



Bluetooth[®] Seminar Series

Tools, Techniques, and Trends

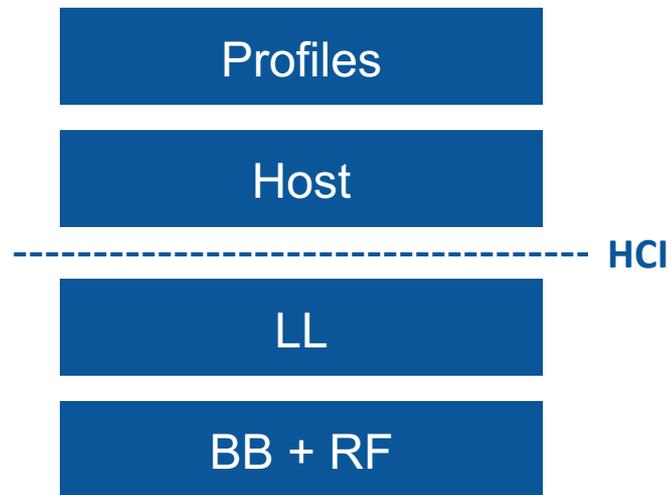
Hands-On Debug of an LE Audio Stream

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Bluetooth Core v5.2: LE Audio Features

- Profiles
 - Generic Audio Profiles
- Host
 - EATT
- Link Layer (LL)
 - Isochronous Channels (BIS, CIS)
- BB + RF
 - No changes on some chip architectures



Audio Sharing

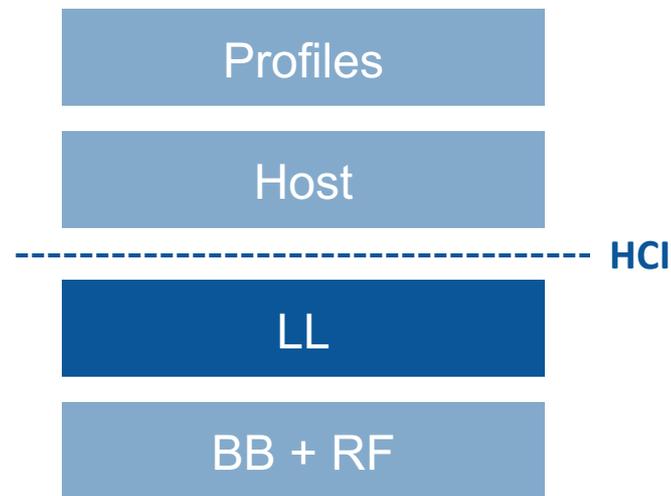
- Public Service Announcements
- Program Selections
- Multi-Language
- Direct to Hearing Aid



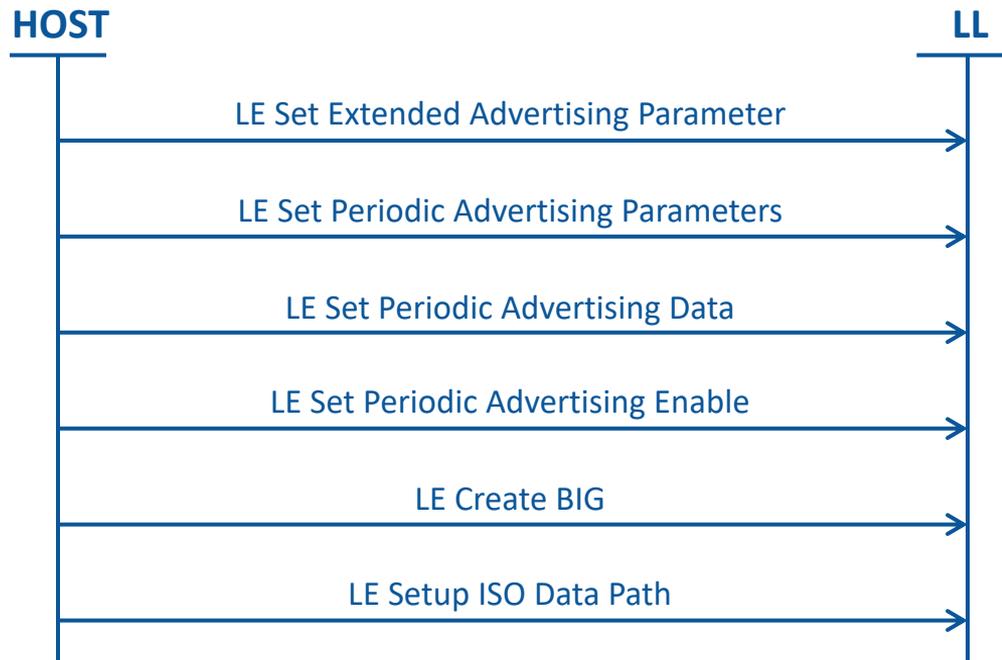
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Case Study: Broadcast Isochronous Stream (BIS)

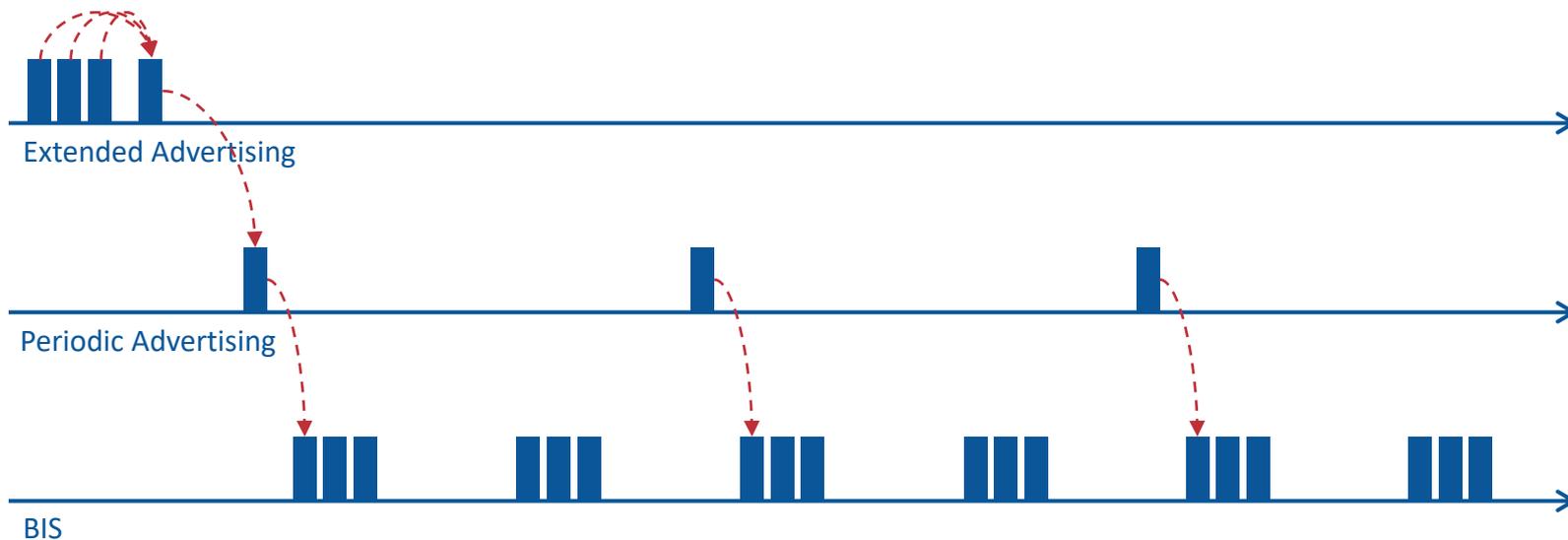
- Legacy Advertising (v4.0)
- Advertising Extensions (v5.0)
- Periodic Advertising (v5.0)
- Channel Selection #2 (v5.0)
- 1M PHY (v4.0)
- 2M PHY (v5.0)
- Broadcast Isochronous Stream (v5.2)



Broadcaster Setup (HCI Interaction)



Logical Channels



Instant Timing

The screenshot displays the Ellipsis Bluetooth Analyzer interface. The main window shows a list of captured packets with columns for Item, Status, Con..., Originator, BL..., Payload, Time, Time delta, and Communication. A specific packet is highlighted in blue, showing its details in the right-hand pane. Below the packet list, the 'Instant Timing' section provides a detailed view of the packet's timing, including a waveform diagram and a table of raw data.

| Item | Status | Con... | Originator | BL... | Payload | Time | Time delta | Communication |
|----------------------------------------------------------------|--------|--------|------------|--------|----------------------------------------------------------------|---------------|---------------|-----------------------------------------------------|
| LE-BIS Packet (LLID=End / Complete, Length=160, PC=136576) | OK | | Master | 136576 | 160 bytes (9C 00 26 04 00 00 00 00 76 67 55 32 76 77 18 81... | 6.456 709 125 | 0.000 834 125 | Master: DE:8A:7B:AD:2F:7F <-> Slave: 'BIS Receiver' |
| LE-BIS Packet (LLID=End / Complete, Length=160, PC=136576) | OK | | Master | 136576 | 160 bytes (9C 00 26 04 00 00 00 00 76 67 55 32 76 77 18 81... | 6.457 543 000 | 0.000 833 875 | Master: DE:8A:7B:AD:2F:7F <-> Slave: 'BIS Receiver' |
| ADV_EXT_IND Packet (DE:8A:7B:AD:2F:7F, AdvA AdvDataInfo ...) | OK | | Master | | 13 bytes (0C 19 7F 3F AD 7B 8A DE AE 0F 48 45 00) | 6.460 752 750 | 0.003 209 750 | Master: DE:8A:7B:AD:2F:7F <-> Slave: 'Scanning De |
| ADV_EXT_IND Packet (DE:8A:7B:AD:2F:7F, AdvA AdvDataInfo ...) | OK | | Master | | 13 bytes (0C 19 7F 3F AD 7B 8A DE AE 0F 48 2E 00) | 6.461 442 625 | 0.000 689 875 | Master: DE:8A:7B:AD:2F:7F <-> Slave: 'Scanning De |
| ADV_EXT_IND Packet (DE:8A:7B:AD:2F:7F, AdvA AdvDataInfo ...) | OK | | Master | | 13 bytes (0C 19 7F 3F AD 7B 8A DE AE 0F 48 17 00) | 6.462 132 625 | 0.000 690 000 | Master: DE:8A:7B:AD:2F:7F <-> Slave: 'Scanning De |
| AUX_ADV_IND Packet (AdvDataInfo SyncInfo) | OK | | Master | | 22 bytes (15 28 AE 0F D9 02 A0 00 FF FF FF FF 79 6C 4E CB ...) | 6.462 824 625 | 0.000 692 000 | Master: DE:8A:7B:AD:2F:7F <-> Slave: 'Scanning De |
| LE-BIS Packet (LLID=End / Complete, Length=160, PC=136576) | OK | | Master | 136576 | 160 bytes (9C 00 26 B4 00 00 00 00 76 76 55 31 3E 4F 32 19... | 6.465 875 000 | 0.003 050 375 | Master: DE:8A:7B:AD:2F:7F <-> Slave: 'BIS Receiver' |
| LE-BIS Packet (LLID=End / Complete, Length=160, PC=136577) | OK | | Master | 136577 | 160 bytes (9C 00 26 B4 00 00 00 00 76 76 55 31 3E 4F 32 19... | 6.466 709 125 | 0.000 834 125 | Master: DE:8A:7B:AD:2F:7F <-> Slave: 'BIS Receiver' |
| LE-BIS Packet (LLID=End / Complete, Length=160, PC=136577) | OK | | Master | 136577 | 160 bytes (9C 00 26 B4 00 00 00 00 76 76 55 31 3E 4F 32 19... | 6.467 543 125 | 0.000 834 000 | Master: DE:8A:7B:AD:2F:7F <-> Slave: 'BIS Receiver' |
| LE-BIS Packet (LLID=End / Complete, Length=160, PC=136577) | OK | | Master | 136577 | 160 bytes (9C 00 26 76 00 00 00 00 85 86 56 22 BF 14 6C 28... | 6.475 875 125 | 0.008 332 000 | Master: DE:8A:7B:AD:2F:7F <-> Slave: 'BIS Receiver' |
| LE-BIS Packet (LLID=End / Complete, Length=160, PC=136578) | OK | | Master | 136578 | 160 bytes (9C 00 26 76 00 00 00 00 85 86 56 22 BF 14 6C 28... | 6.476 709 000 | 0.000 833 875 | Master: DE:8A:7B:AD:2F:7F <-> Slave: 'BIS Receiver' |
| LE-BIS Packet (LLID=End / Complete, Length=160, PC=136578) | OK | | Master | 136578 | 160 bytes (9C 00 26 76 00 00 00 00 85 86 56 22 BF 14 6C 28... | 6.477 543 125 | 0.000 834 125 | Master: DE:8A:7B:AD:2F:7F <-> Slave: 'BIS Receiver' |
| AUX_SYNC_IND Packet (Empty, BIG Info) | OK | | Master | | 37 bytes (24 00 22 2C 26 04 08 23 42 03 00 C6 09 30 A0 00... | 6.484 709 625 | 0.007 166 500 | Master: DE:8A:7B:AD:2F:7F <-> Slave: 'Scanning De |
| LE-BIS Packet (LLID=End / Complete, Length=160, PC=136578) | OK | | Master | 136578 | 160 bytes (9C 00 26 98 00 00 00 00 95 76 55 42 CA BD 46 8... | 6.485 875 125 | 0.001 165 500 | Master: DE:8A:7B:AD:2F:7F <-> Slave: 'BIS Receiver' |

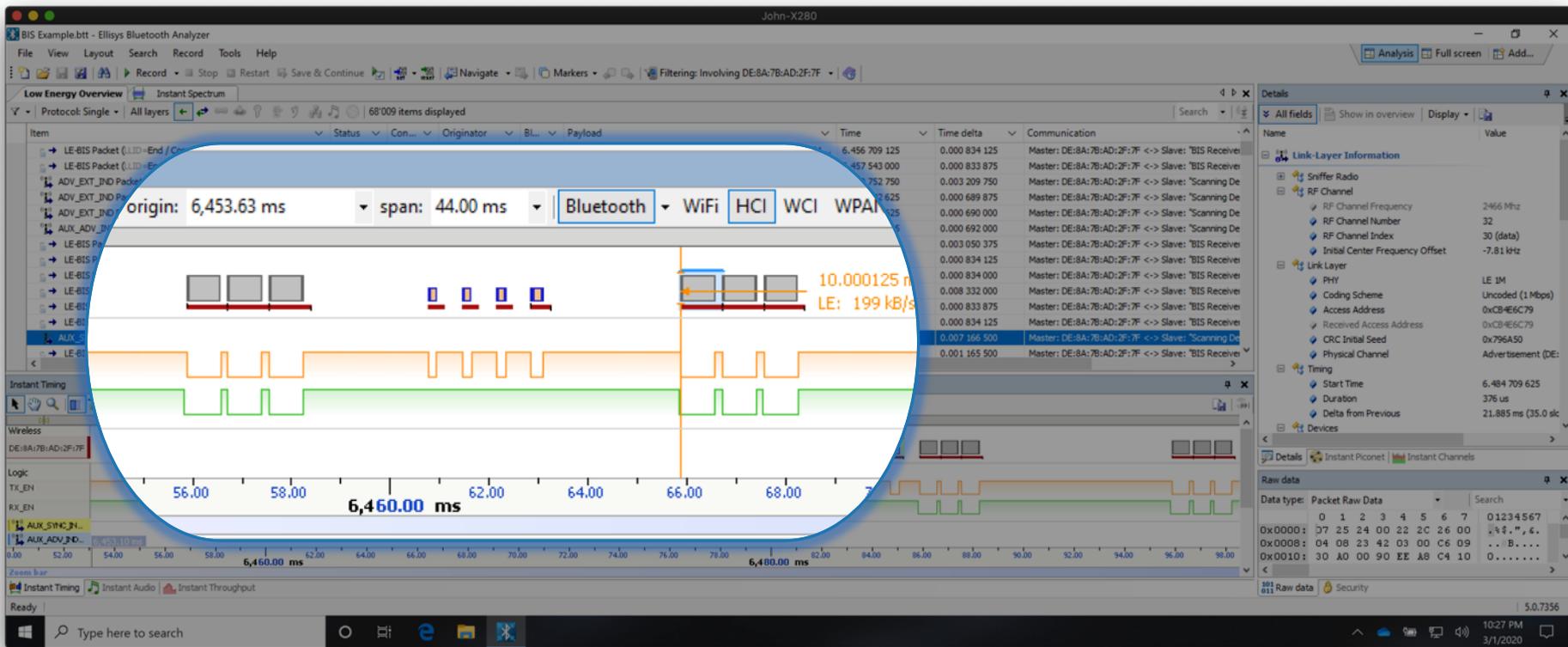
The 'Instant Timing' section shows a waveform diagram with the following parameters:

- origin: 6,453.06 ms
- span: 45.48 ms
- Bluetooth | WiFi | HCI | WCI | WPAN | Logic | Misc | | Display | | Logic inputs
- Wireless: DE:8A:7B:AD:2F:7F
- Logic: TX_EN, RX_EN
- AUX_SYNC_IND: 6.453 10 ms
- AUX_ADV_IND: 6.453 10 ms
- Zoom In
- Instant Timing | Instant Audio | Instant Throughput
- Ready

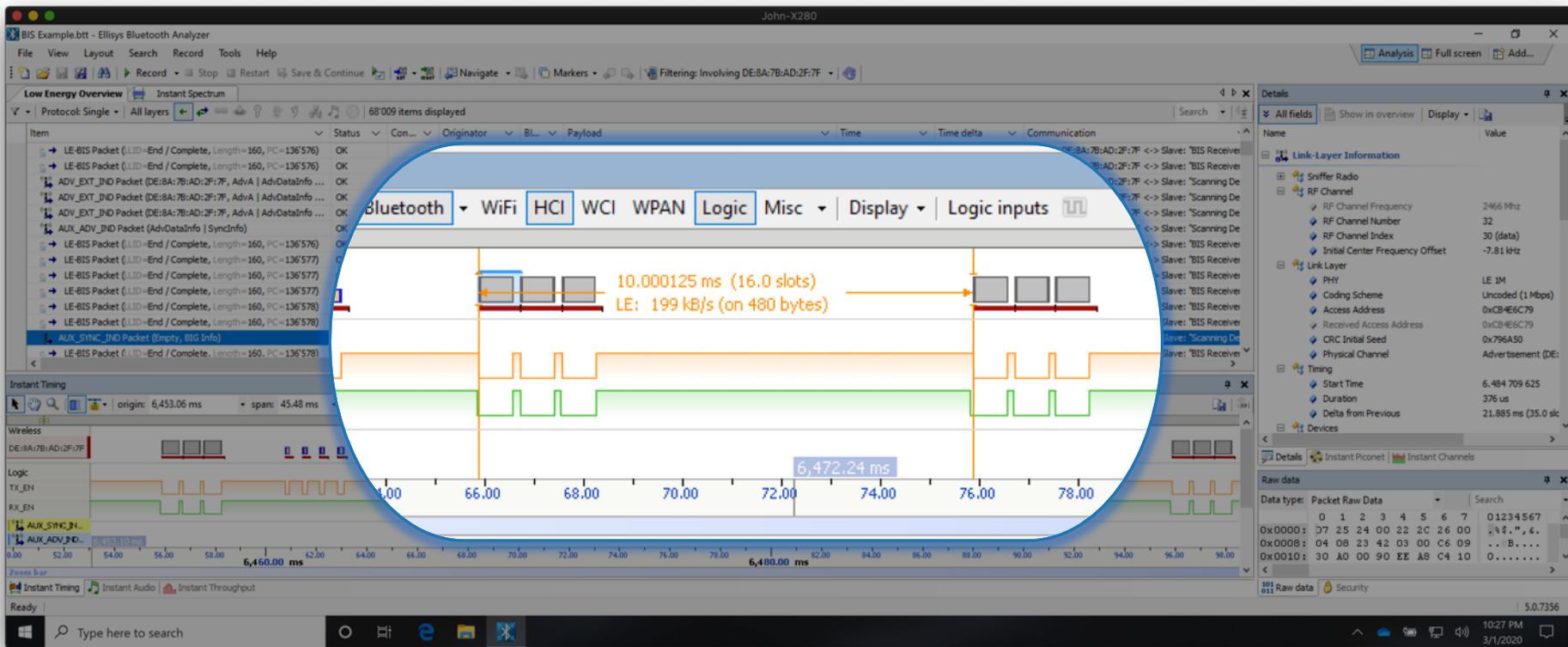
The 'Details' pane on the right shows the following information:

- Name: Value
- Link-Layer Information
 - Sniffer Radio
 - RF Channel
 - RF Channel Frequency: 2466 Mhz
 - RF Channel Number: 32
 - RF Channel Index: 30 (data)
 - Initial Center Frequency Offset: -7.81 Mhz
 - Link Layer
 - PHY: LE 1M
 - Coding Scheme: Uncoded (1 Mbps)
 - Access Address: 0xC94E6C79
 - Received Access Address: 0xC94E6C79
 - CRC Initial Seed: 0x796A50
 - Physical Channel: Advertisement (DE)
 - Timing
 - Start Time: 6.484 709 625
 - Duration: 376 us
 - Delta from Previous: 21.885 ms (35.0 s/c)
- Raw data
 - Data type: Packet Raw Data
 - 0 1 2 3 4 5 6 7 0 1234567
 - 0x0000: 37 25 24 00 22 2C 26 00 ...
 - 0x0008: 04 08 23 42 03 00 C6 09 ...
 - 0x0010: 30 A0 00 90 EE EA C4 10 0

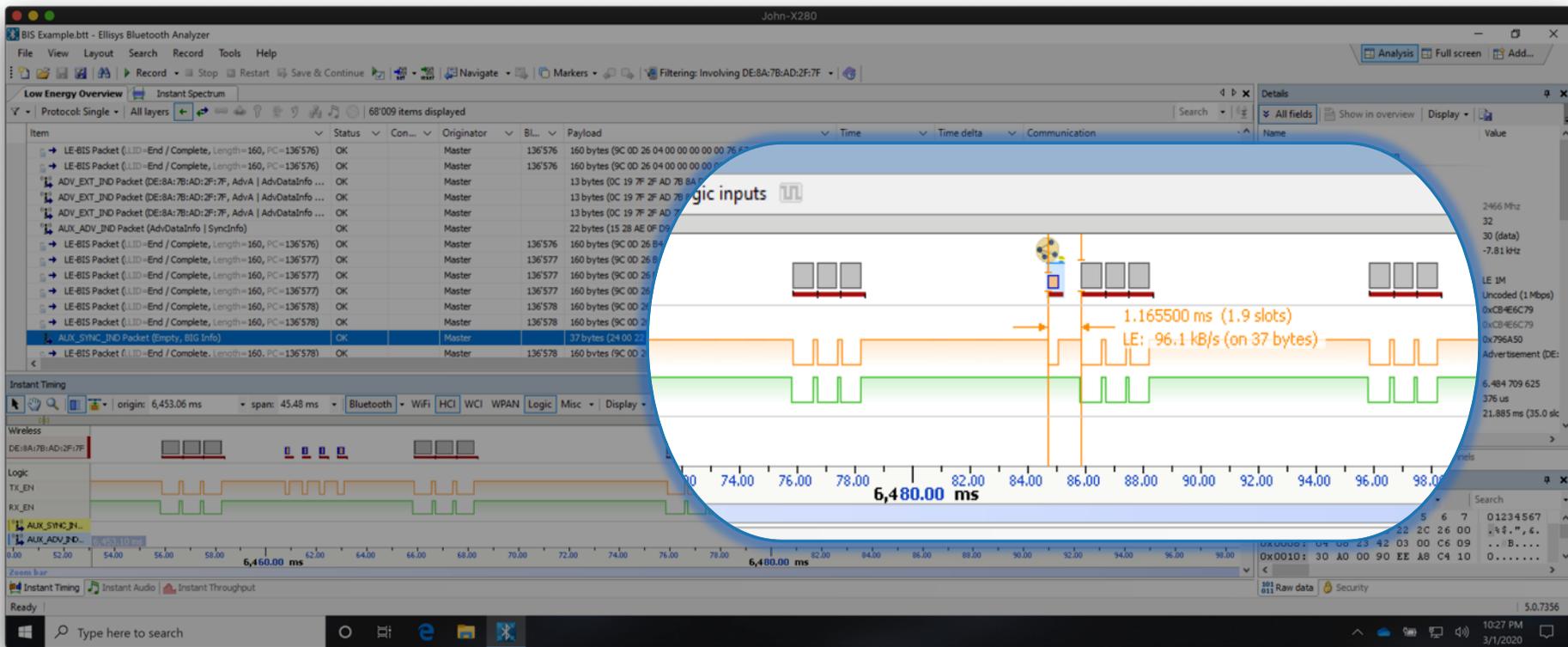
BIS Timing: Logical Scheduling



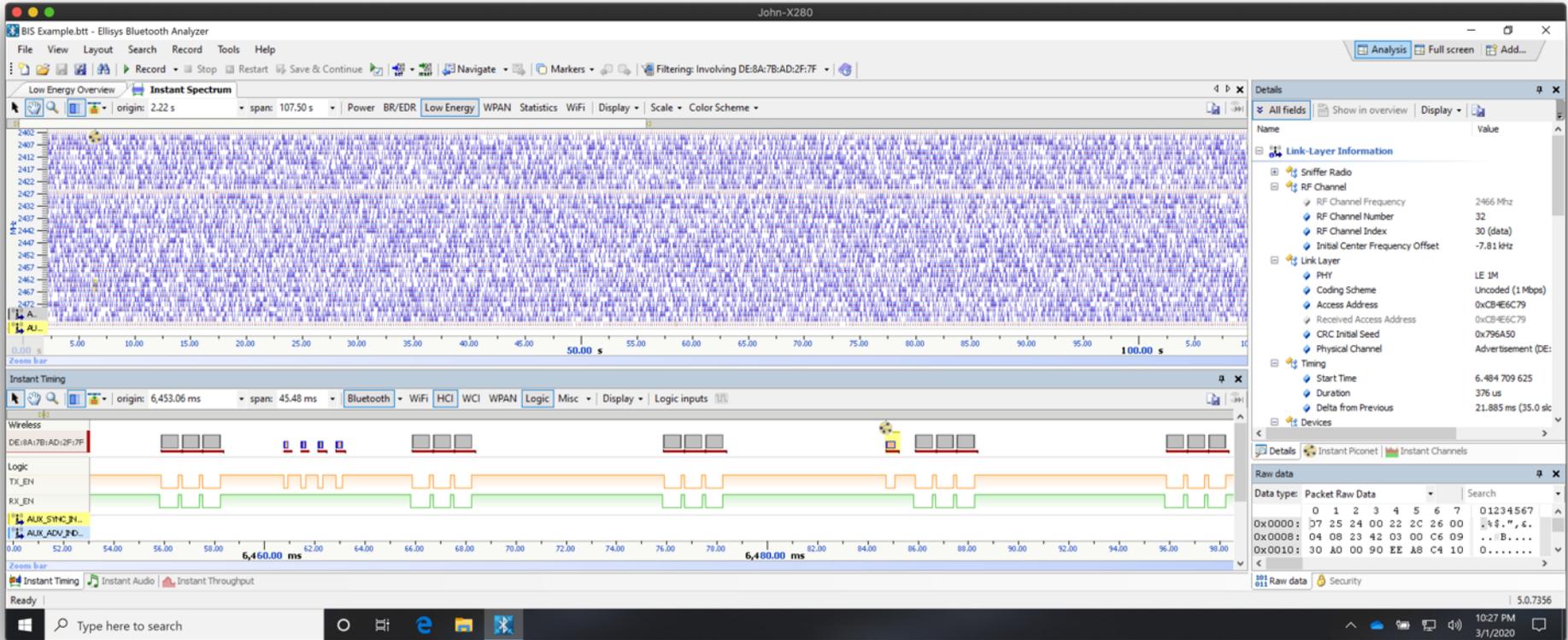
BIS Timing: ISO Interval



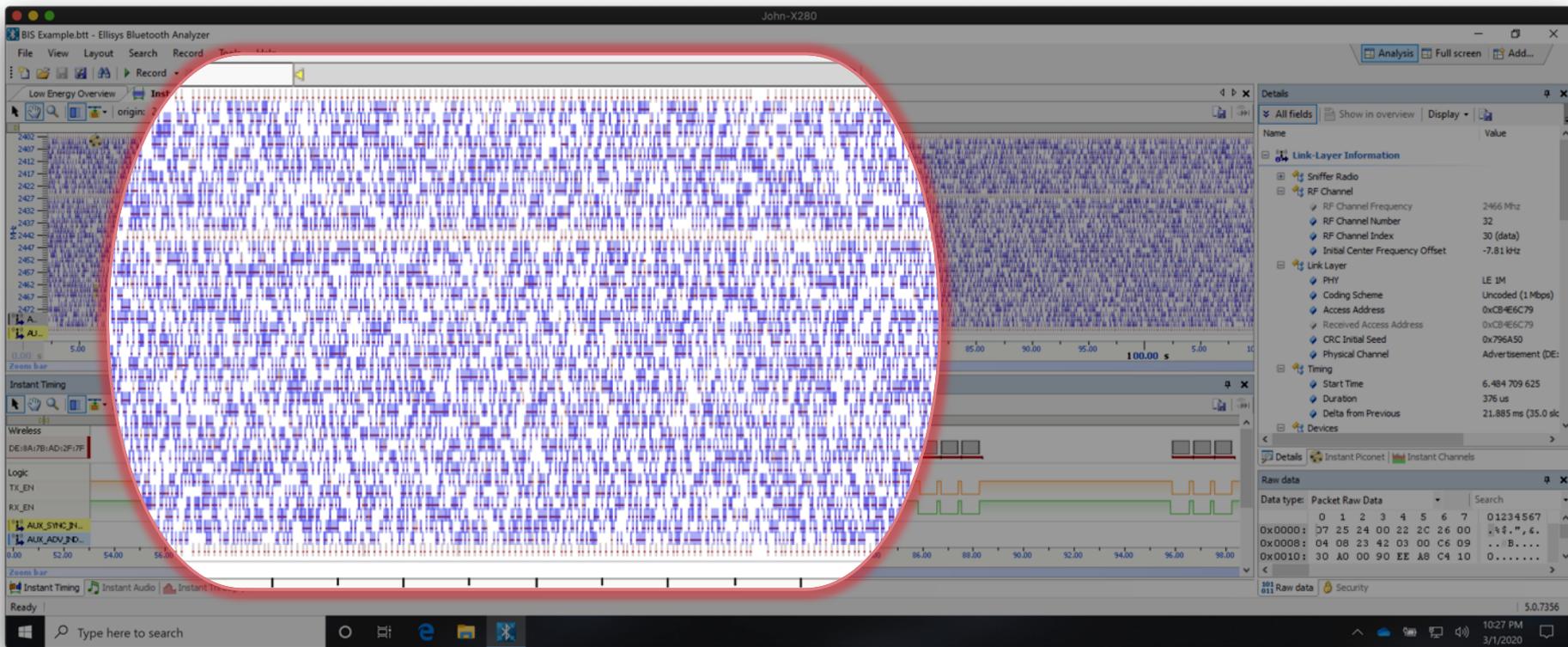
BIS Timing: BIG Offset



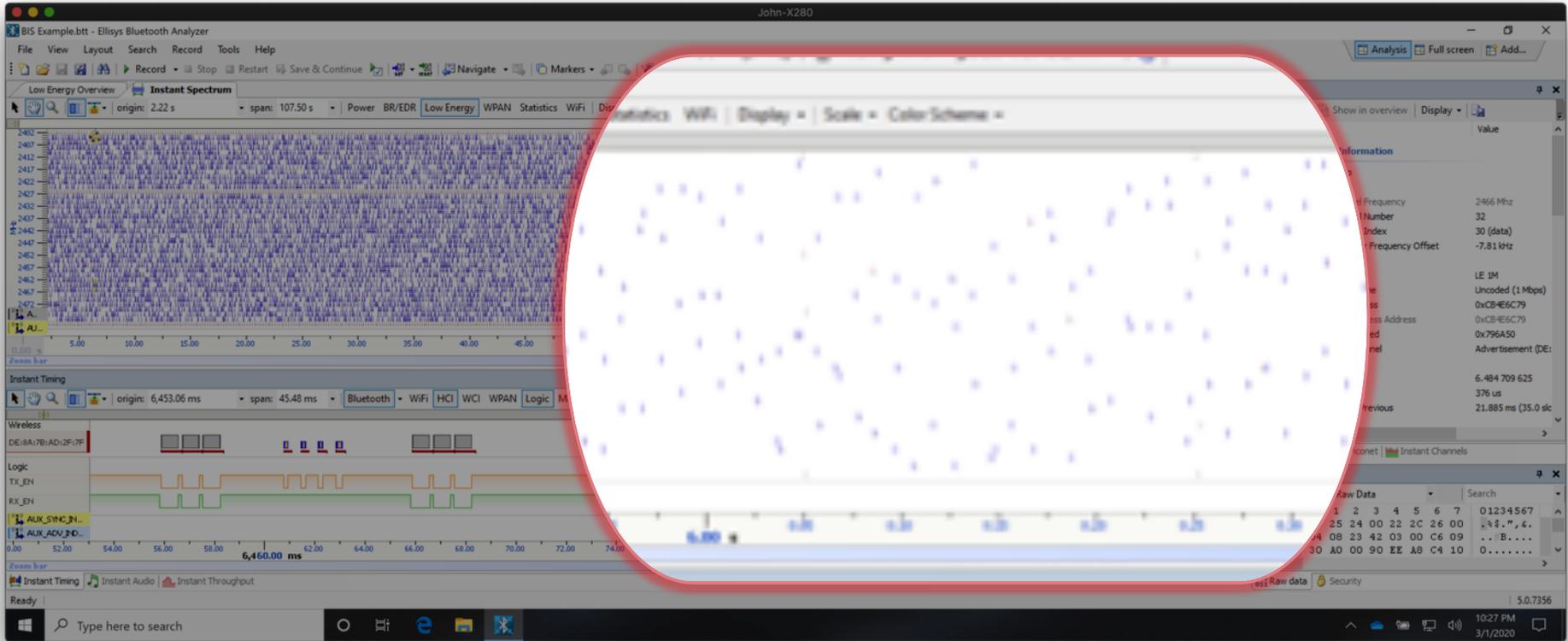
Instant Spectrum



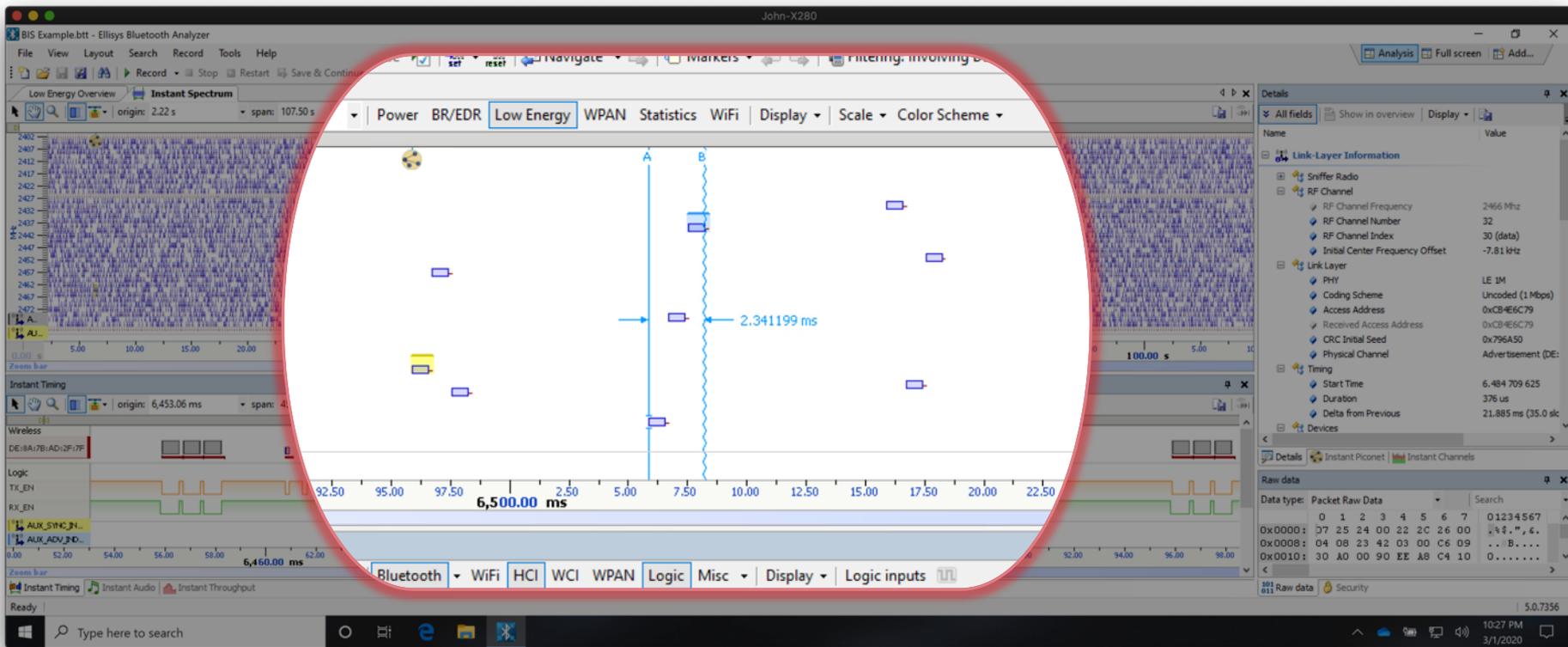
BIS Spectral: Random Distribution



BIS Spectral: Coexistence



BIS Spectral: Avoid Multipath Effects



Missed Packet Analysis

1. Timing
2. Frequency
3. Coding (Access Address, CRC)
4. PHY

The screenshot displays the Ellipsis Bluetooth Analyzer interface. A yellow callout box highlights the four key areas for missed packet analysis: Timing, Frequency, Coding (Access Address, CRC), and PHY. The main window shows a list of captured packets, with the selected packet being an LE-BIS Packet (LLID=End / Complete, Length=160, PC=136578). The timing diagram below shows the signal waveforms for TX_EN, RX_EN, AUX_SYNC_IN, and AUX_ADV_IN. A circular callout provides a detailed view of the packet's information, including:

- PHY: LE 2M
- Coding Scheme: Uncoded (2 Mbps)
- Access Address: 0x39AEEEE90
- Received Access Address: 0x39AEEEE90
- CRC Initial Seed: 0x913701
- Physical Channel: LE BIS Emission (DE:8A:7B:AD:2F:7F)
- Timing: Not Encrypted (35.0 s)

The raw data section at the bottom right shows the packet's hexadecimal and decimal values:

| Offset | Hex | Dec |
|--------|-------------------------|----------|
| 0x0000 | 37 25 24 00 22 2C 26 00 | 01234567 |
| 0x0008 | 04 08 23 42 03 0C 06 09 | ..B... |
| 0x0010 | 30 A0 00 90 EE A8 C4 10 | 0..... |

Final Thoughts: LE Audio

- Multi-Stream
- Audio Sharing
- TWS
- Hearing Aids
- Unique Applications





Thank you!

Questions?

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