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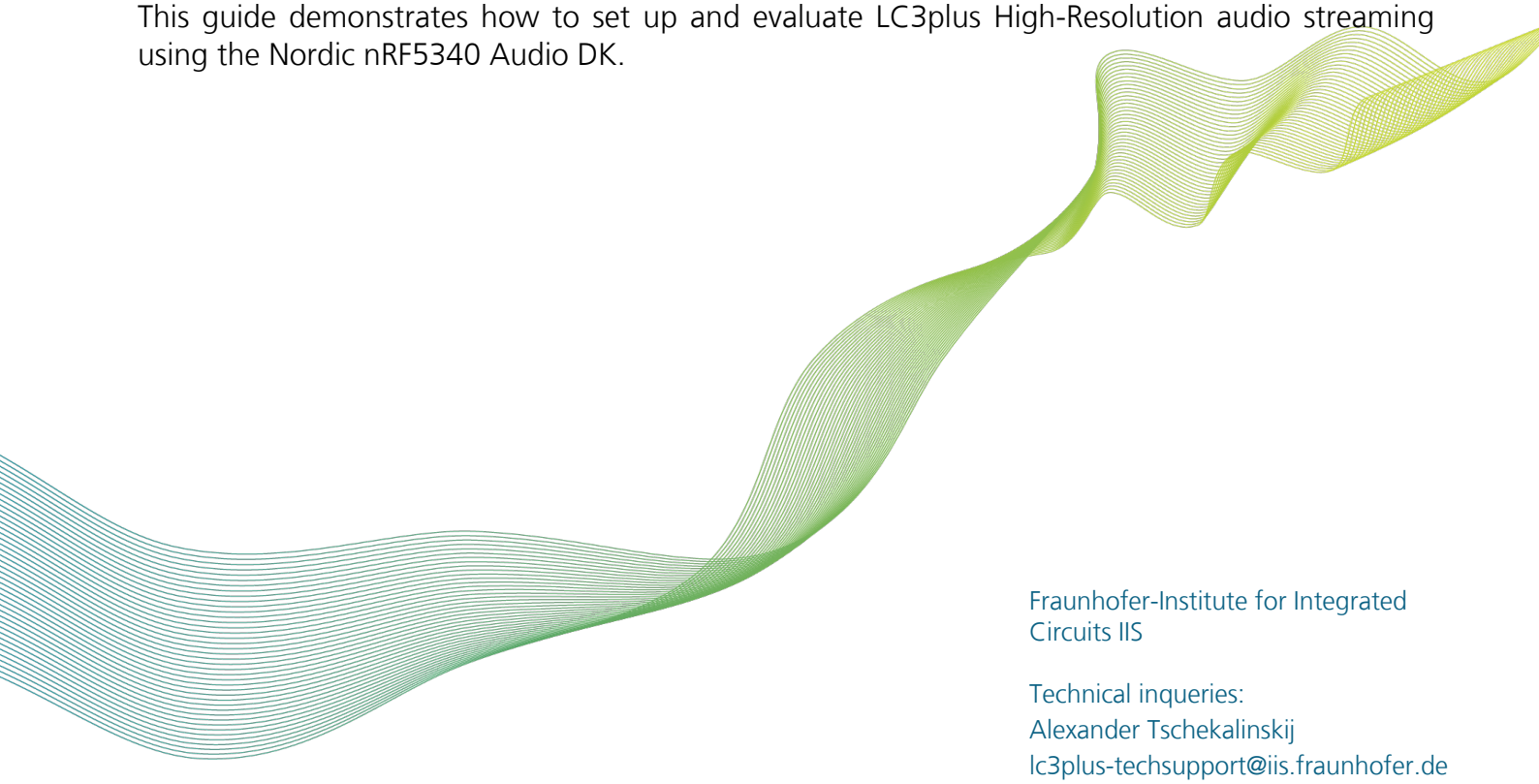
LC3plus High-Resolution for Bluetooth Low Energy Audio Demo Guide

Stream LC3plus High-Resolution Mono & Stereo Audio Over Bluetooth® LE Audio

This guide demonstrates how to set up and evaluate LC3plus High-Resolution audio streaming using the Nordic nRF5340 Audio DK.



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The LC3plus High Resolution audio coding scheme is a development of Fraunhofer in cooperation with Ericsson AB, pursuant to the specification issued in clause 5.8 of the ETSI TS 103 634.

This document describes how to transmit LC3plus High Resolution bitstream via Bluetooth LE Audio by way of signaling a vendor specific codec. The LC3plus High Resolution transport over Bluetooth LE Audio described in this document is not part of any Bluetooth SIG specification.

Implementations of the LC3plus High Resolution audio coding scheme are not compliant with any current Bluetooth specification and cannot be qualified pursuant to the Bluetooth qualification process and the LC3plus High Resolution codec is not a compliant portion according to Bluetooth SIG PCLA.

For the purpose of clarity, the LC3plus High Resolution mode is a codec defined by ETSI. It is different from the low complexity communication codec (LC3) specified by Bluetooth. The LC3plus High Resolution mode is not compatible with LC3 specified by Bluetooth.

This documentation doesn't grant any patent license for the use of LC3plus patent licenses for necessary patent claims for the LC3plus High Resolution codec (including those of Fraunhofer) may be obtained from
the respective patent owners.

For more information regarding licensing of LC3plus, please visit:
https://www.iis.fraunhofer.de/en/ff/amm/lizenz/patent.htm

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1 Overview

1.1 Operating modes

The demonstration kit supports two primary distribution configurations:
- **Mono Mode:** 1 Source Board + 1 Sink Board (requires 2 development boards total).
- **Stereo Mode:** 1 Source Board + 2 Sink Boards (requires 3 development boards total).

1.2 Hardware Interface Reference

The evaluation platform is built on the **Nordic Semiconductor nRF5340 Audio DK (PCA10121)**. Below is a physical mapping of the interface ports and tactile hardware controllers required for this demonstration:

Interface Element		Functional Role in Demo
Line-In Jack (3.5 mm)	Bottom Left	Captures analog input audio from the host PC (Source board only).
Headphone Jack (3.5 mm)	Bottom Left	Outputs decoded, high-resolution analog audio to headphones/speakers (Sink boards only).
VOL- Button	Bottom Right Corner	Switches the active audio routing path to **Line-In Mode** (press on all boards).
RESET Button	Bottom (Left of VOL-)	Resets volatile states and clears cached BLE bonds when switching modes.
USB-C Interface	Top Right Edge	Provides stable board power, flashing access, and serial terminal debug streams.

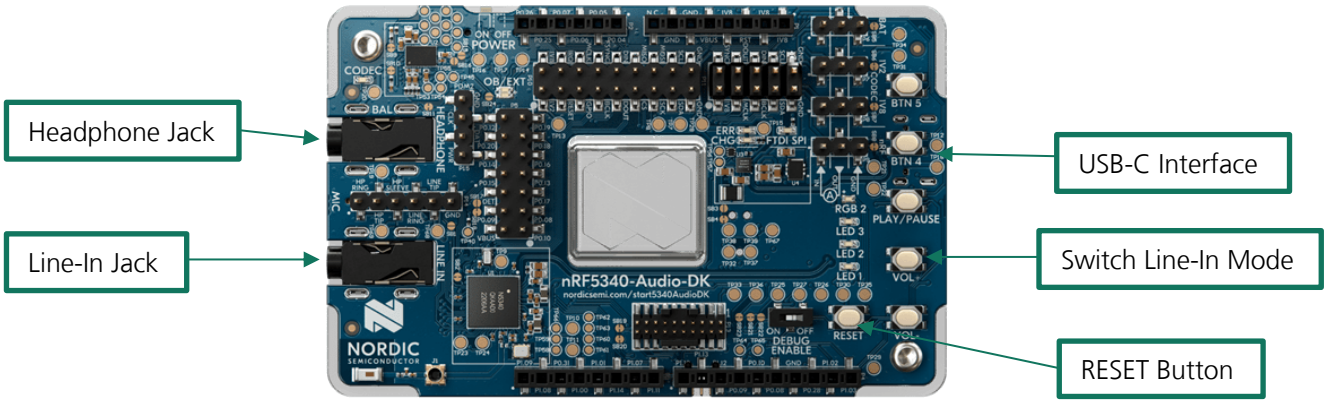


Figure 1: nRF5340 Audio DK (Source: Nordic Semiconductor — nordicsemi.com)

1.3 Requirements

To complete this evaluation setup, you will need:
- **nRF5340 Audio DK Boards**: 2 units for mono evaluation, 3 units for stereo evaluation.
- **USB-C Cables**: One cable per board (for power delivery, flashing, and serial debugging).
- **3.5 mm Auxiliary Audio Cable**: Connects your analog playback source to the Source board.

- **Headphones / Audio Receivers**: 3.5 mm jack connection (one per active Sink board).
- **Host PC**: Serves as the analog audio source and terminal controller.
- **Software Suite**: nRF Connect for Desktop (incorporating the Programmer application module).

2 Setup

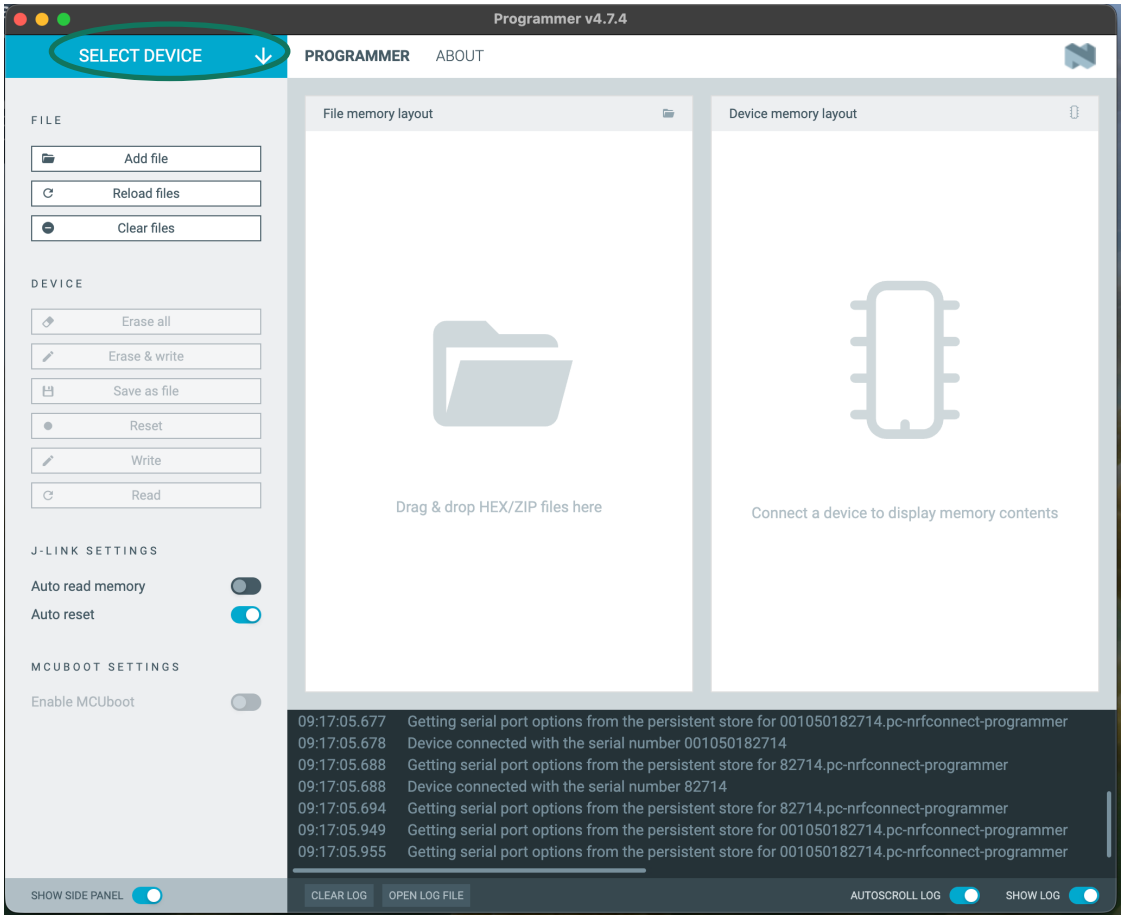
2.1 Installing nRF Connect Programmer

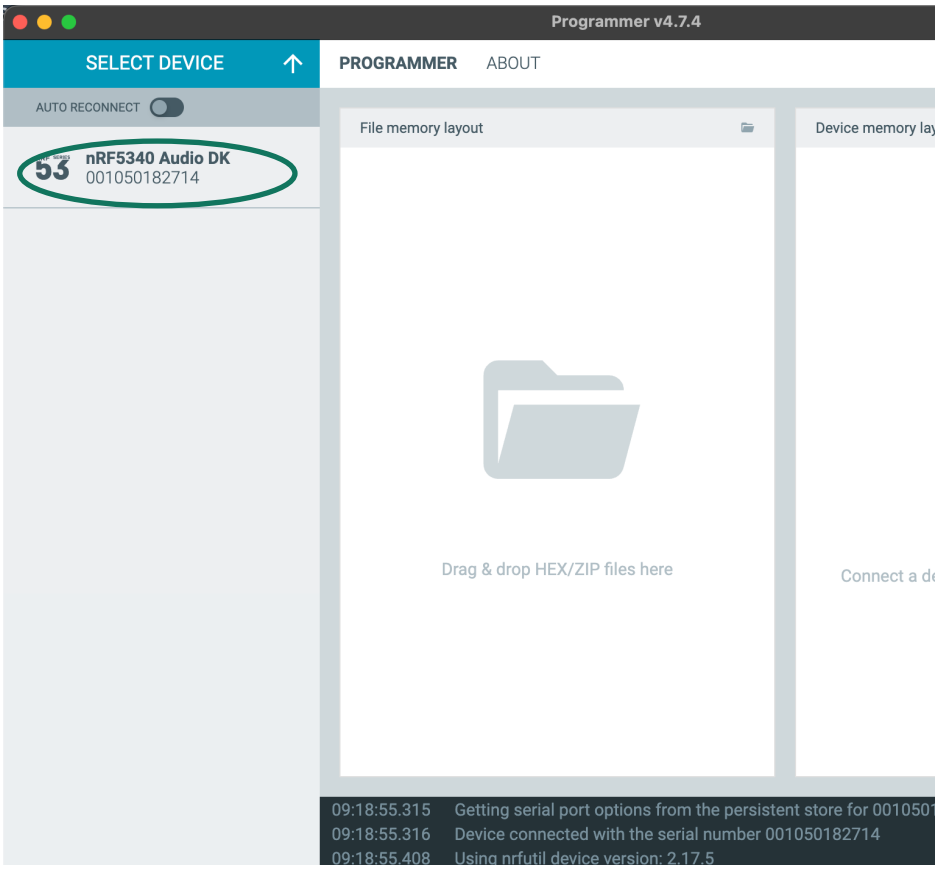
1. Download nRF Connect for Desktop installer matching your operating system:Nordic Semiconductor Desktop Tools
2. Run the installer package and launch the application.
3. Locate the **Programmer** tool within the application registry and click **Install**.

2.2 Flash the Firmware

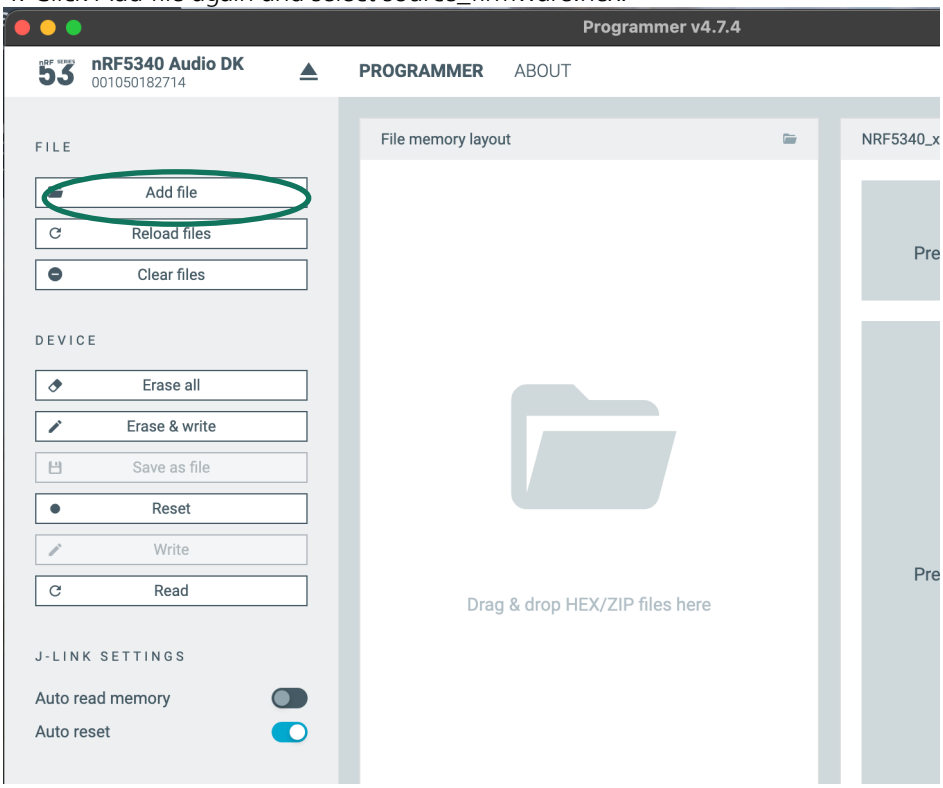
Each development board requires two separate firmware images: the **Network Core** image (running the low-level BLE controller stack) and the **Application Core** image (running the LC3plus high-resolution application layer).

Flashing the Source Board
1. Connect the designated Source board to your PC using a USB-C cable.
2. Launch the nRF Connect Programmer and select the connected board from the device drop-down menu.

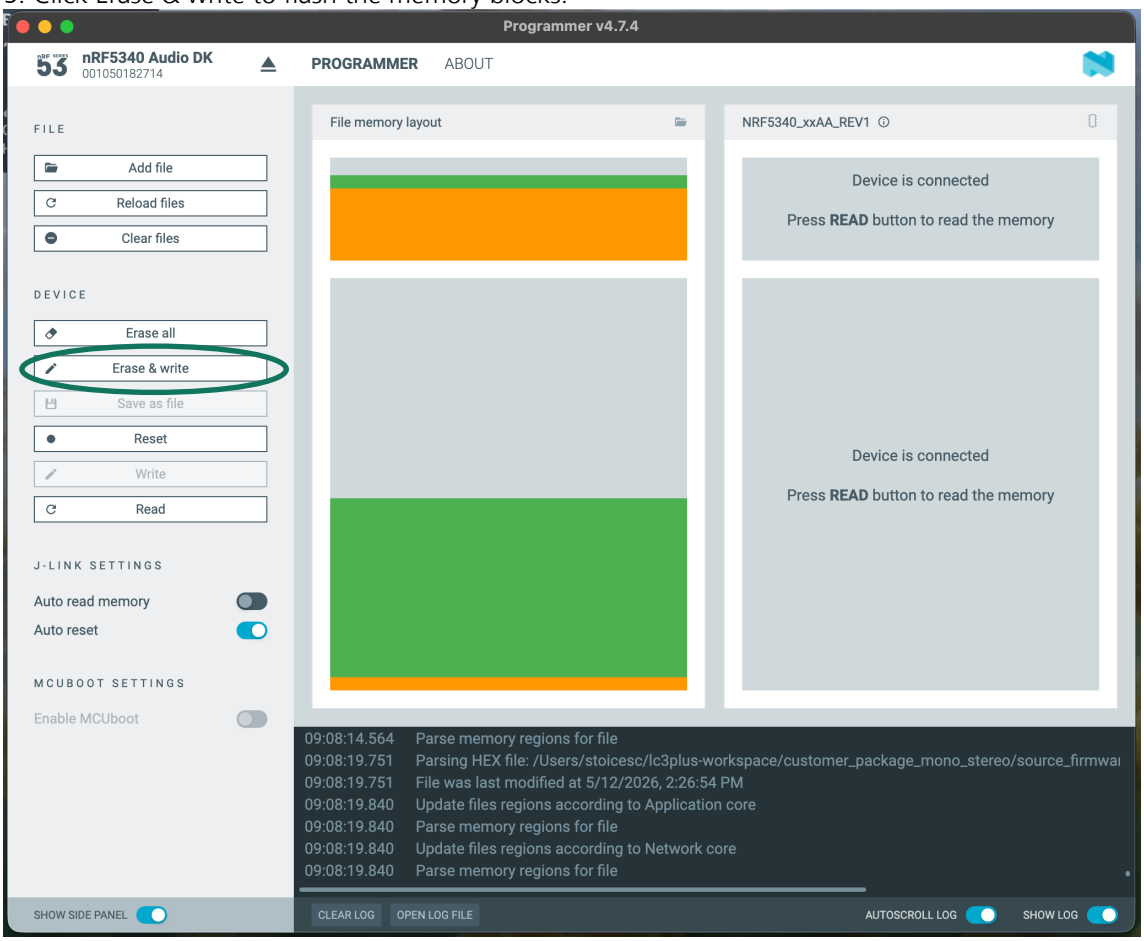




3. Click Add file and select netcore_firmware.hex.
4. Click Add file again and select source_firmware.hex.



5. Click Erase & write to flash the memory blocks.



Flashing the Sink Board(s)
1. Connect the Sink board to your PC via USB-C.
2. Select the corresponding target board interface in the Programmer tool.
3. Click Add file and select netcore_firmware.hex.
4. Click Add file again and select sink_firmware.hex.
5. Click Erase & write.
6. For Stereo Configurations: Repeat steps 1–5 for the second Sink board.

Note: All hardware units run the identical low-level network image (netcore_firmware.hex). Distinguishing between the Transmitter (Source) and Receiver (Sink) roles is handled entirely by the application core image.

2.3 Hardware Connections

1. Refer to the Hardware Interface Reference layout map to locate connection ports.
2. Connect headphones or your analog monitoring equipment to the **3.5 mm output (Headphone) jack** on each active Sink board.
3. Connect a 3.5 mm auxiliary audio cable from your host computer's analog output jack to the **Line-In jack** on the Source board.
4. Ensure all boards remain powered via their respective USB-C connections.

2.4 Serial Terminal Setup

An active serial terminal connection is required to issue configuration commands to the Source board's runtime interface.

macOS/Linux
1. Open a terminal instance and execute the following command to identify the virtual hardware path:

```
ls /dev/tty.usbmodem*
```

***Note**: Each connected board exposes two virtual COM ports. Use the lower-numbered port index.*

2. Connect to the interface at a baud rate of 115200 using the screen utility:

```
screen /dev/tty.usbmodemXXXXX 115200
```

Windows
1. Open PowerShell and execute the following query to locate active hardware ports:

```
Get-WMIObject Win32_SerialPort | Select Name, DeviceID
```

***Note**: Identify the lower-numbered COM port index associated with the target board.*

2. Open PuTTY or your preferred serial client and configure the session parameters:
- Connection Type: **Serial**
- Serial Line: **COMXX** (replace with your identified port index)
- Speed (Baud Rate): **115200**

```
putty -serial COMXX -sercfg 115200
```

2.5 Activating Line-In Input Mode

By default, the demo firmware may prioritize digital inputs. To switch the routing path:
1. Refer to the Hardware Interface Reference image to locate the **VOL-** button on the lower right corner of the boards.
2. Press the physical **VOL-** button on the Source board and on each active Sink board.
3. Confirm that the terminal displays the following status message:

```
Audio I/O mode: Line
```

3 System Operation

3.1 Mono Streaming Setup

For evaluation topologies utilizing a single Sink receiver (2 boards total):
1. Send the following command sequences to the Source board's serial terminal:

```
lc3plus stereo off
lc3plus setting 2
lc3plus start
```

2. Initiate audio playback on the host computer. High-resolution audio will stream through the connected Sink headphones.

3.2 Stereo Streaming Setup

For evaluation topologies utilizing dual Sink receivers (3 boards total):
1. **Critical Step**: If switching operating modes, press the physical RESET button (located adjacent to the VOL- key) on the Source board to clear old volatile state connections.
2. Send the following commands to the serial terminal:

```
lc3plus stereo on
lc3plus setting 2
lc3plus start
```

3. The Source board will scan and connect to both Sinks automatically. Wait for the terminal log to confirm synchronized link-state establishment:

```
Stereo: right CIS started, both active
```

3.3 Dynamic Parameter Configuration

To safely modify active codec settings or bitrates during an active streaming evaluation:
1. Stop the current broadcast stream:

```
lc3plus stop
```

2. Wait **at least 5 seconds** to allow the BLE host controller to safely dismantle the active links.
3. Change the profile setting (e.g., Profile 5) and restart the stream:

```
lc3plus setting 5
lc3plus start
```

4 Available Codec Profiles

The following configuration profiles are available to evaluate the trade-offs between frame duration, latency, and throughput constraints over BLE:

Setting	Sample Rate	Frame Duration	Bitrate	Bit Depth
1	48 kHz	10 ms	128 kbps	24-bit
2	48 kHz	7.5 ms	124.8 kbps	24-bit
4	96 kHz	10 ms	152 kbps	24-bit
5	96 kHz	7.5 ms	150.4 kbps	24-bit
10	48 kHz	5 ms	192 kbps	24-bit

All settings deliver clean, artifact-free audio in mono mode.

5 Troubleshooting & Support

Symptoms / Observed Behaviors	Potential Root Cause	Recommended Corrective Action
Asymmetric Stereo Output *(Audio is only outputting from one Sink board)*	BLE connection desynchronization or legacy bonding cache mismatch.	1. Press **RESET** on the Source board and restart the stream. 2. Re-flash all boards using **Erase & write** to clear cached BLE keys. 3. Verify both Sink boards are explicitly set to Line-In mode.
"Group create failed" (Command rejected)	Inadequate delay during stream lifecycle modifications.	1. Wait at least **5 seconds** between stopping and starting a stream. 2. Press the physical **RESET** button on the Source board.
Complete Loss of Audio Output	Cable routing error, digital volume level mute, or incorrect active channel routing.	1. Check the analog connections on the Sink outputs and the Source Line-In interface. 2. Verify active media playback is occurring on the computer. 3. Re-verify that the terminal outputs Audio I/O mode: Line when pressing **VOL-**.
BLE Connection Drop / Link Failure	Insufficient power supply or mismatched hardware firmware files.	1. Connect all boards directly to USB-C ports (avoid unpowered hubs). 2. Verify Sink boards are flashed with sink_firmware.hex. 3. Power-cycle all boards and retry.
Acoustic Distortion / Crackling	Analog input clipping at the transmitter stage or RF channel interference.	1. Lower the software volume slider on your host PC to prevent input amplifier clipping. 2. Verify auxiliary cable integrity by using alternative 3.5 mm lines. 3. Revert to **Setting 2** (48 kHz / 7.5 ms) for a profile optimized for BLE reliability.
Background Hissing / Noise Floor During Silence	Low signal-to-noise ratio on the computer's built-in analog DAC.	1. Reduce host computer volume to **60–70%** and increase receiver gain. 2. Use a dedicated USB external audio interface for clean analog feed.