The Benefits of Standard Radio-to-Baseband Digital Interfaces

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Major changes are taking place within the wireless industry in regard to GSM radio transceivers and how they interface with industry-standard baseband products. Historically, differential analog I and Q signals have been used in commercial and proprietary digital cellular systems. While analog I and Q signals are still used today, digital interfaces are emerging and are expected to become the standard.

Digital interfaces used in today's products are proprietary, however, it's only a matter of time until industry standards are developed to enable interoperability between basebands and radio transceivers.

What's Driving These Interface Changes?

So what has happened to drive the use and acceptance of digital interfaces? There is a growing consensus that both radio and baseband vendors can benefit from digital interfaces. In fact, it is not only digital interfaces that bring the benefit, but it's also the change in system partitioning which is enabled by digital interfaces—lowering the cost and accelerating time-to-market. Cost is improved by using the lowest-cost process technology for the baseband and time-to-market is improved because new baseband processors can migrate more quickly from older to new technologies.

Benefits for the Radio

Digital signal processing (DSP) techniques have become commonplace in many digital applications and are used extensively within baseband processors. By converting from RF to digital within the radio, DSP techniques can easily be utilized by radio designers. Radio performance can be increased by supporting the implementation of FIR filters for anti-aliasing, anti-droop, channel filtering, notch filtering, digital modulation and other functions unique to specific radio architectures.

In many cases, it takes less die area to implement the same function using DSP techniques than it does using the analog-equivalent method. Additionally, performance is more stable and predicable, since digital functions are not prone to variation over process, temperature and voltage like analog functions are.

Digital modulators are becoming more popular, and they naturally interconnect with the baseband processors using digital interfaces. For example, RFMD's POLARIS™ TOTAL RADIO™ transceiver uses a fractional-N synthesizer-based digital GMSK modulator, which can benefit in terms of performance if the baseband's GMSK bit stream is available to the transceiver. Alternatively, analog I/Q signals can be used, but do not provide optimum performance. Digital interfaces support access to the baseband's bit-stream information more easily than analog I and Q signals.

Benefits for the Baseband

When analog-to-digital conversion occurs in the radio, the baseband system can be partitioned to exclude all analog functions, which can then be placed in a separate mixed-signal device. This mixed-signal device could include all the power management functions, audio codec functions plus any auxiliary data converters. By removing all analog functions from the baseband, upgrading the baseband to newer technologies can be implemented more easily. Today's development tools allow the porting of digital designs to newer technologies using an almost "push-button" approach. In this case, the design effort could be focused on signal timing as apposed to redesigning the basic function. Keep in mind that the ease of transferring to new technologies varies somewhat with the type of design.

Many of today's baseband designs include analog functions that must be completely redesigned when upgrading to new process technologies. Some analog functions are easier to redesign than others, primarily depending on the speed of the function. For example, analog-to-digital converters sampling at high frequencies to recover radio signals are much more difficult to redesign than low frequency analog-to-digital converters within a voice codec.

Several challenges are presented when upgrading baseband functions to a new silicon process. The first challenge is found in the voltage requirements of the circuit. Often times, analog functions cannot take advantage of shrinking process geometry; headroom requirements cannot be met using lower voltage transistors. This issue could force the use of multi-voltage processes—typically three—requiring more process steps to include transistors with different breakdown voltages. This adds costs when compared to a pure digital process that usually uses a one- or two-voltage process. In a two-voltage process, one voltage transistor is used for internal digital functions (lowest voltage) and the other is used for input and output functions. A third type of higher-voltage transistor, used for analog functions, requires additional mask steps increasing costs.

Device modeling, specifically for high speed CMOS, is critical to the analog designer, where transistor and passive models are suspect until proven reliable. This is especially true when dealing with a new process, and can lead to multiple revisions of a particular function, as simulation results may not be achieved with real silicon.

Purely digital basebands can take advantage of semiconductor process density improvements, which are achieved much more rapidly in digital technology compared to analog. A change from .25 micron digital process to a .18 micron process can reduce the die area by 30 percent to 50 percent. A similar savings is seen when going from .18 micron to .13 micron technology.

In today's highly integrated GSM transceivers, the die area can be dominated by analog passive components, including capacitors and inductors. Process improvements have been slow to develop in this area, because the physics for these improvements are very different than shrinking an active transistor. The area required for a given capacitance has been reduced over the last few years, but not like the doubling of density described by Moore's law for digital functions.

Implications to the Industry

The historic analog I and Q interface has become an industry *de facto* standard, allowing handset manufacturers to interchange radios and basebands. This has been beneficial to handset suppliers, carriers and consumers, as it has maximized competition and driven down pricing in the component arena. This type of standardization is also needed with digital interfaces to enable the continued ability to combine various basebands and radios. Digital interface standards will also be more precise than analog and could remove some of the historic ambiguities that exist with analog I/Q interfaces.

RF Micro Devices is encouraging activity toward the development of digital interface stand-ards. Until an industry standard is available, RFMD has implemented programmable analog interfaces and a variety of digital interfaces in the POLARIS TOTAL RADIO transceiver enabling usability with the majority of currently available basebands products.

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