Enabling Automation in Logistics and Retail—Part 2

Colm Slattery, Strategic Marketing Manager, and
Alessandro Vinco, Staff Engineer, Systems Integration

Introduction

In "Enabling Automation in Logistics and Retail—Part 1", we explored battery management in handheld devices and the impact on the bottom line in logistics and retail applications. In Part 2, we will focus on how overall automation efficiency can be improved by introducing advanced capabilities in handheld devices, including high-*g* impact detection, dynamic speaker management, and built-in automatic object dimensioning.

Reliability and Warranties: High-*g* Impact Detection

The nature of handheld devices such as mobile computers and barcode scanners is that they will more than likely be dropped multiple times during their lifetime. With each drop, the unit becomes more susceptible to physical damage and/or functional failure of its many integrated subsystems. In such events, the device is more likely to encounter physical or functional damage as a result.

The intensity of a drop can vary from a small tumble to a highly accelerated fall, where the acceleration or *g* count of a device falling on a factory floor can reach several hundred *g*'s and substantially reduce a device's resilience to avoiding damage. It is important to avoid exceeding product specifications to ensure that devices have a long working lifetime. From an original equipment manufacturer (OEM) standpoint, particularly for high priced devices, the warranty can be voided when misuse or accidental falls damage the electronic device. To enforce such a warranty, it becomes critical to detect the high acceleration levels of the falling object at a high sampling rate as these falls often show short acceleration impacts (see Figure 1).

Manufacturers also have specific test environments and procedures to check the impact limits of their devices before releasing them to market. For example, standards such as the U.S. Military Standard, MIL-STD-810G 516.6, define a process distributed over five test units where each device is dropped 26 times (8 corner drops, 12 edge drops, and 6 face/side drops) at test method-defined temperatures. If the device powers off, reboots, or loses data during testing, the device is deemed to have failed the drop test. Environmental factors, such as temperature and chemical exposure, can also degrade a device's ability to continue to function after it has been dropped.

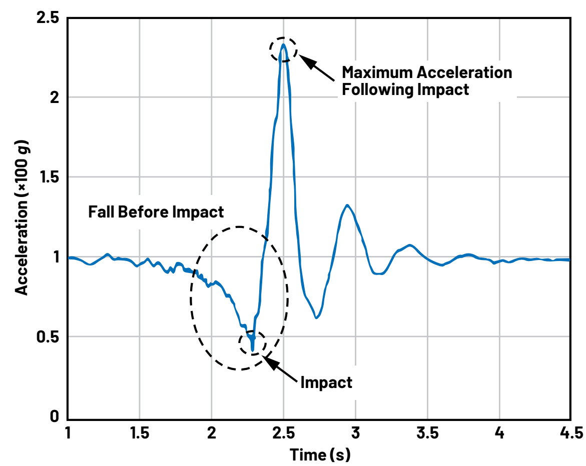

Figure 1. Typical acceleration levels for a handheld drop test. Note that maximum acceleration follows actual impact.

Fast, high quality monitoring of all the accelerations that devices are exposed to during their use is possible with MEMS accelerometers such as the ADXL37x series of high-*g* accelerometers. These MEMS accelerometers have a 3 mm × 3 mm footprint and are designed to withstand up to ±400 *g* accelerations. They operate at low power levels even at the maximum sampling rate (over 5 kHz), using less than 45 μA in continuous operation, making them suitable for use in handheld and battery-powered devices. Conventional accelerometers do not have the speed to correctly detect and characterize falls. With a 3× higher sampling rate than many conventional accelerometers, high-*g* accelerators can detect the fastest transients, accurately identify an accidental fall, and specify the type of fall event, all at 10× lower power consumption. High-*g* accelerometers such as the ADXL37x also undergo extensive testing, including guillotine tests and highly accelerated life tests (HALT), which reproduce the tough environmental and operating conditions in which handheld equipment must be able to operate robustly and reliably (see Figure 2).

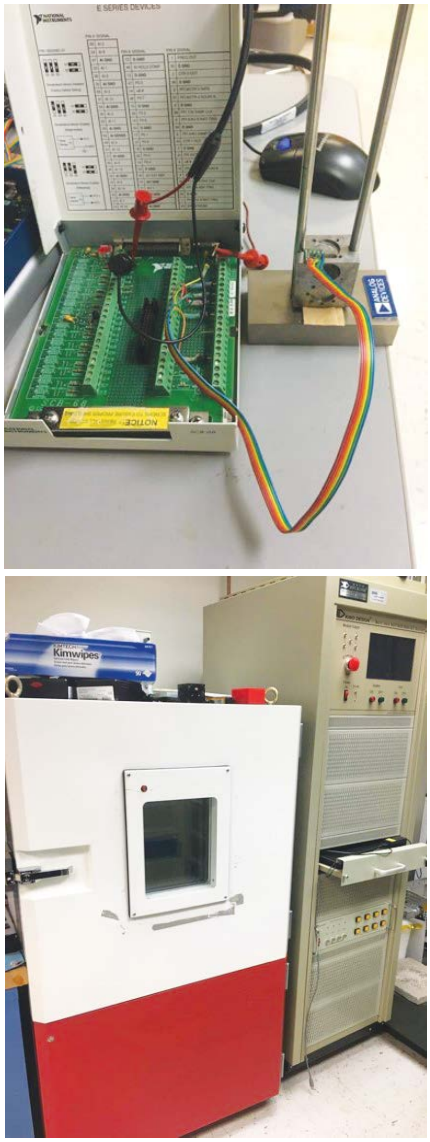

Figure 2. Guillotine test and highly accelerated life test (HALT) equipment used for MEMS shock testing.

With high-*g* accelerometers, high end barcode scanners, and mobile computers, warehouses can now be monitored for any accidental conditions. This can help guarantee the safe and reliable use of the equipment to the end user. It can also allow manufacturers of such equipment to void product warranties in case of detected misuse and avoid expensive in-warranty repairs when the OEM is not accountable for such damages.

Dynamic Speaker Management

Factory floors are extremely noisy environments. Constantly moving robots, conveyor belts, and other machinery can make audible communications of all types difficult. For example, a barcode scanner might offer an audible beep to verify that a scan has been completed. To be heard, the handheld or wearable device must project sound loudly and clearly. However, at the same time, power consumption of audio amplifiers must not significantly reduce battery life. Put another way, OEMs simply can't increase the size of the amplifier and speaker to increase speaker volume.

Dynamic speaker management (DSM) enables developers to increase the output of microspeakers by a factor of 2.5× without increasing power consumption or negatively affecting safety operating conditions. This is possible using compact, low power, and highly efficient Class D audio amplifiers with an integrated boost converter. Such an architecture preserves battery life by leveraging the concept of perceptual power reduction (PPR): By utilizing the speaker's sound pressure level (SPL) response acquired via DSM, coupled with the human hearing threshold (see Figure 3), it is possible to dynamically attenuate signals that are inaudible to end users. Attenuating these signals saves 10% to 25% power compared to conventional static filters (see Table 1).

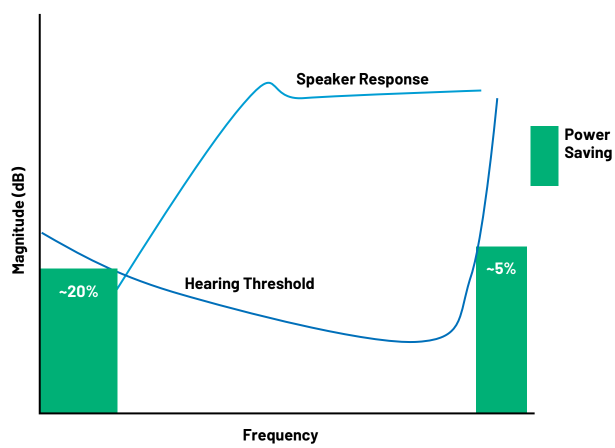

Figure 3. PPR dynamically attenuates signals that are inaudible to users.

For example, consider the integrated 10 V boost converter of the MAX98390 from Analog Devices. This device allows up to an 8 dB SPL increase compared to a conventional amplifier without exceeding the thermal limits of the speaker (see Figure 4).

Table 1. End User Case Study on Flagship Phone

HPF	PPR Cutoff	PPR Thresh	Music	Volume (x/15)	PPR OFF (mA)	PPR ON (mA)	Delta (mA)	Total PPR Power Saving
180 Hz	300 Hz	–36	Track 1 (Rock Music)	15	225.6	205.8	19.8	8.78%
180 Hz	300 Hz	–36	Track 1 (Rock Music)	13	157.3	119.6	37.7	23.97%
180 Hz	300 Hz	–36	Track 2 (Piano and Voice)	15	228.8	206.65	22.15	9.68%
180 Hz	300 Hz	–36	Track 2 (Piano and Voice)	13	186.4	148.4	38	20.39%

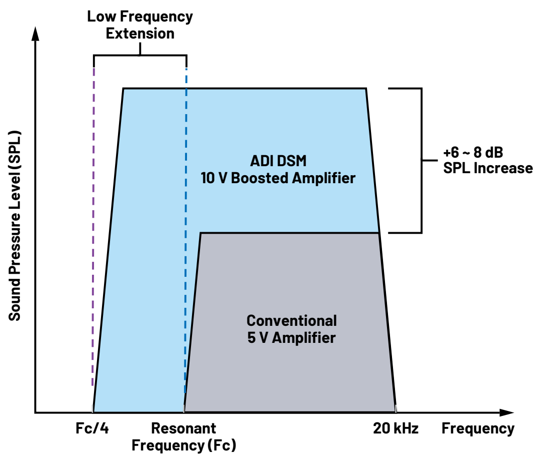

Figure 4. A DSM amplifier like the MAX98390 allows up to an 8 dB SPL increase compared to the same speaker with a conventional amplifier.

Additionally, sounds are louder without the accompanying buzz typical of traditional amplifiers. Because the dynamic notch filter only attenuates the interaction of the mechanical rattling with the port resonance without attenuating both sound and buzzing effects, this results in both clearer and louder sound compared to conventional notch filters (see Figure 5).

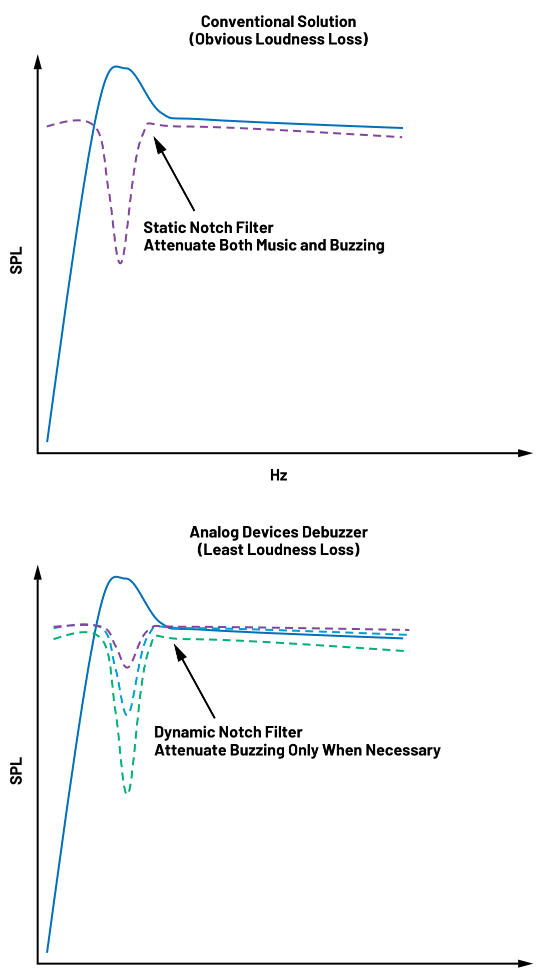

Figure 5. Because the dynamic notch filter only attenuates the interaction of the mechanical rattling with the port resonance without attenuating both sound and buzzing effects, this results in both clearer and louder sound compared to conventional notch filters.

To enable fast prototyping and accelerated application development, ADI offers the MAX98390EVSYS evaluation kit for microspeakers, complete with reference design files and a fully GUI-based automatic speaker parameter extraction tool to best extract key parameters from the speaker (see Figure 6).

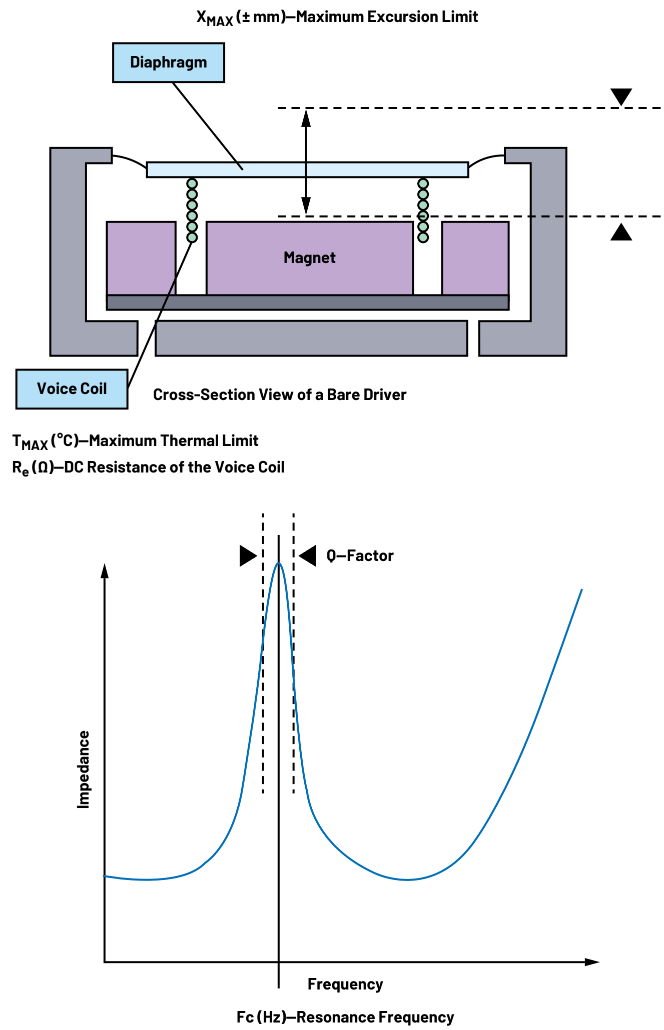

Figure 6. With a microspeaker evaluation kit like the MAX98390EVSYS, the design can quickly and easily extract the key speaker parameters required to begin audio design.

With an integrated amplifier like the MAX98390, OEMs can introduce DSM into handheld and wearable devices to deliver louder and clearer sound without negatively impacting battery life. For example, the MAX98390 has the industry's lowest noise floor (9 µV) and power consumption (24 mW at 3.7 V) for a DSM speaker while providing the highest dynamic range (117 dB). The device is also available in a compact package size as small as 6.3 mm². In short, OEMs can improve operator safety through DSM for louder and clearer sound without requiring a different microspeaker or larger battery pack.

Automatic Object Dimensioning

Global parcel shipments are expected to reach 256 billion packages in 2027.[1] The dimensions and weight of each of these billions of parcels must be measured multiple times during transit through warehouses, trucks, and couriers' hands. Manual processes, such as a person using a measuring tape, are prone to error but more importantly, slow down the throughput of the supply chain and distribution of goods.

Goods can be packaged bigger than they need to be. This leads to inefficiencies throughout the supply chain. For example, the utilization of van capacity is less efficient than it could be with more accurate object dimensioning. In addition, larger packaging introduces unnecessary waste of packaging materials.

While fixed automatic measuring systems can improve efficiency, they can be expensive to deploy and limited to operation in a specific location. An alternative to fixed automatic measuring systems is portable and handheld scanners that employ machine vision and automatic object dimensioning to increase efficiency, reduce waste and impact on the environment, and lower operating costs across the entire supply chain.

These portable systems can measure an object of any size with millimeter accuracy. With such accuracy, parcels can be moved throughout the supply chain using the minimum/optimal amount of packaging required. In addition, they can be moved more safely across logistic centers via autonomous robots and loaded in vans that can be now loaded to full capacity. With such scanners, no other tools or measuring devices are required to measure objects in logistic centers, warehouses, or in the field. Thus, the measuring process is simplified while increasing accuracy, improving efficiency, reducing waste, and lowering operating costs across the entire supply chain compared to fixed automatic measuring systems.

Automatic object dimensioning utilizes time of flight (ToF) technology to accurately measure objects. ToF is based on a controlled light source and a photodetector. The sensor is used to measure the distance from a point by transmitting modulated light and then measuring the phase shift over the time it takes the beam to be reflected to the photodetector.

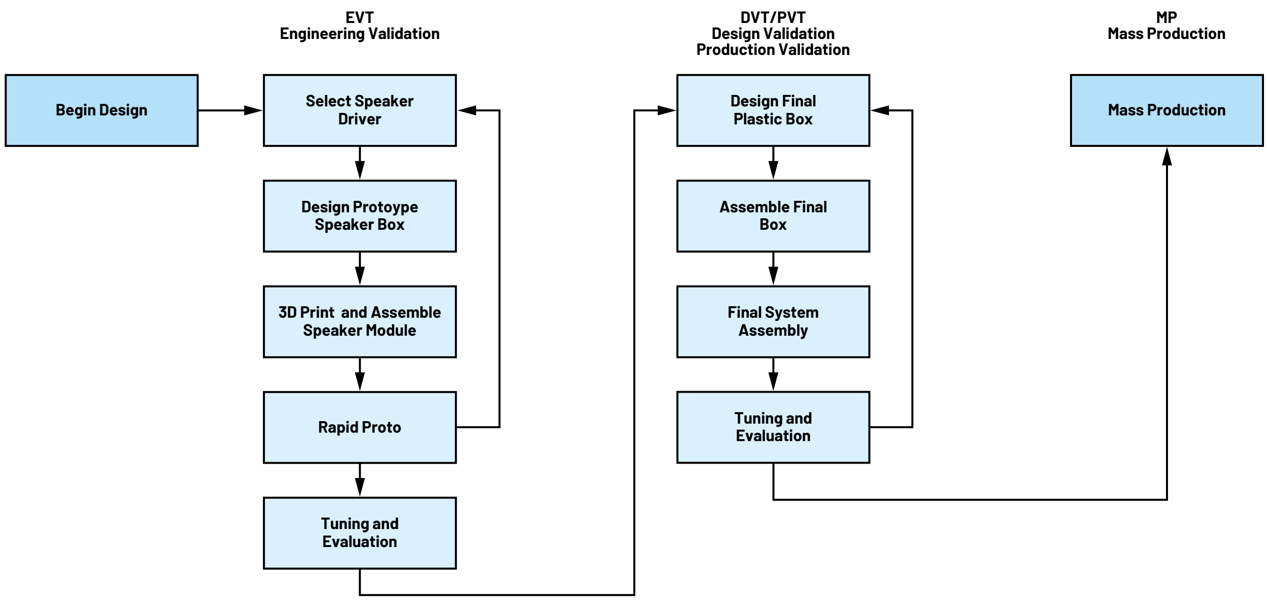

Figure 7. The simplified design process for microspeaker amplifiers, such as that enabled by the MAX98390EVSYS microspeaker evaluation kit from ADI, accelerates the design of audio systems.

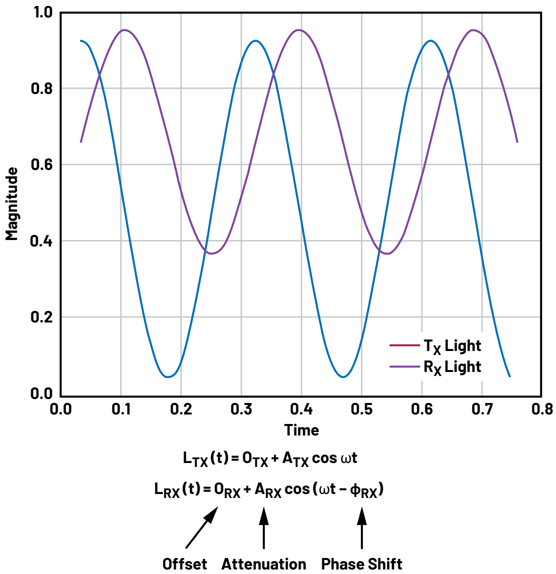

Figure 8. The basic principle of ToF computation using the phase shift of a sinusoidal wave.

ToF involves complex computations using three correlations (120° shifted) per modulation frequency to solve ϕrx. In addition, multiple modulation frequencies are used to increase unambiguous ranges (see Figure 8). The highest levels of accuracy can be reached using a per-pixel phase offset correction and temperature drift correction, together with spatial filtering to reduce noise. With an optimal resolution and frame rate, edges and faces of any shape can be accurately detected and measured.

Figure 9 shows an example of a ToF module that enables real-time object dimensioning in a handheld scanner. This module is based on both the ADTF3175 1 MP ToF module and image signal processor ADSD3500 from ADI. High resolution is required by machine vision algorithms for object identification and object recognition/dimensioning. The ADTF3175 ToF sensor provides high resolution for a 3D sensor at 1 MP (1024 × 1024 native resolution). The sensor also supports a frame rate of up to 40 fps at full resolution, as well as up to 90 fps at VGA (640 px × 480 px) resolution to enable automatic object dimensioning for applications involving fast-moving objects. In addition, the ADTF3175 sensor utilizes infrared active illumination. This makes it possible for scanners to operate robustly in all warehouses and industrial environments where light levels can vary from bright to completely dark.

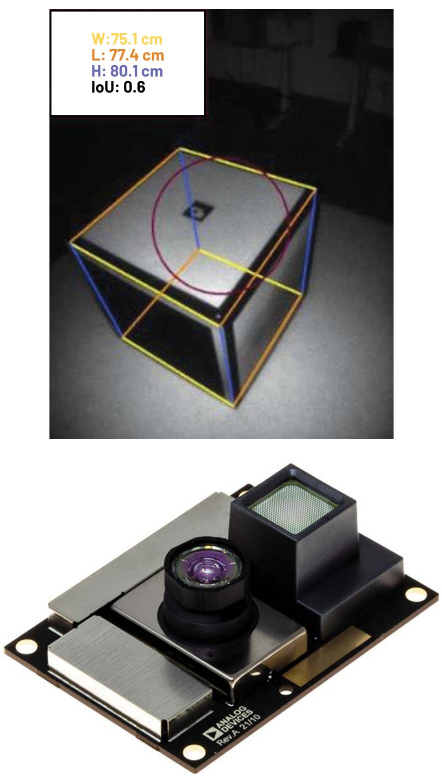

Figure 9. An example of box dimensioning application (top using the ADTF3175 ToF module (bottom).

Figure 10. A handheld device integrated with 3D object dimensioning using the ADI ToF sensor.

Figure 10 shows the level of detail and accuracy 3D object dimensioning can achieve when combined with an image signal processor such as the ADSD3500. The ADSD3500 has a dedicated depth compute engine to accelerate the image processing datapath, enabling full depth processing at up to 800 × 600 resolution and prephase-unwrap processing at up to 1280 × 1024 resolution. Internally, data communication is available over 4× input MIPI CSI-2 lanes at up to 2.5 Gbps per lane or 2× output MIPI CSI-2 lanes at up to 2.5 Gbps per lane for fast frame rate measurements of ToF data.

A ToF-based system based on a ToF sensor and image processing like the ADTF3175 and ADSD3500 greatly simplifies the design process for a ToF system. Raw data frames from the ToF sensor are fed directly to the image processor, which performs any ToF calculations. The resulting depth data can be passed to an external low end microcontroller. In effect, high video processing is offloaded from the microcontroller and no additional DRAM memory is required.

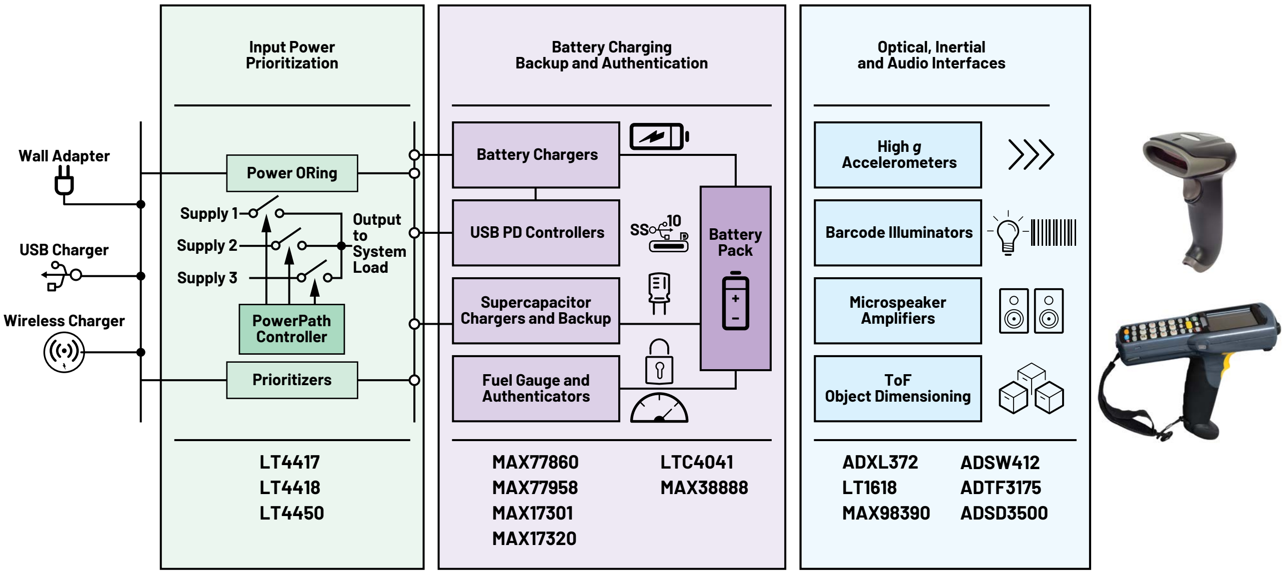

Figure 11. ADI's extensive technology offering for handheld automatic data capture devices.

In addition to simplifying system design, the overall power consumption of the system is considerably reduced compared to conventional ToF approaches. Thus, ToF can be implemented in battery-operated handheld scanners and mobile computers without compromising performance or power efficiency. Based on the application and an OEM's particular application requirements, ADI offers a complete portfolio of innovative technology for handheld automatic scanners for logistics and retail end applications, including power management devices, battery gauges, and integrated components enabling advanced capabilities such as high-*g* accelerometers, microspeaker amplifiers, ToF sensors, and image processors.

The need for greater efficiency and lower operating costs is helping to drive growth in automation for logistics and retail end applications. As a result, automated data capture devices have become much more than simple barcode scanners. These handheld devices are essential for enabling the logistics automation transformation through real-time data management, enabling efficiency enhancements.

By introducing advanced capabilities such as high-*g* impact detection to ensure device reliability, dynamic speaker management to increase user safety, and built-in automatic object dimensioning to increase accuracy, these scanners can deliver even greater productivity. Combined with smart battery management, OEMs can design and deliver next-generation scanners that improve efficiency and lower costs across the entire logistics supply chain.

Reference

[1] James Melton. "Global Parcel Volume to Grow at 8.5% CAGR Through 2027." Digital Commerce 360, September 2022.

About the Authors

Colm Slattery graduated from the University of Limerick with a bachelor of electronics engineering degree. He joined Analog Devices in 1998 and has held various roles including test development and product and system applications. Colm has also spent three years on assignment in a field role in China. Colm is currently a marketing manager in the Industrial Business Unit, focusing on new sensor technologies and new business models.

Alessandro Vinco works as a system applications engineer in the Intelligent Infrastructure Business Unit at Analog Devices. He worked in startups and private companies in Ireland and the UK before joining Analog Devices in 2018. His background spans across several wireless systems and technologies for smart buildings and environmental sensors, power management, and electrical communications.