronization is unsuccessful, 3DG shall perform a Truncated Page procedure with the 3DD with which it has completed Proximity Association and then retry Synchronization establishment

3. Within 500 ms after successfully completing Synchronization establishment, 3DG shall set up to receive the Connectionless Slave Broadcast transmission for the associated 3DD using the parameters for LT_ADDR 1 obtained from Synchronization establishment.

4. 3DG shall receive 3D Broadcasts and decode the 3D Broadcast Message in them using the format from section 8.3.

5. 3DG may skip receiving 3D Broadcasts to conserve power.

6. If the 3DG has skipped receiving 3D Broadcasts, but has not received them during several recent attempts, it should stop skipping intervals and attempt to receive every 3D Broadcast until a 3D Broadcast is received.

7. If the 3DG detects a significant loss of reception of the 3D Broadcast packets, it should repeat Synchronization establishment with the 3DD with which it has completed Proximity Association. The suggested threshold is 50% or greater failure of attempts to receive a 3D Broadcast. This behavior is recommended to facilitate dynamic AFH that might provide a solution to the loss of reception of the 3D Broadcast caused by RF interference.

8. 3DG shall use timing information from the 3D Broadcast Message to control the left and right lens shutters.

9. If 3DG loses, and cannot re-establish, reception of the 3D Broadcasts, it shall open both lens shutters when it has determined that the maximum shutter control timing error has increased beyond 500 µs as specified in section 9.3.

# 9  Shutter Timing Generation

The 3DG uses timing information from the 3D Broadcast Message to control the left and right lens shutters.

## 9.1  Lens Shutter Delays

The left and right lens shutter control timing information in the 3D Broadcast Message assumes idealized lens shutters opening and closing instantaneously. The manufacturers of 3DG need to understand the transmissivity response characteristic of their lens shutters and should compensate accordingly.

## 9.2  Supported Lens Shutter Frame Rates

3DG shall support the mandatory lens shutter frames rates per eye of 50 Hz and 59.94 Hz within a tolerance range of ±1%. 3DG should support a continuous, wide range of lens shutter frame rates to allow for greater interoperability.

3DG shall open both lens shutters if any of the following conditions are met:

1.  The 3D Broadcast Message informs a lens shutter frame rate that is outside the supported lens shutter frame rate range of the 3DG.

2.  The 3D Broadcast Message informs a lens shutter frame rate below 25 frames/second.

## 9.3  Lens Shutter Control Timing Accuracy

Actual testing of 3D systems has shown that when the synchronization timing error between the 3DD displayed images and the 3DG lens shutters increases beyond 500 µs, this out-of-sync condition becomes visually noticeable to the typical viewer. Therefore, if the maximum shutter control timing error has increased beyond 500 µs, both the left and right lens shutters of the 3DG shall be opened and shall be kept open until the 3DG has determined that the maximum timing error has decreased to ≤ 500 µs.

# 10 Core Specification Dependencies

This section describes additional requirements beyond those defined in the Bluetooth Core Specification [1] and the Bluetooth Core Specification Addendum 4 [2].

## 10.1 Link Manager Protocol (LMP) Requirements

This section describes LMP requirements for 3DD and 3DG beyond those defined in [2].

| Feature | Support in 3DD | Support in 3DG |
|---|---|---|
| Connectionless Slave Broadcast – Master Operation | M | X |
| Connectionless Slave Broadcast – Slave Operation | X | M |
| Synchronization train | M | X |
| Synchronization Scan | X | M |

*Table 10.1: Link Manager Protocol Requirements*

## 10.2 Logical Link Control and Adaptation Protocol (L2CAP) Requirements

This section describes L2CAP requirements for 3DD and 3DG beyond those defined in [2].

| Feature | Support in 3DD | Support in 3DG |
|---|---|---|
| Unicast Connectionless Data Reception | C.1 | N/A |
| Unicast Connectionless Data Transmission | N/A | C.2 |

*Table 10.2: Logical Link Control and Adaptation Protocol Requirements*

C.1 Mandatory if Association Notification Reception or Battery Level Reporting Reception is supported, otherwise optional.

C.2 Mandatory if Association Notification Transmission or Battery Level Reporting Transmission is supported, otherwise optional.

## 10.3 Generic Access Profile (GAP) Requirements

This section describes GAP requirements for 3DD and 3DG beyond those defined in [2].

| Feature | Support in 3DD | Support in 3DG |
|---|---|---|
| Synchronizable Mode | M | X |
| Non-Synchronizable Mode | M | M |
| Synchronization Establishment Procedure | M | M |
| General Discoverable Mode | M | X |
| Connectable Mode | C.1 | X |

*Table 10.3:* Generic Access Profile Requirements

C.1 Mandatory IF (Association Notification Reception is supported OR Battery Level Reporting Reception is supported OR 3DD is not continuously in Synchronizable mode); otherwise optional.

## 10.4  Service Discovery Protocol (SDP) Requirements

The following service records are defined for the 3DD and 3DG roles of the 3D Synchronization Profile. There shall be only one service record for each supported role. The device shall support at least one service record on the device for the applicable role(s) supported.

### 10.4.1 SDP record for the 3DD role

| Item | Definition | Type | Value | Status | Default |
|------|-----------|------|-------|--------|---------|
| ServiceClassID List | | | [Note 1] | M | |
| ServiceClass #0 | | UUID | 3D Display [Note 1] | M | |
| ServiceName | Displayable text name | String | Service-provider defined | O | "3D Display" |
| Bluetooth Profile Descriptor List | | | [Note 1] | M | |
| Profile #0 | Supported Profiles | UUID | 3D Sync Profile [Note 1] | M | |
| Param #0 | Profile Version | UINT16 | 0x0100 | M | |

*Table 10.4:* SDP Record for 3DD Role

Note 1: For actual values for this field please refer to the Bluetooth Assigned Numbers section of the Bluetooth SIG website [3].

### 10.4.2 SDP record for the 3DG role

| Item | Definition | Type | Value | Status | Default |
|------|-----------|------|-------|--------|---------|
| ServiceClassID List | | | [Note 1] | M | |
| ServiceClass #0 | | UUID | 3D Glasses [Note 1] | M | |
| ServiceName | Displayable text name | String | Service-provider defined | O | "3D Glasses" |
| Bluetooth Profile Descriptor List | | | [Note 1] | M | |
| Profile #0 | Supported profiles | UUID | 3D Sync Profile [Note 1] | M | |
| Param #0 | Profile version | UINT16 | 0x0100 | M | |

*Table 10.5:* SDP Record for 3DG Role

Note 1: For actual values for this field please refer to the Bluetooth Assigned Numbers section of the Bluetooth website [3].

# 11 References

[1]   Specification of the Bluetooth System, Core Package Version 3.0 + HS or 4.0 or later.
[2]   Bluetooth Core Specification Addendum 4
[3]   Bluetooth Assigned Numbers (http://www.bluetooth.org/assigned-numbers)
[4]   Bluetooth Core Specification Supplement v2 or later

# 12 Appendix: Reference Protocol

The Reference Protocol includes over-the-air interactions between one Legacy 3DD and one or more pairs of Legacy 3DGs.

The Reference Protocol delivers the following 4 services.

- Association
- Synchronization establishment
- 3D synchronized operation
- External clock capture and generation

## 12.1 Association

During association, the Legacy 3DG (and the user) finds and selects the desired Legacy 3DD. This service requires 2 actions from the user:

1) Some action (such as a button press) to initiate the procedure at the Legacy 3DG.

2) Make sure the Legacy 3DG is physically close to the desired Legacy 3DD.

The Legacy 3DG responds to the above actions by associating with the Legacy 3DD that exhibits the lowest path loss as calculated by the difference between the Legacy 3DD transmitted power (reported in the EIR) and the Legacy 3DG received power. Note that the EIR transmitted from the Legacy 3DD also contains a path loss threshold that is used by the Legacy 3DG to prevent it from associating with the Legacy 3DD unless the path loss falls below this threshold.

The procedure requires three steps:

1. The Legacy 3DG sends a general inquiry and collects EIR data from all responding devices that have a specific Class of Device as specified in section 12.1.1and a correctly-formatted 3D EIR data type.

2. The Legacy 3DG calculates path loss for each Legacy 3DD. If one or more Legacy 3DDs satisfy the path loss threshold, the Legacy 3DG selects the Legacy 3DD with the lowest path loss to associate with.

3. The Legacy 3DG sends a second general inquiry, waits for the EIR from the selected Legacy 3DD, and responds with a Reference Protocol Association Notification message.

## Top Level Sequence Diagram

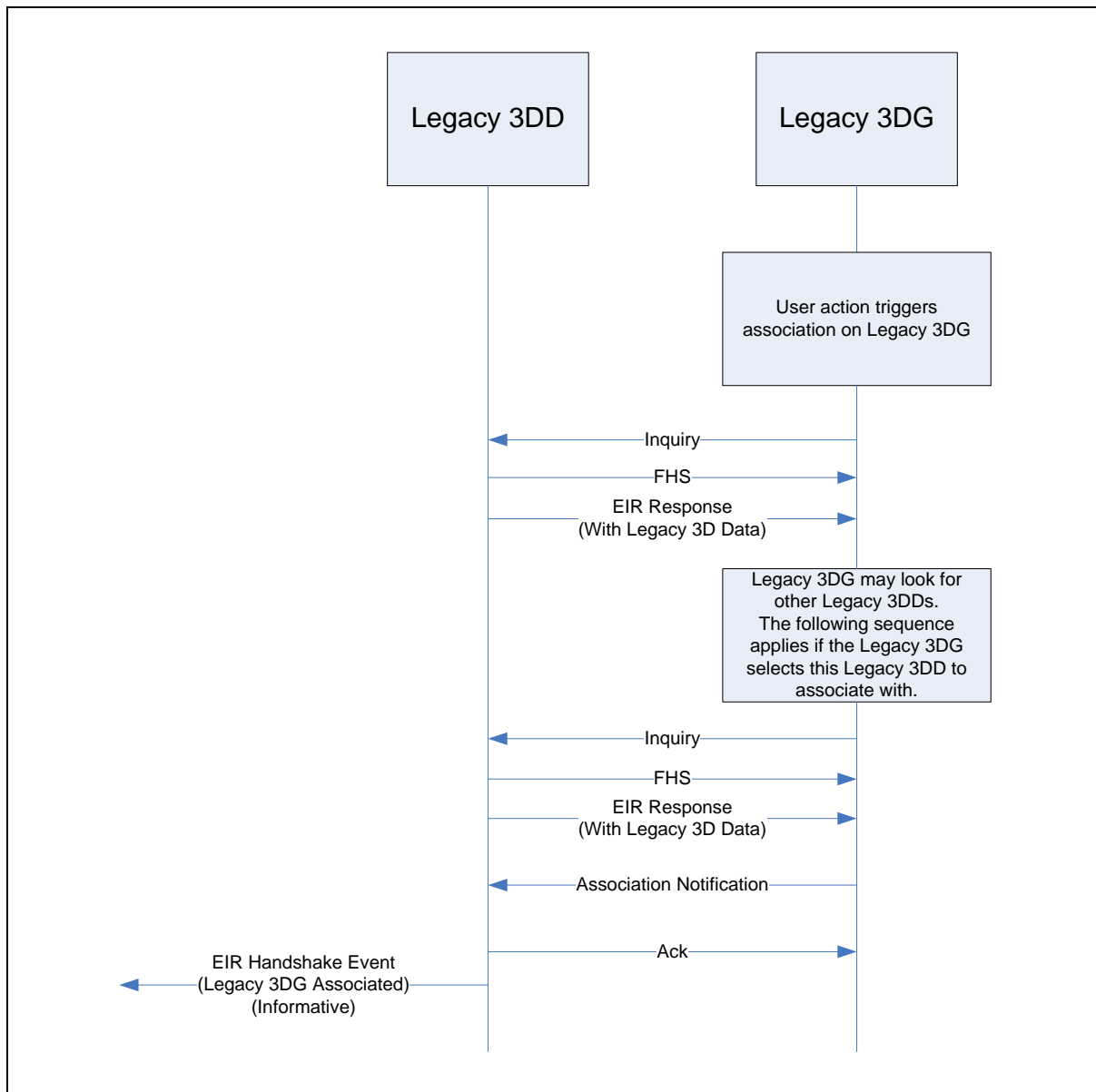Figure 12.1 illustrates how a Legacy 3DG associates with a Legacy 3DD.



*Figure 12.1: Association – Sequence Diagram*

## 12.1.1 FHS Packet Format

Table 12.1 specifies the detailed format of the FHS packet provided by the Legacy 3DD to the Legacy 3DG in response to the inquiry. All fields in this packet are formatted, transmitted, and processed according to the Bluetooth Core specification.

| Field | # of bits | Value | Notes | Legacy 3DG Behavior |
|---|---|---|---|---|
| Parity Bits | 34 | derived from Legacy 3DD LAP | | |
| LAP | 24 | Legacy 3DD LAP | | |
| EIR | 1 | 1 | | |
| Un-defined | 1 | 0 | | |
| SR | 2 | 01 | R1 | Legacy 3DG does not use this parameter for association or Association Notification. |
| Reserved | 2 | 00 | | |
| UAP | 8 | Legacy 3DD UAP | | |
| NAP | 16 | Legacy 3DD NAP | | |
| Class of device | 24 | 0x00043C or 0x08043C | | Legacy 3DG only accepts these 2 values during association. |
| LT_ADDR | 3 | 000 | | |
| $CLK_{27-2}$ | 26 | Legacy 3DD CLK | | |
| Page scan mode | 3 | 000 | | |

*Table 12.1: FHS packet format*

Table 12.2 specifies the values to use for the Class of Device field.

| Field | Value | Description |
|---|---|---|
| Major Service Class | 00000000000b or 00001000000b | Unspecified or Capturing |
| Major Device Class | 00100b | Audio/Video |
| Minor Device Class | 001111b | Video Display and Loud Speaker |

*Table 12.2: Class of Device field*

## 12.1.2 Reference Protocol 3D Information EIR Data Format

Table 12.3 lists the Reference Protocol 3D Information data provided by the Legacy 3DD to the Legacy 3DG in an extended inquiry response (EIR). Note that Reference Protocol 3D Information must appear somewhere in the EIR data, i.e., other EIR data can and typically will also be provided.

Note also that the TX power parameter is a standard parameter in the table below and is not part of the manufacturer specific data. This field must be present in EIR but does not need to be immediately after the manufacturer specific section.

*Bluetooth 3D Synchronization Profile*

| EIR Data Type | Field | Type | Value | Notes | Legacy 3DD Behavior Notes | Legacy 3DG Behavior Compatibility |
|---|---|---|---|---|---|---|
| Manufacturer Specific Data | Length-Manufacturer | UINT8 | 6 | # of bytes in this data | | Required by Legacy 3DGs. |
| | Manufacturer Specific | UINT8 | 0xFF | | | Required by Legacy 3DGs. |
| | Manufacturer | UINT16 | 0x000F | Broadcom (little endian) | | Required by Legacy 3DGs. |
| | Reserved | UINT8 | 0 | | Must set to 0 | Required by Legacy 3DGs. |
| | Multicast Capable TV | bit 0 | 1 | | 1 – Multicast capable 0 – Not multicast capable | Required by Legacy 3DGs (set to 1). |
| | Reserved | bit 1 | 0 | | | Ignored by Legacy 3DGs. |
| | Sending Sync Train | bit 2 | 0 | | 1 - Legacy 3DD sending sync trains 0 – Legacy 3DD not sending sync trains | Ignored by Legacy 3DGs. |
| | Remote Paired | bit 3 | | | 0 – no remote paired 1 – remote paired | Ignored by Legacy 3DGs. |
| | Showroom Mode | bit 4 | | | 0 – Showroom mode disabled 1 – Showroom mode enabled | Required by Legacy 3DGs. |
| | Remote Pairable Mode | bit 5 | | | 0 – Not in remote pairable mode 1 – In remote pairable mode | Ignored by Legacy 3DGs. |
| | Reserved | bit 6 | 0 | | | Required by Legacy 3DGs. |
| | Test Mode | bit 7 | 0 | | 0 – Normal mode 1 – Legacy 3DD is in factory 3DG test mode. See Note 1 below | Used by Legacy 3DGs during factory testing. |
| | Path loss threshold | UINT8 | 60-100 (typical) | In dB. See Note 2 below | | Required by Legacy 3DGs for path loss calculations. |
| Tx Power Level | Length-TX Power | UINT8 | 2 | # of bytes in this data | | Required by Legacy 3DGs. |
| | TX Power ID | UINT8 | 0x0A | Assigned number | | Required by Legacy 3DGs. |
| | TX Power Value | INT8 | 0-10 (typical) | In dBm. See Note 3 below | Set to the default TX power of the Legacy 3DD. | Required by Legacy 3DGs. |

*Table 12.3: Format of Reference Protocol 3D Information EIR Data from Legacy 3DD to Legacy 3DG*

Note 1: Factory test mode is for manufacturing convenience. Support of this mode and device behavior in this mode is up to the manufacturer.

Note 2: Max allowable path loss from Legacy 3DD to Legacy 3DG. If the calculated path loss is greater than this threshold, the Legacy 3DG will conclude that the Legacy 3DD in question is too distant and will continue to search for a closer proximity Legacy 3DD.

Note 3: Legacy 3DGs incorrectly interpret the value of this field as an unsigned integer. In order to maximize interoperability, a 3DD should set this field to a value between 0 and 127.

## 12.1.3 Reference Protocol Association Notification

The Legacy 3DD listens for a Reference Protocol Association Notification immediately after sending the EIR. After selecting the Legacy 3DD, the Legacy 3DG performs an inquiry and waits for an EIR from the selected Legacy 3DD. The Legacy 3DG recognizes the selected Legacy 3DD based only on the BD_ADDR of the Legacy 3DD. The Legacy 3DG then sends the Reference Protocol Association Notification message. The Legacy 3DD sends an Ack to acknowledge the Reference Protocol Association Notification message with a NULL packet as specified by Table 12.3. Once the Ack is received, the Reference Protocol Association Notification is complete. Typically, upon successful Reference Protocol Association Notification, a visual confirmation on the Legacy 3DD would be displayed to the user.

If the Legacy 3DG does not receive the Ack, it continues the inquiry procedure and attempts to deliver the message if it receives another inquiry response from the targeted Legacy 3DD. If the inquiry times out, the Legacy 3DG repeats the inquiry and association notification procedure a configurable number of times before giving up. Even if the Reference Protocol Association Notification fails, the Legacy 3DG unit considers itself associated with the Legacy 3DD. The Legacy 3DD does not change over-the-air behavior based on Legacy 3DG(s) associating or not.

The Reference Protocol Association Notification packet and Ack is transmitted using the same channel as the EIR packet.

The Reference Protocol Association Notification packet should be transmitted with the same output power as the associated ID packet.

The Reference Protocol Association Notification Ack packet should be transmitted with the same output power as the EIR packet.

The Legacy 3DG sends the Reference Protocol Association Notification message in a DM1 packet. The Reference Protocol Association Notification message is specified in Table 12.4.

| Packet Entity | Field | Value | Notes | Compatibility |
|---|---|---|---|---|
| Access Code | Sync Word | Derived from the Legacy 3DD LAP. See Note 1 | | Required by Legacy 3DDs. |
| Packet Header (Whitening Disabled) (Required by Legacy 3DD) | LT_ADDR | 1 | | Required by Legacy 3DDs. |
| | TYPE | DM1 | | Required by Legacy 3DDs. |
| | FLOW | 0 | | Ignored by Legacy 3DDs. |
| | ARQN | 0 | | Ignored by |

*Bluetooth 3D Synchronization Profile*

| Packet Entity | | Field | Value | Notes | Compatibility |
|---|---|---|---|---|---|
| | | | | | Legacy 3DDs. |
| | | SEQN | 0 | | Ignored by Legacy 3DDs. |
| | | HEC | Derived from the Legacy 3DD UAP | | Required by Legacy 3DDs. |
| Payload (Whitening Disabled) | Payload Header | LLID | 2 | | Ignored by Legacy 3DDs. |
| | | FLOW | 0 | | Ignored by Legacy 3DDs. |
| | | LENGTH | 17 | | Required by Legacy 3DDs. |
| | Payload Body | 6 bytes used by the Legacy 3DG for the 3DG BD Address | BD_ADDR of Legacy 3DG | | Field is required by Legacy 3DDs but the contents can be any value. |
| | | Device/Service Type | 0 – 3DG 1-255 – Reserved | UINT8 | Required by Legacy 3DDs. |
| | | Reserved | 0x00 | 10 Bytes | Ignored by Legacy 3DDs. |

*Table 12.4: Format of the Reference Protocol Association Notification Message from Legacy 3DG to Legacy 3DD*

Note 1: This can create potential timing issues with other slaves (primarily slaves in long sniff/park) on the Legacy 3DD piconet as they might sync to this packet accidently. This requires a match of the hop frequency (probability =1/79) and a timing alignment that depends on the sniff interval of the slave device. Typically slaves would also look for a valid HEC which may match by accident as whitening is disabled on this packet (probability=1/256). An LT_ADDR check may or may not be done (probability=1/8), which would further reduce the possibility of this match.

The Reference Protocol Association Notification Ack is specified in Table 12.5.

| Packet Entity | Field | Value | Notes | Compatibility |
|---|---|---|---|---|
| Access Code | Sync Word | Derived from the Legacy 3DD LAP | | Required by Legacy 3DGs. |
| Packet Header (Whitening Disabled) | LT_ADDR | 1 | | Required by Legacy 3DGs. |
| | TYPE | NULL | | Ignored by Legacy 3DGs. |
| | FLOW | 0 | | Ignored by Legacy 3DGs. |
| | ARQN | 1 | | Required by Legacy 3DGs. |
| | SEQN | 0 | | Ignored by Legacy 3DGs. |
| | HEC | Derived from the Legacy 3DD UAP | | Required by Legacy 3DGs. |

*Table 12.5: Format of the Reference Protocol Association Notification Ack from Legacy 3DD to Legacy 3DG*

### 12.1.4 Reference Protocol Association Notification Packet Timing

In a standard Bluetooth inquiry procedure, the slave snaps its clock phase to match the master's clock when the slave receives an ID packet from the master. This allows the slave to transmit an FHS packet and an EIR packet at fixed delays from when it received the ID packet. However, the slave cannot determine if it received the ID packet in the first or the second half slot of the inquiry. Therefore, the Legacy 3DD cannot determine when to listen for the Reference Protocol Association Notification packet and so it is up to the Legacy 3DG to transmit the Reference Protocol Association Notification packet at a time that makes reception of the packet equally probable from the perspective of the 3DD.

The Reference Protocol Association Notification packet is transmitted in the 2<sup>nd</sup> slot after the reception of the EIR as specified in Figure 12.2 and Figure 12.3 below and section 12.1.4.3.

#### 12.1.4.1 First Half Slot
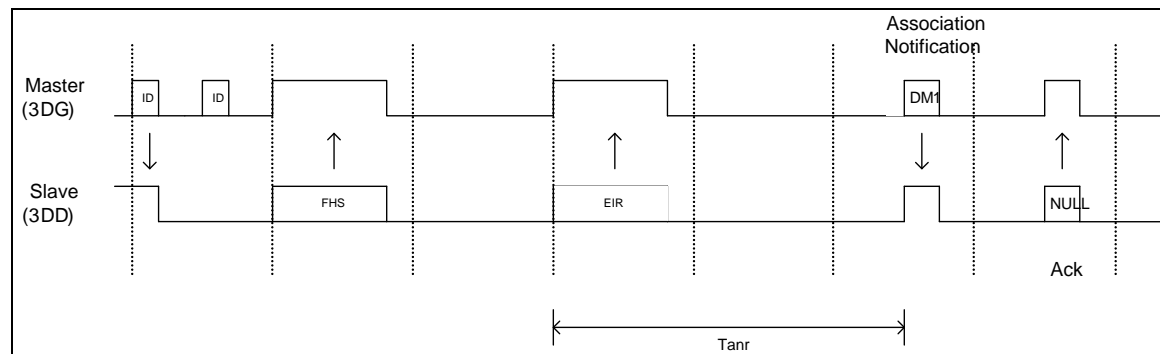


*Figure 12.2: First half slot timing (single slot EIR shown)*

#### 12.1.4.2 Second Half Slot
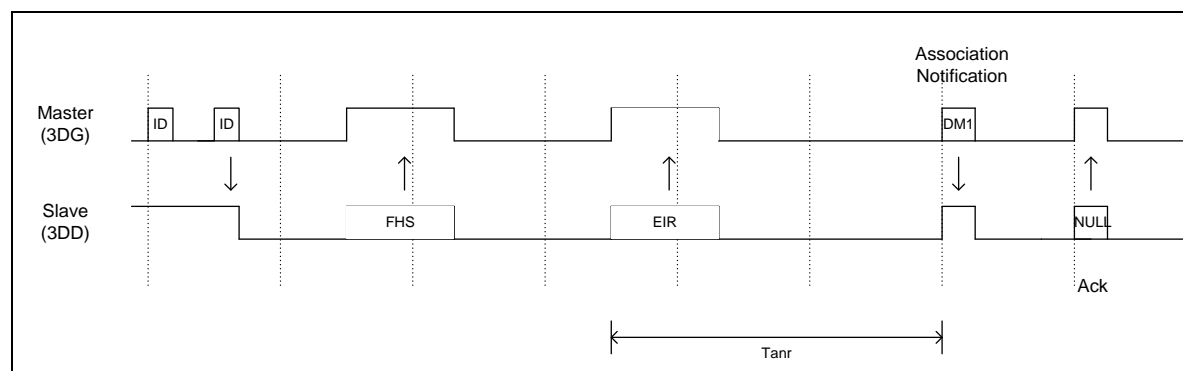


*Figure 12.3: Second half slot timing (single slot EIR shown)*

#### 12.1.4.3 Timing Offset from EIR

The parameter $T_{anr}$ (Association Notification Response Time) is defined as the timing offset from the start of the EIR packet to the start of the Reference Protocol Association

Notification packet and depends on the EIR packet type. The $T_{anr}$ depends on the EIR packet type, the length of the packet, and the role of the device.

Table 12.6 and Table 12.7 provide the combinations of $T_{anr}$ values for different packet types/lengths used by Legacy 3DDs and Legacy 3DGs to receive/transmit Reference Protocol Association Notification. These tables should be referenced and used to maximize interoperability of Legacy Association Notification transmission and reception between a 3DD and 3DG.

| EIR Packet Length (Bytes) | Packet Type | 3DD $T_{anr}$ (Receive) (ms) | 3DG $T_{anr}$ (Transmit) (ms) | Association Notification Interoperability |
|---|---|---|---|---|
| 0x09-0x11 | DM1 | 1.5625 | 1.5625 | High |
| 0x11-0x1b | DM3 | 1.5625 | 1.5625 | High |
| 0x1c | DM3 | 1.5625 | 1.5625 | Low |
| 0x1d-0x4e | DM3 | 1.5625 | 1.5625 | High |
| 0x4f-0x51 | DM3 | 1.5625 | 1.5625 | Low |
| 0x52-0x56 | DM3 | 1.5625 | 2.8125 | Low |
| 0x57-0x6d | DM3 | 2.8125 | 2.8125 | Low |
| 0x6e-0x79 | DM3 | 2.8125 | 2.8125 | High |

*Table 12.6: $T_{anr}$ Values for DMx Packets*

| EIR Packet Length (Bytes) | Packet Type | 3DD $T_{anr}$ (Receive) (ms) | 3DG $T_{anr}$ (Transmit) (ms) | Association Notification Interoperability |
|---|---|---|---|---|
| 0x0b-0x1b | DH1 | 1.5625 | 1.5625 | High |
| 0x1c | DH3 | 1.5625 | 1.5625 | Low |
| 0x1d-0x36 | DH3 | 1.5625 | 1.5625 | High |
| 0x37 | DH3 | 1.5625 | 1.5625 | Low |
| 0x38-0x51 | DH3 | 1.5625 | 1.5625 | High |
| 0x52 | DH3 | 1.5625 | 1.5625 | Low |
| 0x53-0x59 | DH3 | 1.5625 | 1.5625 | High |
| 0x5a-0x7d | DH3 | 1.5625 | 1.5625 | Low |
| 0x7e-0x83 | DH3 | 1.5625 | 2.8125 | Low |
| 0x84-0xb6 | DH3 | 2.8125 | 2.8125 | Low |

*Table 12.7: $T_{anr}$ Values for DHx Packets*

### 12.1.4.3.1 Recommendations for Timing Offsets from EIR for Bluetooth 3D Devices

The use of DM5 and DH5 packets on 3DD for EIR is not recommended.

Some of the packet type/length combinations listed in the tables above have different $T_{anr}$ values for 3DD reception and for 3DG transmission of Legacy Association Notification. To maximize interoperability, it is recommended that 3DD implementations use the $T_{anr}$ value that is recommended for the 3DG for a given EIR packet type/length, and 3DG implementations use the $T_{anr}$ value that is recommended for the 3DG for a given EIR packet length/type.

To maximize interoperability, the 3DD should preferably use DMx packet types instead of DHx packet types. This can be configured at the HCI level by setting the FEC_Required parameter to "FEC required" in the HCI_Write_Extended_Inquiry_Response command.

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To further improve interoperability, it is recommended that 3DD limit their EIR length and packet types to one of the combinations listed in Table 12.8.

| EIR Packet Length (Bytes) | Packet Type |
|---|---|
| 0x0a-0x11 | DM1 |
| 0x11-0x1b | DM3 |
| 0x1d-0x4e | DM3 |
| 0x6e-0x79 | DM3 |

*Table 12.8: Recommended 3DD EIR Packet Lengths and Types*

The EIR length 0x1c should be avoided. Note: BR/EDR Controllers may truncate any octets of 0x00 at the end of an EIR packet, which may cause a longer packet to contain a length field shorter than what was provided by the Host.

## 12.2 Synchronization Establishment

This section describes how the Legacy 3DG obtains initial sync to the 3D beacon from the Legacy 3DD.

### 12.2.1 Top Level Sequence Diagram

The top level sequence diagram Figure 12.4 shows the sequence of actions used by a Legacy 3DG to synchronize to the Legacy 3D beacon.
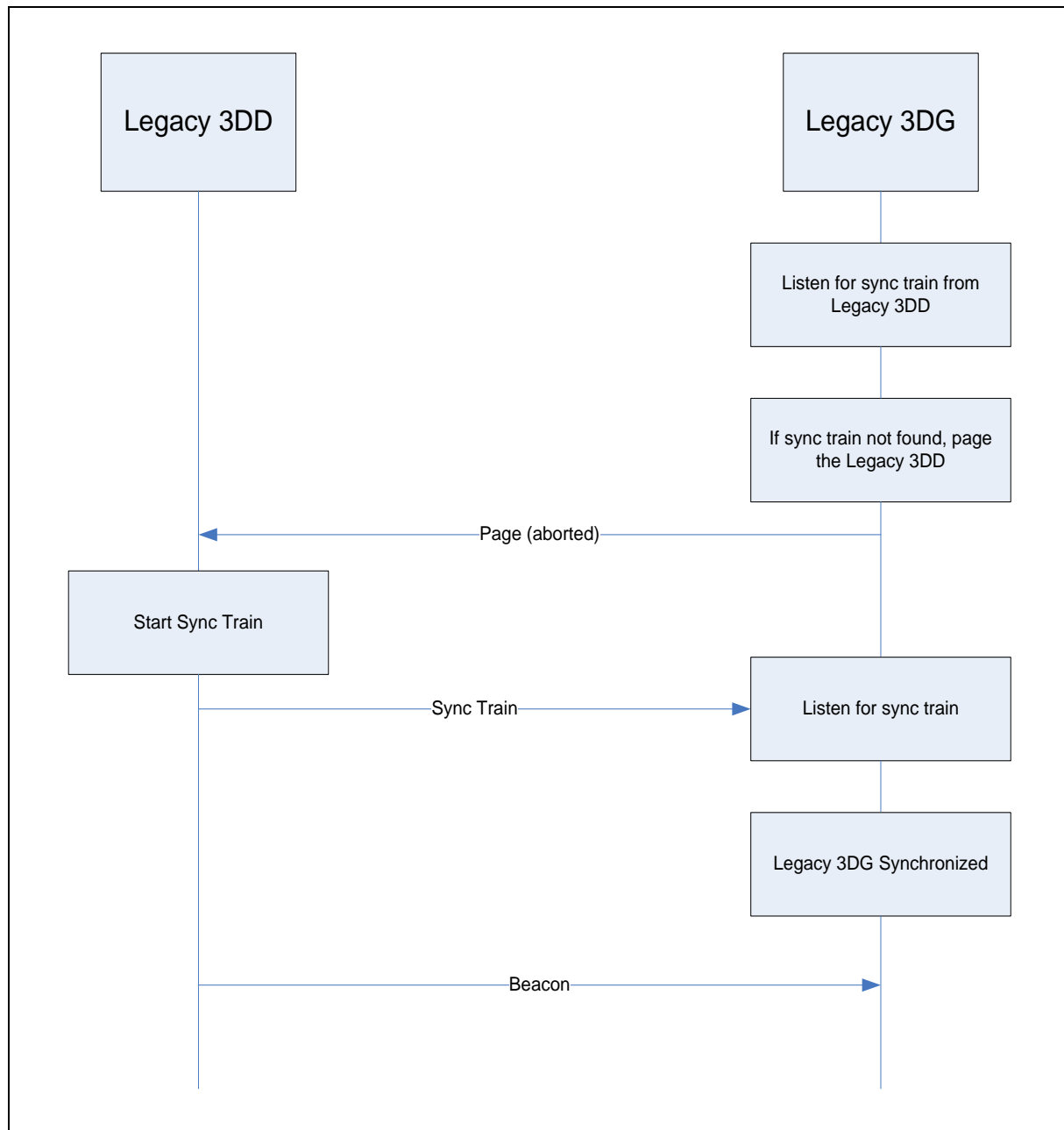
*Figure 12.4: Synchronization Procedure*

1.  The Legacy 3DG starts by listening for the synchronization train from the Legacy 3DD. The synchronization train is a periodic sequence of packets generated in the controller and sent by the Legacy 3DD.

2.  If the synchronization train is not found, the Legacy 3DG will page the Legacy 3DD but abort the connection. This acts as a trigger to the 3DD to start the synchronization train.

3.  The Legacy 3DG listens again for the synchronization train. This train has all the necessary information for the Legacy 3DG to synchronize to and receive the 3D beacon from the Legacy 3DD. The 3D beacon contains the synchronization

information packets periodically generated by the Legacy 3DD host and broadcast by the Legacy 3DD controller.

4. Legacy 3DG are now synchronized to the Legacy 3DD's 3D beacon.

The following sections specify how the page sequence is aborted to trigger the synchronization train. In both cases, the synchronization train shall be triggered when no FHS packet is received for the number of slots defined in the baseband timer, pagerespTO.

### 12.2.1.1  First Half Slot Sync Train Trigger
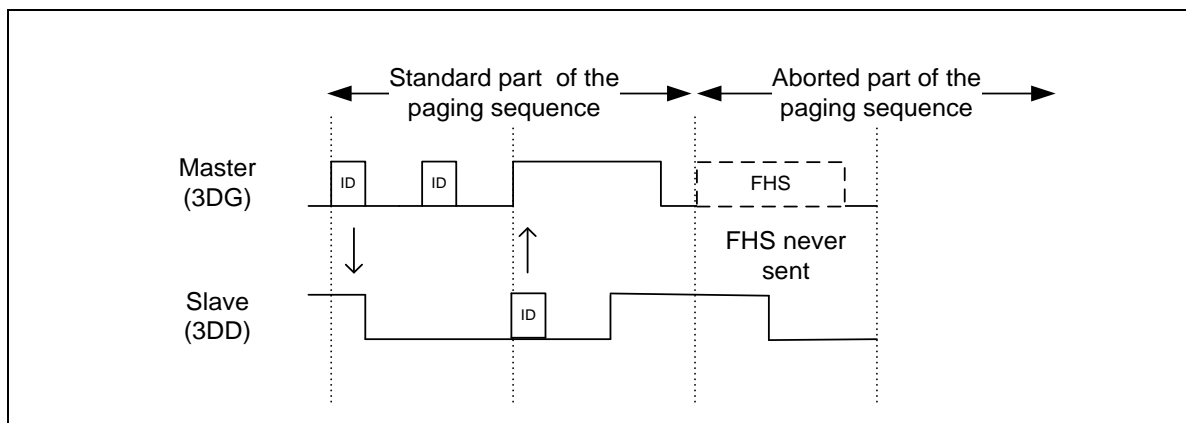


*Figure 12.5: First half slot sync train trigger timing*

### 12.2.1.2  Second Half Slot Sync Train Trigger
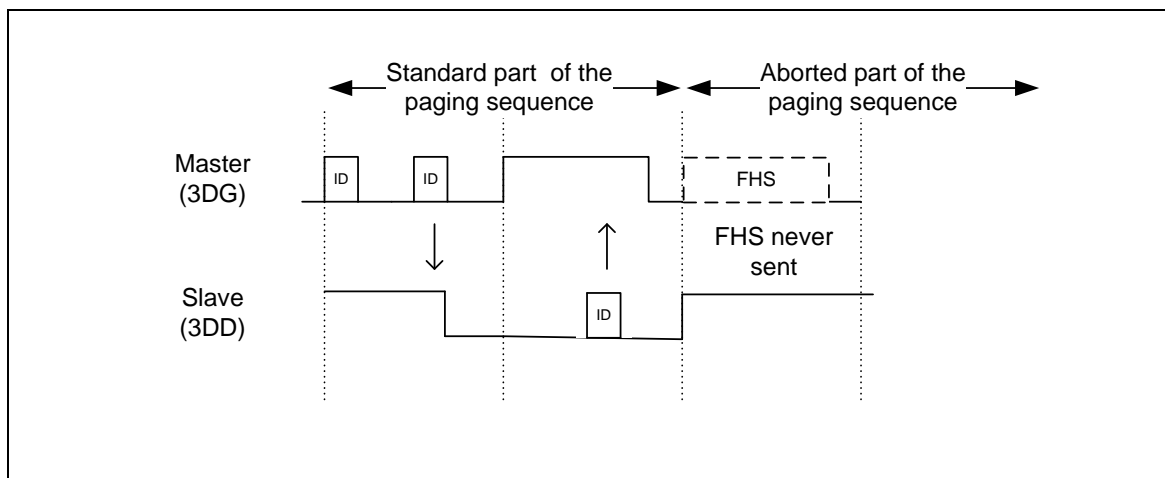


*Figure 12.6: Second half slot sync train trigger timing*

## 12.2.2 Synchronization Train

The synchronization train is a periodic sequence of DM3 packets sent on specific frequencies. Figure 12.7 below illustrates an example of the synchronization train timing.
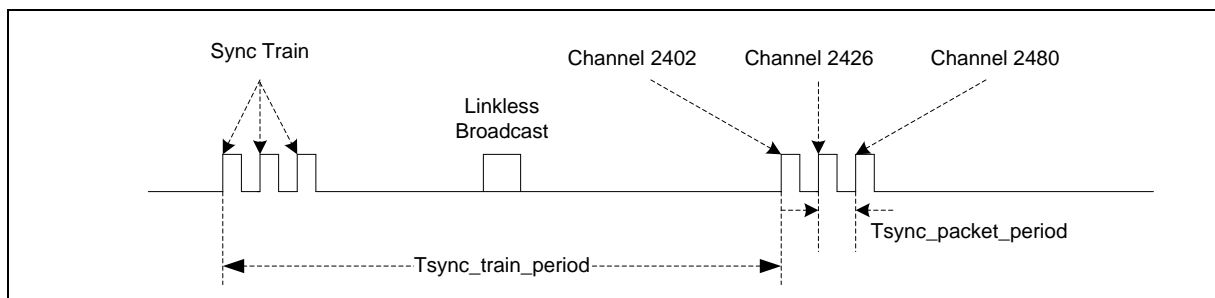
*Figure 12.7: Synchronization train frequency and timing example.*

$T_{sync\_train\_period}$, the period between sync train instants, is 80 ms. Three packets are transmitted at every Sync Train instant, with the first on channel 2402, second on channel 2426, and third on channel 2480. The use of three channels is for redundancy. As long as reception on one of the channels is successful, the system will work. $T_{sync\_packet\_period}$ is defined as the time from the start of a sync train packet to the start of the next sync train packet in the same sync train instant. In the Reference Protocol, $T_{sync\_packet\_period}$ = 1 slot pair. But $T_{sync\_packet\_period}$ = 1 slot pair is not required to be backward compatible. To be backward compatible, $T_{sync\_packet\_period}$ is limited only by the requirement that the Legacy 3DD shall send 3 sync train packets every $T_{sync\_train\_period}$. It is recommended that on any single channel, the sync train packet is sent at a periodic interval of $T_{sync\_train\_period}$.

Legacy 3DG products scan for the sync train by receiving continuously on each channel for 103.75 ms. Each channel is scanned in turn until the sync train is detected or a timeout defined by the host application is reached. The timeout for Legacy 3DG varies and is in the range of 1-5 seconds depending on the Legacy 3DG model. Legacy 3DG scan for the sync train as follows:

1. Start timeout timer
2. Scan 3 frequencies for 103.75 ms each
3. If sync message is received,
    1. Stop timeout timer
    2. proceed to synchronized operation (beacon reception)
4. Else, (no sync message is detected),
    a) Trigger sync train by paging (continue until ID received or timeout)
    b) If ID received,
        i.   Then Scan for sync train until resync or timeout
        ii.  If sync message received,
            1. Stop timeout timer
            2. proceed to synchronized operation
    c) Else, (timeout expires),
        i. Enter low power mode

Table 12.9 and Table 12.10 provide the parameters of the reconnect train and its format. All packet fields are transmitted least significant byte first. All bytes are transmitted least significant bit first.

| Train Parameter | Values | Comments | Compatibility |
|---|---|---|---|
| Frequencies | 2402, 2426, 2480 | One DM3 per frequency per period sent in master slot | Legacy 3DGs only scan these 3 frequencies. |
| Tsync_train_period | 80ms | | Legacy 3DDs use 80 ms. Legacy 3DGs scan for 103.75 ms. Legacy 3D product implementations should work with sync train transmit periods between 10- 100 ms. |
| Duration | 120 seconds | Train is only sent for a short interval to allow Legacy 3DG to sync. This minimizes RF interference for other devices | 120 seconds is not a requirement. The duration depends only on use case, power consumption requirements, and required probability of detection. |

*Table 12.9: Synchronization Train Parameters*

| Packet Entity | | Field | Value | Notes | Compatibility |
|---|---|---|---|---|---|
| Access Code | | Sync Word | Derived from the Legacy 3DD LAP | | Required by Legacy 3DGs. |
| Packet Header (Whitening Disabled) | | LT_ADDR | 0 | | Legacy 3DGs can accept any LT_ADDR. |
| | | TYPE | DM3 | | Required by Legacy 3DGs.<br><br>Other packet types will be dropped. See Note 1. |
| | | FLOW | 0 | | Legacy 3DGs can accept 0 or 1. |
| | | ARQN | 0 | | Legacy 3DGs can accept 0 or 1. |
| | | SEQN | 0 | | Legacy 3DGs can accept 0 or 1. |
| | | HEC | Derived from the Legacy 3DD UAP | | Required by Legacy 3DGs. |
| Payload (Whitening Disabled) | Payload Header | LLID | 2 | | Legacy 3DGs can accept any LLID. Ignored by Legacy 3DGs. |
| | | FLOW | 0 | | Legacy 3DGs can accept 0 or 1. |
| | | LENGTH | 28 | | Legacy 3DGs can accept 28 to 121 byte packets. Additional bytes beyond 28 bytes are ignored. |
| | Payload Body | Current clock | Snapshot of bits 27:0 of the current Legacy 3DD Bluetooth clock | 4 Bytes | Required by Legacy 3DGs. Upper 4 bits of the 4-byte field |

| Packet Entity | | Field | Value | Notes | Compatibility |
|---|---|---|---|---|---|
| | | | | | are not used (masked out). |
| | | Next Beacon clock | Bits 27:1 of the Legacy 3DD Bluetooth clock/2 at the next beacon transmission (units of slots) | 4 Bytes | Required by Legacy 3DGs. Upper 5 bits of the 4 bytes field shall be zero. |
| | | AFH Channel Map | AFH channel map used for the beacon transmissions | 10 Bytes | Required by Legacy 3DGs. The format used is as defined in the LMP specification. Bit 79 is set to zero by the Legacy 3DD and ignored by the Legacy 3DG. |
| | | 3DD BD Addr | Legacy 3DD BD_ADDR | 6 Bytes | Required by Legacy 3DGs. |
| | | Beacon Interval | In number of slots | 2 Bytes, (current products use 128 slots = 80 ms) | This field is required by Legacy 3DG but values other than 80 ms (e.g., 60-100 ms) should work. |
| | | Version | 1 | 1 Byte | Ignored by Legacy 3DGs. |
| | | Display ID | 0: Home use 1: Cinema use 2-255: Reserved for future use | UINT8 | Some Legacy 3DGs use a value of 1 as a Cinema mode. LEDs are typically disabled in Cinema mode. Some Legacy 3DGs also treat any value greater than 0 as Cinema mode. |

*Table 12.10: Synchronization Train Message Format*

## 12.3 3D Synchronized Operation

After the Legacy 3DG has established synchronization with the host controller 3D beacon, it maintains sync by periodically listening to the beacon and adjusting its 3D shutter timing based on the information in the beacons. Legacy 3DGs listen for the beacon every 560 ms (7 times the Beacon Interval). If the Legacy 3DG fails to detect a beacon at that time, then it listens every 80 ms (1 times the Beacon Interval). If the Legacy 3DG fails again to detect the beacon, it will continue to listen for beacons with a timeout of 5 seconds, after which it will return to a disconnect state. Subsequent behavior of Legacy 3DG varies by model; some attempt to resynchronize immediately while others go into a low power state until the user initiates resynchronization (profile behavior).
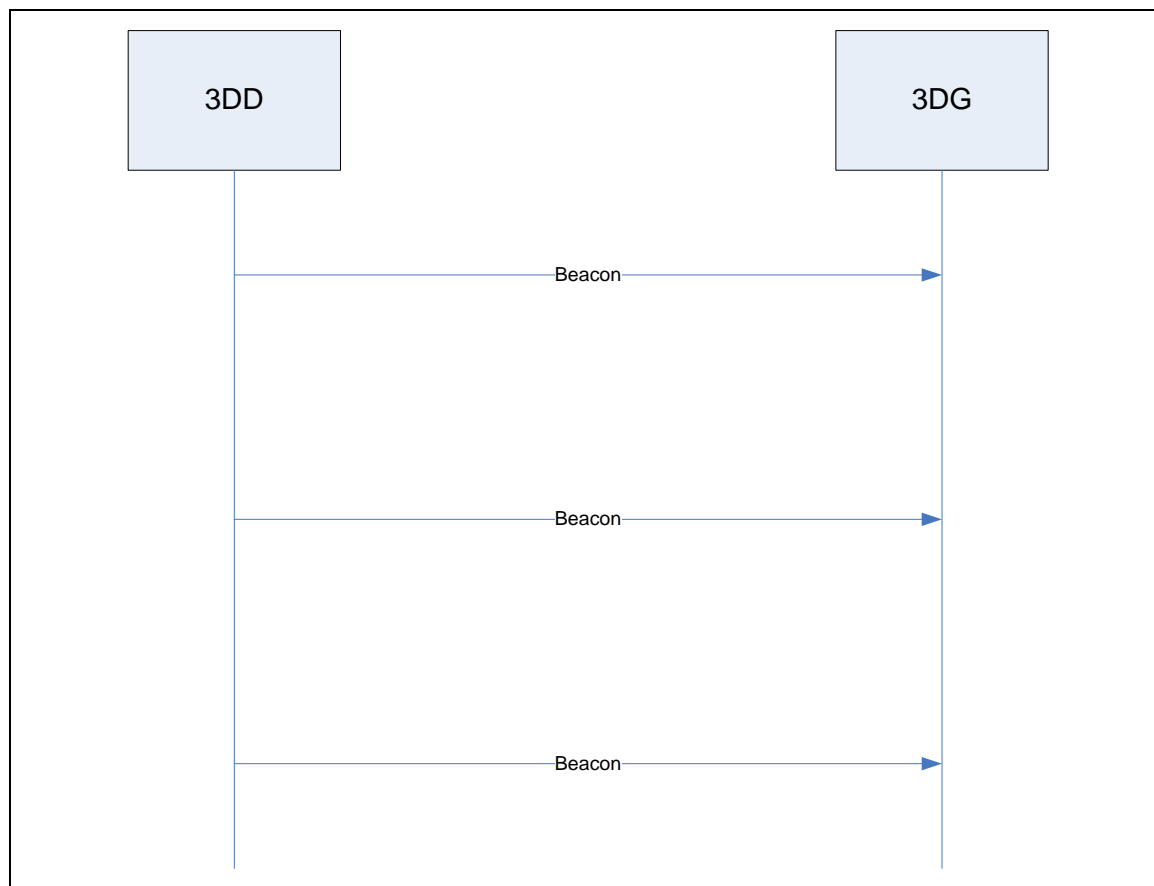
*Figure 12.8: 3D Synchronized Operation*

### 12.3.1 Beacon Format

The beacon provides 3D timing information to the Legacy 3DG listening to it. It provides the Frame Sync rising edge relative to the Legacy 3DD Bluetooth clock and shutter control timing relative to Frame Sync (also relative to the Legacy 3DD Bluetooth clock).

All values in the following tables are in little-endian format.

Table 12.11 describes the contents of the Beacon Packet payload used by the Reference Protocol. Any change to the contents of this profile should be specified at the profile level.

| Field | Type/Size | Size | Comments |
|-------|-----------|------|----------|
| Bluetooth clock at rising edge of Frame Sync | Bits[27:0] (Unsigned) | 28 bits | Includes 4 LSB of the most significant Byte. |
| Reserved | Bits[29:28] | 2 bits | Set to 0 by transmitter, ignored by receiver. |
| Dual Video Stream Mode | Bit[30] | 1 bit | 0 – 3D mode<br><br>1 – Two image stream mode. In this mode left shutter control signal should be interpreted as timing for video stream 1 |

| Field | Type/Size | Size | Comments |
|---|---|---|---|
| | | | and Right shutter control information as timing for video stream 2. |
| Reserved | Bit[31] | 1 bit | Set to 0 by transmitter, ignored by receiver. |
| Bluetooth clock phase at rising edge of Frame Sync (us) | Unsigned | 16 bits | Range 0-312 |
| Left shutter open delay (us)<br><br>(Video Stream 1 in dual stream mode) | Unsigned | 16 bits | Special value of 0xFFFF signals Legacy 3DG to go into 2D mode. |
| Left shutter close delay (us)<br><br>(Video Stream 1 in dual stream mode) | Unsigned | 16 bits | |
| Right shutter open delay (us)<br><br>(Video Stream 2 in dual stream mode) | Unsigned | 16 bits | |
| Right shutter close delay (us)<br><br>(Video Stream 2 in dual stream mode) | Unsigned | 16 bits | |
| Frame Sync Period (us) | Unsigned | 16 bits | |
| Frame Sync Fraction (1/256 us) | Unsigned | 8 bits | |

*Table 12.11: Beacon Packet Payload Fields*

| Field | Type/Size | Comments | Compatibility |
|---|---|---|---|
| Frequency | Per the adapted piconet connection state hopping sequence. | The transmit frequency for each packet shall be chosen using master timing and clock. AFH may be used but AFH information must be provided in the sync train and cannot change after the beacon has been started. | Required by Legacy 3DGs. |

*Table 12.12: Beacon Packet Parameters*

| Packet Entity | Field | Value | Notes | Compatibility |
|---|---|---|---|---|
| Access Code | Sync Word | Derived from the Legacy 3DD LAP | | Required by Legacy 3DGs. |
| Packet Header (Whitening Enabled, based on Legacy 3DD clock bits [6:1]) | LT_ADDR | 1 | An LT_ADDR of 1 must be reserved by controllers that support Connectionless Slave Broadcast and used only for Connectionless Slave Broadcast. | Required by Legacy 3DGs. Legacy 3DGs will ignore any beacon packet with LT_ADDR not equal to 1. |
| | TYPE | DM1 | | Required by Legacy 3DGs.<br><br>Any packet with a type field not equal to DM1 will be |

| Packet Entity | Field | Value | Notes | Compatibility |
|---|---|---|---|---|
| | | | | ignored. |
| | FLOW | 0 | | Legacy 3DGs can accept 0 or 1. |
| | ARQN | 0 | | Legacy 3DGs can accept 0 or 1. |
| | SEQN | 0/1 | Toggles per packet | Toggled by Legacy 3DD, ignored by Legacy 3DGs. Legacy 3DGs can accept 0 or 1. |
| | HEC | Derived from the Legacy 3DD UAP | | Required for Legacy 3DGs. |
| Payload (Whitening Enabled, based on Legacy 3DD clock) | Payload Header | LLID | 2 | | Ignored by Legacy 3DGs. Legacy 3DGs can accept any value. |
| | | FLOW | 0 | | Legacy 3DGs can accept 0 or 1. |
| | | LENGTH | 17 | | Legacy 3DGs will ignore packets that are not 17 bytes. |
| | Payload Body | See Table 12.11: Beacon Packet Payload Fields | | |

*Table 12.13: Beacon Packet Format*

## 12.4 External Clock Capture and Generation

The objective of the 3D glasses is to open and close the left/right shutters to match precisely the frame timing of the 3D display. To accomplish this objective, the Reference Protocol utilizes the ability inherent in all Bluetooth devices to align the slave Bluetooth clock to the master Bluetooth clock. The slave only needs to know the state of the master Bluetooth clock at the rising edge of the Frame Sync and the period of the Frame Sync to accurately reproduce the Frame Sync signal at the slave.

The glasses don't actually generate a Frame Sync signal directly. Instead, they use the Frame Sync timing to generate Left/Right shutter signals as shown in Figure 12.9.
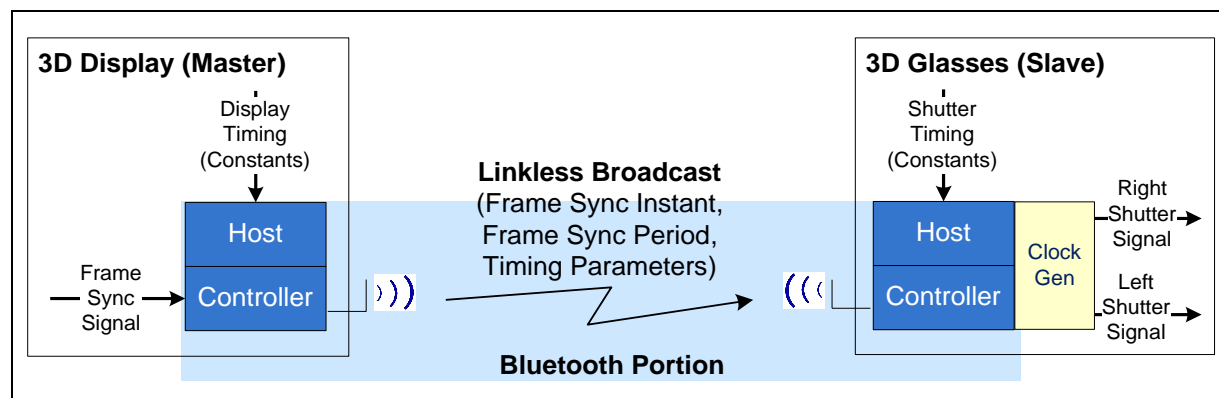


*Figure 12.9: The Reference Protocol broadcasts synchronous clock signals over a wireless link.*

The timing parameters include the following values:

1. Left Shutter Open Delay,

2. Left Shutter Close Delay,

3. Right Shutter Open Delay,

4. Left Shutter Close Delay.

These 4 timing parameters provide enough flexibility to implement several modes of operation as illustrated in Figures 12.10, 12.11, and 12.12. Note that the timing parameters sent by the display and the timing signal delays may be different. For example,

Left Shutter Rising Edge Delay = Left Shutter Open Delay + open_offset.

The offset may be positive or negative and is determined by the glasses manufacturer to optimize the viewing experience given the response behavior of the optics in those particular glasses.

The Frame Rate is the inverse of the Frame Sync Period. The Legacy 3DG and Legacy 3DD support a range of Frame Rates from 48 Hz to 120 Hz.
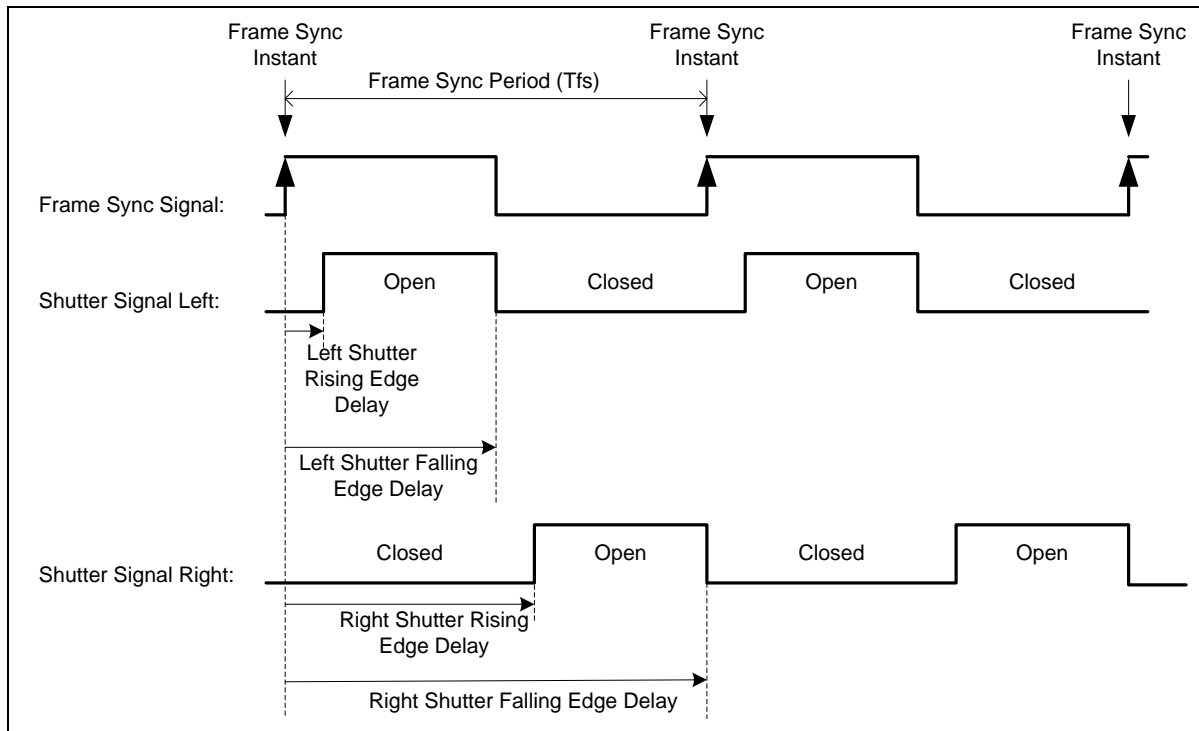


*Figure 12.10: In 3D mode, the left and right lenses alternate in open/close states.*

*Bluetooth 3D Synchronization Profile*
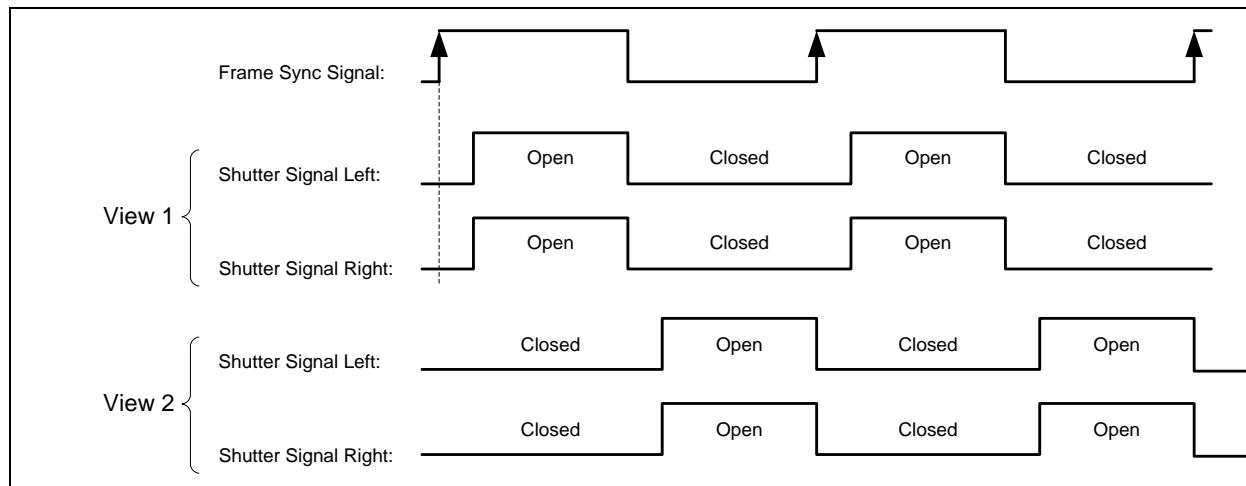


*Figure 12.11: In dual view mode, the left and right open at the same time, but alternate with a 2nd pair of glasses to create view 1 and view 2.*
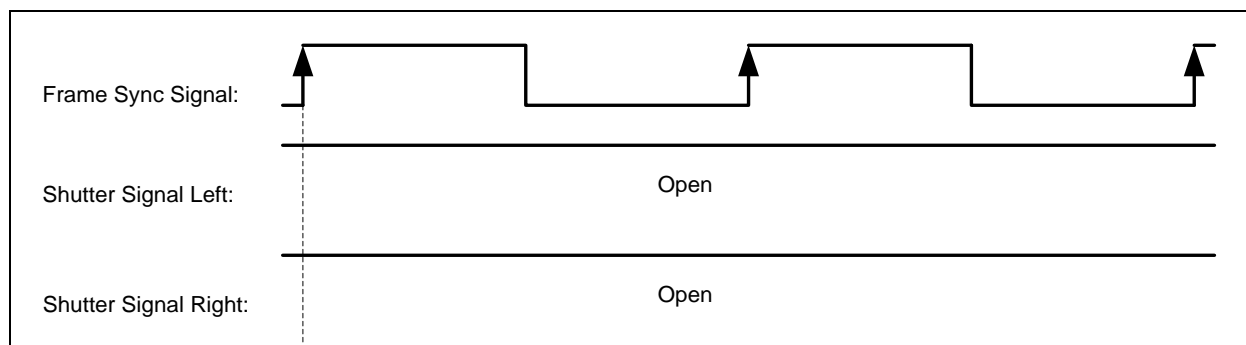


*Figure 12.12: In 2D mode, the shutters stay open continuously.*

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