Electronic Component & Smart Tech Device:

Inside the Amazon Echo Dot 2

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**History of the Echo Dot**

The Amazon Echo Dot 2 is the second generation of the Echo Dot and the most popular device in Amazon's Echo smart speaker product line. The original Amazon Echo debuted in 2014 and served as the vanguard for smart speaker technology which has now been duplicated by other major tech companies like Google and Apple. The original Echo allowed users to accomplish a variety of everyday tasks—playing music, reading the news and weather, getting traffic updates, creating lists, creating reminders, controlling other smart home devices, etc.—simply by using their voice to ask a question or give a command. The original Echo device is a cylindrical tower that stands 9.3" x 3.3" x 3.3" and weighs about 2.3 pounds.

The Echo Dot 1 debuted in March 2016, followed quickly by the Echo Dot 2 in October 2016 (Jaffe, 2016). The Echo Dot 2 provides the same capabilities as the Echo, but excludes the large onboard speaker. As a result, the Echo Dot 2 measures only 1.3" x 3.3" x 3.3" and weighs only 5.7oz. The Echo Dot 2 boasts a significant improvement in voice recognition ability versus the Echo Dot 1 and is the first of the Echo products that allows users to connect an external speaker via Bluetooth or 3.5mm stereo audio.

**Components and Operation**

The Echo Dot 2 contains a wealth of small but powerful electric components that work together to operate the system. The order of components discussed below is the order in which they are encountered upon disassembly of an Echo Dot 2 unit.

The first component in the Echo Dot 2 is a small speaker inside of a hollow plastic housing. This speaker is what the device uses to communicate with users when it is not connected to an external speaker; however, it is not intended to be used as a primary media speaker and the sound quality is relatively low. There are two metal contacts on the speaker housing that are connected to mechanical spring clips soldered to the top of the first circuit board (Hughes, 2016).

The first circuit board is home to some of the most important components in the system, including the power management integrated circuit (PMIC), processor, memory, Wi-Fi/Bluetooth chip, digital-to-analog converter (DAC), and input ports (micro-USB for power and 3.5mm stereo audio for external speakers). The PMIC is a MediaTek 6323, which is optimized for 2G/3G devices, smart phones, tablets, and other portable systems. The MediaTek 6323 has an input range of 3.4 ~ 4.5V and is able to support high-quality audio systems and up to 4-channel LEDs (MediaTek, 2013). This single PMIC is able to regulate power needs for the entire Echo Dot 2 system.

The processor is a MediaTek MT8163 highly integrated SoC (System on Chip) which incorporates a 1.3GHz, 64-bit quad-core ARM-A53 processor, an ARM Mali-T720 GPU, a 13 megapixel camera, and connectivity for Wi-Fi, Bluetooth, GNSS, and FM Radio (MediaTek). The MT8163 is compatible with DDR3 and LPDDR3 memory, which for the Echo Dot 2 comes in the form of a 4GB Micron LPDDR3 module (Hughes, 2016). Despite the processor having built-in communication capabilities, the Echo Dot 2 has a separate MediaTek MT6625L connectivity chip. The MT6625L is a 4-in-1chip that contains a 2.4GHz Wi-Fi and Bluetooth transceiver, a 5GHz Wi-Fi transceiver, a GPS receiver, and an FM receiver (MediaTek, 2014). Considering that all of the utility of the Echo product series relies on connectivity, it is logical that a dedicated chip would be included in the Echo Dot 2 system.

The digital-to-analog converter is the DAC 32031 by Texas Instruments (TI). Technical specifications for this model DAC weren't readily available on the TI website; however, in general, DACs do exactly what their name implies: they convert digital signals to analog signals. In the Echo Dot 2, it is therefore logical to assume that this chip is responsible for the audio output you hear when communicating with Alexa (i.e., Alexa's voice).

Whereas the first circuit board handles most of the Echo Dot 2's computing operations, the second circuit board is responsible for much of the system's audio and visual inputs and outputs. The top of the second circuit board contains four tactile switches that correspond to the volume up/down, microphone mute, and action buttons on the top of the Echo Dot 2 unit. There is also what appears to be some type of optical sensor (Hughes, 2016), though information on exactly what this component is and what it does was unavailable.

The bottom of the board houses seven surface-mount microphones. Six of these microphones are spaced evenly along the outside of the circular board, while a seventh, slightly smaller microphone resides in the exact center of the board. These microphones are constantly listening for the Echo Dot's wake word ("Alexa") and transmit the analog signals they receive to one of the four analog-to-digital converters (ADCs) located in the middle of the board. These four ADCs are TI model TLV320ADC3101 which boast a low power requirement and a respectable 92-dBA signal-to-noise ratio (Texas Instruments, 2014). A high signal-to-noise ratio means that the Echo Dot 2 will be able to pick out a user's voice commands despite the presence of background noises like music, television, conversation, traffic, and so on. A much higher signal-to-noise ratio is arguably the Echo Dot 2's greatest improvement over the Echo Dot 1 (Crist, 2016). T

Two RGB LEDs flank either side of each outer microphone, for a total of 12 LEDs. These LEDs are used to indicate things like a change in volume, an action, or microphone mute. The LEDs are connected to switches by a microcontroller that was difficult to identify (Hughes, 2016). Finally, the second circuit board is connected to the first circuit board by a ribbon cable.

# Applications

# The Echo Dot 2 combines its impressive hardware with Amazon's "Alexa" software—a hands-free, virtual-assistant ala Apple's Siri or Microsoft's Cortana (and superior to both)—to accomplish a wide variety of tasks for its users. The Echo Dot 2 can play music through Amazon Prime Music, Spotify, Pandora, iHeartRadio, and more; make hands-free calls or send hands-free text messages; serve as a two-way radio with other Echo devices in your home; control other smart home systems like the Nest thermostat, LED lights, TVs, alarms, garage doors, sprinklers, etc; look up news, weather, and traffic reports; create and manage shopping lists, to-do lists, and other task lists; tell terribly corny jokes; look up recipes; and a whole lot more. Alexa can even learn all new "skills" which can be downloaded through the Amazon Alexa app on your phone or PC to extend the Echo Dot's capabilities.

# Voice-activated devices like the Echo Dot 2 and Alexa can also be used to increase access to smart technology for people who live with physical disabilities like blindness, lack of manual dexterity, or lack of mobility. As this technology continues to develop, it could play a pivotal role in providing these individuals with increased independence, interpersonal communication options, and safety. Additionally, there is high potential for educational use, particularly in the realm of language learning—imagine being able to have a fully interactive conversation in another language without leaving own home or paying a tutor.

# The Echo Dot 2—like other voice-activated smart devices—isn't perfect, but it is nevertheless an impressive, efficient device with numerous useful applications. Sales figures for the Echo Dot 2 indicate that these products are desirable and add real value to users' lives, and therefore it is expected that the technology will continue to grow and improve over the next several years as companies like Amazon, Google, and Apple ramp up investment and competition. Given the almost limitless number of applications for voice-activated tech, such investment could have a significant impact on society in the near future.

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