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TND6325/D
Rev. 1, SEPTEMBER – 2020

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# Developing a Voice Controlled Bluetooth® Speaker Based on the LC823455



September, 2020 – Rev. 1
Publication Order Number:
TND6325/D

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# Developing a Voice Controlled Bluetooth Speaker Based on the LC823455

## INTRODUCTION

Streaming music is now the standard way to listen to music. Whether it is at home on a desktop, TV or a phone, it is available almost everywhere. The smartphone may be the most popular device capable of streaming as a Bluetooth connection allows a user to listen to music from more than a tiny speaker. External Bluetooth connected speakers allow a streamer to listen to music on a number of different types of speakers. These can range from simple single speaker to multi speaker stereo solutions.

ON Semiconductor provides several products designed specifically for this market of audio systems. Key among them is the LC823455, a low−power, highly integrated audio processing SoC which contains an energy efficientDSP for audio and dual Arm® Cortex®−M3 processor cores for controlling various peripherals. The LC823455 has several built−in audio functions and includes over 4 MB of RAM. Driving various types of speakers is made possible with the ONA10IV, a high−quality class D amplifier. When used with the LC823455, the ONA10IV can be configured in several different ways using $I^2S$. It can also be configured to operate in TDM mode with the use of a different DSP. The Arm core in the LC823455 can be used to control other features such as capacitive touch control, LED drivers, temperature sensors, and other peripherals.

This paper provides details on designing a high−performance, energy efficient, voice controlled Bluetooth speaker incorporating several ON Semiconductor products and technologies.

## BLUETOOTH SPEAKER OVERVIEW

Based on the LC823455, the Bluetooth speaker has four ONA10IV 16 Watt and one ONA40A 50 Watt Class D amplifiers. Audio can be streamed from a Bluetooth device using the A2DP. The LC823455's DSP converts the input audio to PCM audio used by the amplifiers. The LC823455 uses one microphone for local voice commands in addition to echo cancelling.

A “4.1” system is created using the ONA10IV’s driving 4 x Dayton Audio DMA58−4 2″ speakers and the ONA40A driving a 5.5″ Anarchy−554 woofer. The 4 Ω Anarchy speaker was chosen based on its performance, but the ONA40A is capable of driving an impedance all the way down to 1 Ω.

The LC823455 incorporates voice control technology that supports control commands such as: play, stop, next song, previous song, and volume up and volume down.

The LC717A10AR capacitive touch sensor can be used to manually control volume, play, pause and next track. Although only 4 channels are used, the LC717A10AR has up to 16 channels of capacitance−sensor input. The controls are located on top of the device and are easily sensed through the enclosure. There are two LV52511 which control a combined 16 RGB LEDs. The LV52511 has the ability to change LEDs either individually, or up to all of the LEDs can be changed together.

The product is Strata enabled allowing all documentation to be accessed by plugging in to a computer with the Strata application installed. In addition to all relevant documents, certain features can be controlled live through the Strata interface. These include volume control, mute, EQ settings and track selection. Telemetry is also available with displays of audio input rail voltage, current and board temperature.

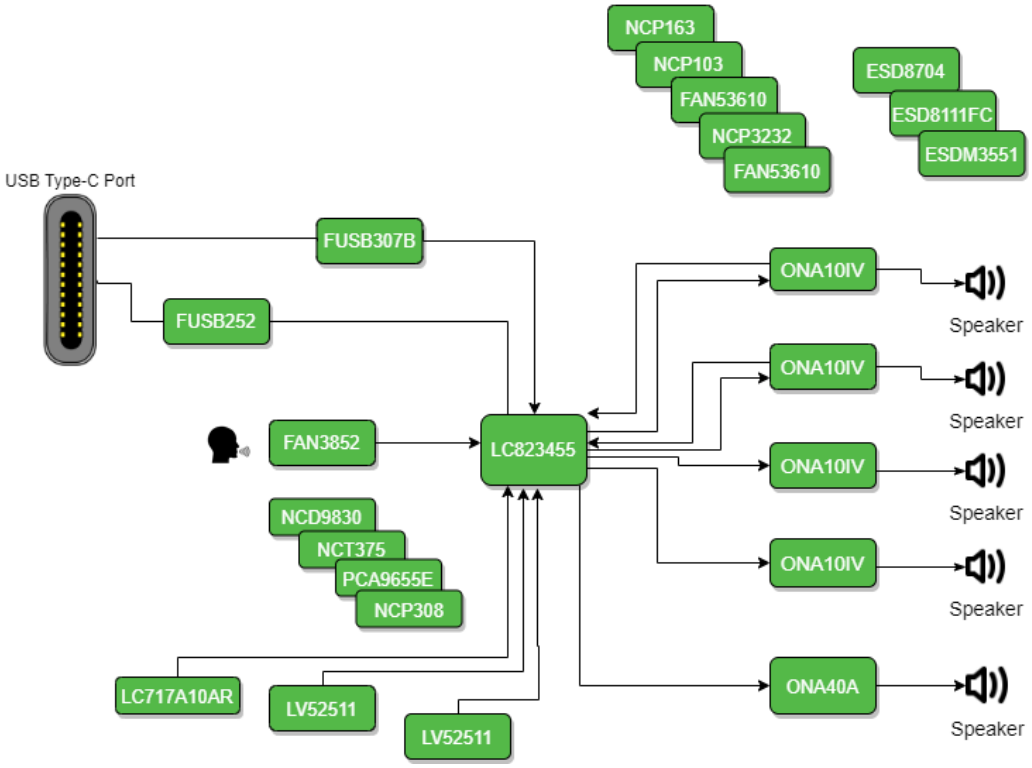


**Figure 1. Bluetooth Speaker System−Level Block Diagram**

## Bluetooth Speaker Features

- Bluetooth Audio (A2DP)
- 10 Band EQ
- Voice Recognition Feature
- 16 W Class D Amplifiers (4)
- Touch Control


**Figure 2. Photograph of the Bluetooth Speaker Demo**

## COMPONENTS OVERVIEW

### Strata Developer Studio™ Interface

Strata Developer Studio is a cloud−connected development software for ON Semiconductor evaluation boards and design kits. With Strata, the user can plug in any Strata enabled board to start simulation and evaluation with the easy to use graphical user interface. Strata automatically downloads the most recent design documents and files, such as schematic, layout, test report, user guide, etc.

Providing the ability to change settings, or read live values is not necessary in a finished product, but for a developer, a UI is a handy tool which allows a user to configure settings to fit their requirements easily.

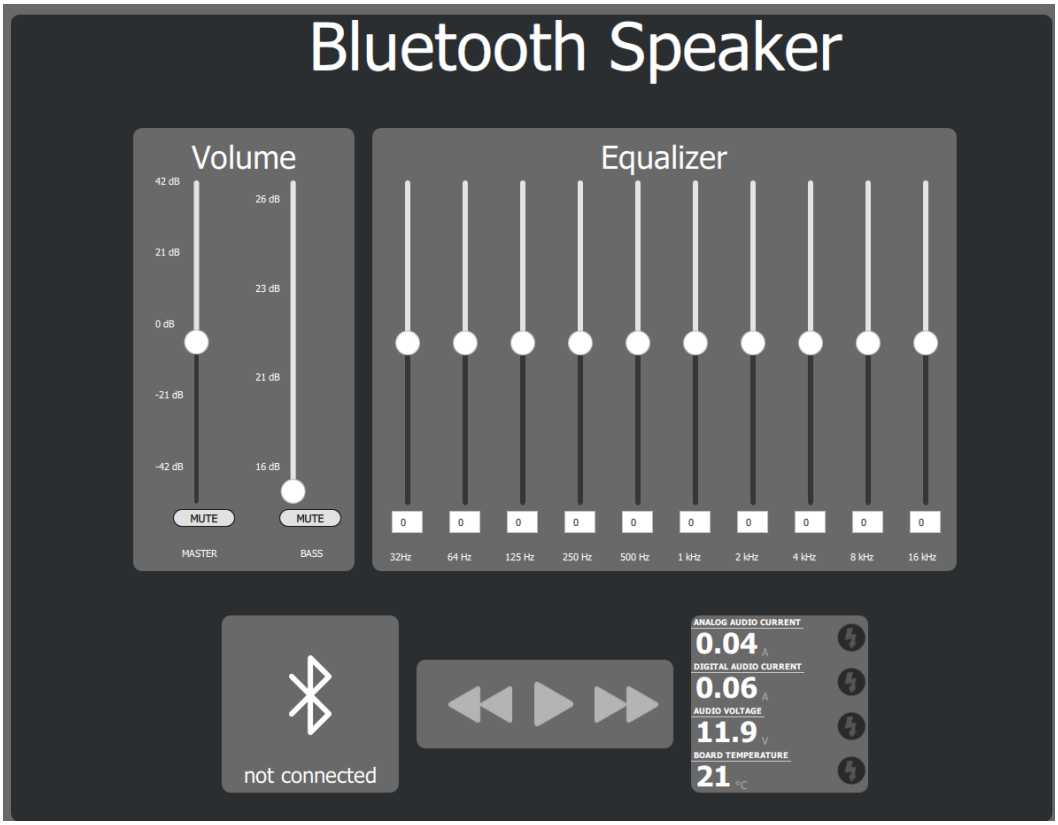


**Figure 3. Bluetooth Speaker Interface in the Strata Developer Studio**

The UI shows several different features of the design as well as allow some control while in the UI. Telemetry includes:

- Audio rail voltage and currents
- Bluetooth connection status
- Volume and EQ settings

Along with the telemetry, the UI provides the ability to adjust the master volume, bass volume, track control and a 10 band EQ. The EQ allows a user to change the gain at each given frequency. These frequencies include 32, 64, 125, 250, 500, 1k, 2k, 4k, 8k, 16k Hz.

### LC823455

The LC823455 is a low power, high resolution audio processing SoC that comes in a small form factor WLCSP package (~4 mm square). Up to 4 microphones can be used dependent on the design. There are 2 PCM channels with the ability to drive up to 4 speakers. An internal class D amplifier with left and right channels is also offered.

The DSP has an audio processing capability of 192 kHz and has multiple audio processing capabilities. These include, but not limited to MP3 codec, SBC codec, FLAC codec, noise cancelling and echo cancelling.

The EQ allows up to 10 bands to be adjusted. The user is able to adjust the gain, center frequency and the Q value for each band. Gain is adjustable from −18 to 18 dB and can be adjusted in real time. The center frequency is in the range of 125 Hz to 16 kHz. The Q value is adjustable between 0.3−4.0. Like frequency, the Q factor can only be changed at initialization.

### ONA10IV

The ONA10IV is a 16 W digital input Class−D audio amplifier with speaker sense digital output. Since the ONA10IV is a filterless mono amplifier, the device saves size and cost by removing the need for bulky external filter. The digital audio can be PCM, PDM or TDM. PDM Mode is offered with a frequency of 3.072 MHz. PCM and TDM have data rates of 16, 24 and 32 bit with sampling rates between 16 kHz and 96 kHz. The speaker sense works in real time sensing voltage and current of the speaker it is driving.

In TDM Mode, the ONA10IV can support up to 8 slots. Each slot is capable of sending I/V sense data, which allows all speakers to be different. This allows a design to use fewer part numbers and can cut design time down.

Using the current and voltage sense readings from the ONA10IV many speaker characteristics can be calculated using algorithms running on a microcontroller. These speaker parameters can be used to calculate speaker resistance, resonance, temperature, Qes, Qms and Qts. From these values, algorithms can be created to perform a range of tasks. Features such as speaker protection, range extension, or detecting and correcting speaker non−linearity are all possible. Whether a design needs to drive a range of speaker impedances, or simply dealing with a lower quality speaker issue, the ONA10IV can help.

## SUMMARY

As the need for portable audio solutions grows within the Internet of Things, the need for cost effective, energy efficient system−level components will only increase.

Through the combination of the LC823455 and ONA10IV, the Bluetooth Speaker Demonstration is a complete solution that also allows a designer the option to explore the assortment of components offered and see the interaction in a full solution design. Although every manufacturer's specific needs will be different, the Bluetooth speaker will give the first order of evaluation for a low power audio solution whether that be a speaker, stereo or any other audio−infused product.



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