Radar-System Designers Now Have a Choice of Discrete or Integrated Components

by Jeff Postupack and Sam Weinstein, Analog Devices

A 25-year-old male driver is checking his smartphone when congested city traffic starts to move. Just as he steps on the gas, the car in front of him brakes suddenly due to bumper-to-bumper conditions. Within milliseconds, the in-car radar system steps in. Adaptive Cruise Control with Stop&Go detects the decelerating car in front, maintaining a pre-programmed distance from the leading traffic and stopping the vehicle to avert the impending collision.

Welcome to the age of the intelligent vehicle – where technology is advancing every day.

Automotive safety has come a long way in the two decades since airbags became a standard safety feature. “Passive safety,” defined by seat belts, airbags and crash detection systems, has evolved into “active safety” – ABS, electronic stability control, adaptive suspension, and yaw/roll control. The latest phase is “driver assistance” safety, which includes adaptive cruise control (ACC), blind-spot detection (BSD), and lane-change assist (LCA). These systems are beginning to merge with the communication systems in the vehicle, making the vehicle more autonomous and more intelligent.

Radar is an especially promising driver-assistance technology. Radar systems have the potential to greatly decrease the number and severity of accidents, particularly "distracted driver" incidents. Driver fatalities are at an all-time low in many countries because of national vehicle safety legislation, which has helped fuel development of the intelligent vehicle. Until recently, radar has been limited to aircraft and luxury vehicles, but now it's come front-and-center in cars.

The looming challenge for designers is how to pack in multiple safety features while also meeting the auto industry's exacting quality and cost requirements. Those goals don't have to be at odds. For the first time, highly integrated systems are rolling out that enable ACC and other radar-based detection and avoidance applications, all in a very small package(about the size of a smartphone.) Advances in on-chip signal conditioning let designers program the settings needed for different driving conditions, whether it's city traffic or highway cruising, all in one economical package.

As a result, radar-system designers now have a choice: discrete components or integrated solution. Electronics integration has happened in many industries – for example, medical imaging, communications infrastructure, and consumer devices – and now it's come to automotive radar. There are trade-offs to each path that designers must consider.

Size and cost

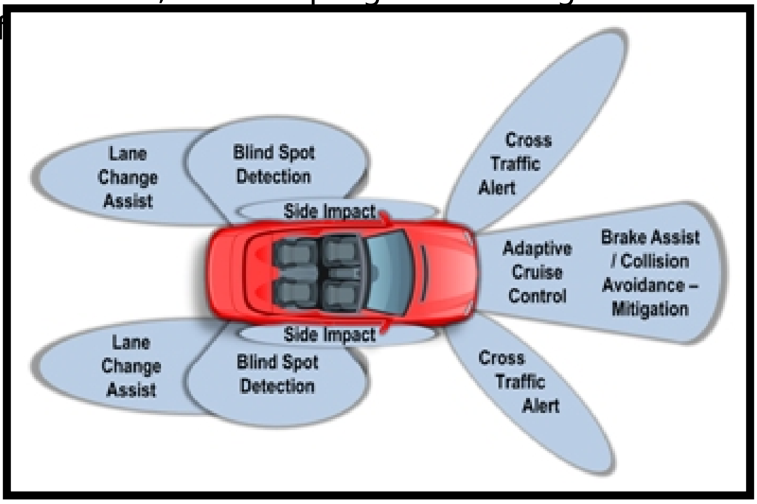
Radar is moving from standard equipment in luxury cars to an option in midrange cars and is expected to become a widely adopted safety feature in cars five years from now. The pace of adoption will increase with the availability of affordable radar with better target classification and range resolution. The design approach to the analogue front-end (AFE) can make all the difference. Discrete parts can be used to build a top-of-the-line custom solution, and there will always be the purists that want to optimize every parameter. But it will take more time, occupy more space and cost more to build a radar system of discrete parts. An integrated IC provides most of the features a car manufacturer is likely to want, even for multiple applications like ACC and BSD, at a fraction of the size and cost.

Now it’s possible to get the signal conditioning and data capture circuitry all on one IC. Size is everything since the radar sensor module must fit in small compartments, such as behind the bumper, not originally designed to house such electronics. With an integrated solution, you can expect to reduce the footprint by at least half compared to equivalent discrete parts. Integrated devices can be cost-effective yet retain the high performance levels required of radar systems designers.

You can hand build a discrete system to do exactly what you want, but the cost can quickly get prohibitive to roll out on any scale. An integrated solution means radar systems can be placed more affordably into more cars, meaning safer cars for everyone.

Ease of use

Integrated devices may add built-in innovations, such as programmable gain and flexible filters. Such features shave off



time to market not only for the first system designed, but for all subsequent systems by enabling a platform design approach.

Filters, for example, need to be fine tuned for different driver-safety applications. A discrete design makes it difficult to reprogram the filters; designers have to physically swap out resistors and capacitors to change the filtering characteristics. Integrated components with tuneable filters solve this problem. All the adjusting is done by reprogramming the chip via the serial port. This can even be accomplished “on the fly,” shortening design time by quickly allowing multiple iterations.

Multiple channels on one chip also make it easier for the designer, because the channels are well matched, and for the driver because the sensor has a wider range of detection. The ideal radar system would sense objects around the car in a 180-degree field of view, much like human peripheral vision. A receiver system equipped with as many as six channels can do this with better angular resolution since it receives a higher number of transmitted signals. That means there’s more time on target and better ability to resolve the approximate size of the target. Designers might accomplish the same objective with discrete electronics, but it can be a little more unwieldy.

The latest integrated solutions tailor the nature of the radar sensor automatically for long or short range. In transmitting radar signals back to the vehicle, designers must prevent system overload. If a target is directly in front of the vehicle, the return signal will have high amplitude and must be attenuated. If the car ahead is 400 feet away and the return signal is weak, the microprocessor is continually trying to optimize the signal to noise ratio to help classify that target, determine where it is in the field of view and how close it is to the vehicle. Most of this is accomplished through the programmable gain amplifier. One might use a discrete PGA, but not nearly so easily or economically as a PGA controlled through the same serial port as the programmable filter.

Flexibility is a compelling argument for an integrated solution given the variability in requirements for radar systems. Highway ACC requires a wide dynamic range, while ACC Stop&Go requires less range but greater field of view and faster response time to adjust to traffic immediately ahead. The user-programmable settings with integrated solutions can allow for one platform to offer increased performance under different operating conditions, accommodating both highway and congested driving.

A platform approach using integrated application-specific parts makes the design process easier, enables radar systems with smaller form factors, and most importantly, offers the chance to improve the safety of affordable cars.

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