Semiconductor Innovation and Integration Drives Next-Generation 3G Multimedia Devices

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Abstract

The author describes powerful new integration strategies and techniques that will continue to propel us toward even more exciting products and applications.

Sustained innovation in the rapidly evolving wireless communications' market requires a comprehensive mix of products plus multi-chip module (MCM) packaging expertise and manufacturing and assembly/test technologies.

Innovation is accelerating along multiple paths. The first path is functional integration at both the die and package level. The second is system integration, which has enabled complete solutions encompassing all major ICs plus full operator-qualified network-approved protocol stacks, all necessary development tools, and customer design support for building complete Internet-enabled platforms.

On the first, functional integration path, the pace of innovation has been particularly brisk. The demand for extremely feature-rich phones, combined with the migration to advanced communication standards such as 3G, has led to a "tiering" of handset products to meet the distinct needs of various market segments. This tiering has been achieved by using a combination of system-in-package (SiP) and system on chip (SoC) integration approaches to achieve the necessary combination of technical capabilities, time-to-market, performance and customization, depending on the target market segment.

SIP DRIVES MID/HIGH-END PRODUCT DEVELOPMENT.

SiP has been, and will continue to be, increasingly important especially in the middle- and higher-end product tiers, where design flexibility and cost/performance tradeoffs favor a combination of discrete-component or SiP approaches across the system partitioning, plus integration evolution in the core devices. SiP techniques have driven such integration breakthroughs as transceiver front-end modules (FEMs), 802.11b/g WLAN FEMs, and single-package radios (SPRs).

SPRs offer a key early example of SiP success. They combine all of the radio circuitry required for a dual- or tri-band GSM/GPRS handset in one-third the footprint of alternative solutions created from discrete components. This includes a transceiver, power amplifier (PA) and associated controller, two surface acoustic wave (SAW) filters and a switchplexer module with switches and low-pass filters into a compact 40-pin 13x13 mm laminate MCM package with excellent insulation properties.

Before the advent of SPRs, handset manufacturers had to combine discrete components in a much larger and complex area, while also resolving difficult board and circuit-level RF design issues and bearing the costs of shielding, insertion/assembly and other discrete-component integration tasks. In contrast, the SPR solution incorporates functional blocks fabricated with proven high-performance process technologies to optimize performance and power efficiency.

SPRs and other SiP solutions are also significantly less costly than discretes. It can cost up to $7, or more, for all of the GSM radio subsystem's discrete components, not counting the cost of shielding, insertion/assembly and other expenses. One can achieve the same functionality in an SPR module at a comparable or only slightly higher price, while removing the individual purchasing, inventorying and packaging costs associated with each of the discrete components. The package consists of proven die for each component, and occupies a compact, 13x13-millimeter footprint. Today's wafer-level testing ensures at least 98 percent yield levels for each die in this package, and manufacturers today routinely ship high-volume, high-yield solutions.

SiP-based modules have provided critical steppingstones to quad-band and 3G handsets while opening up both space and processing horsepower on the handset platform. SiP also is propelling the industry toward multi-functional products that can seamlessly roam between Wi-Fi and cellular networks, for instance.

Moving forward, semiconductor manufacturers will further integrate the various die in each of the individual SiP functional sections, enabling designers to follow flexible and risk-free development roadmaps. The most recent achievements in this area combine field-proven FEM technology with radio functionality (including the world's first SoC direct conversion transceiver that works with a PA/PAC to create a seamless closed-loop transmit system) to create a complete radio solution for GSM, GPRS and EDGE mobile handset applications. Solutions like these minimize external component count and significantly improve talk times through better PA efficiency, while enabling handsets to support advanced features of varying complexity.

SoCs Drive Innovation in Lower-End Product Tiers

While SiP technology is ideal for the higher-end market tiers, the focus in the lower-end product tiers will continue to be on core mobile-phone functionality and those few advanced features that have become highly standardized and commoditized. Here, designers are leveraging advances in SoC technology in both the digital and RF realms.

For instance, SoCs have been proven in the form of transceiver solutions that integrate previously discrete devices such as a receiver, transmitter, voltage-controlled oscillator and LNAs into a very small, cost-effective device. Similar achievements have been prominent in the baseband, and this trend will continue and be successful if optimized integration goals are targeted.

Comparing SiP and SoC Integration Paths

The radio section of a cell phone illustrates the key differences between SiP and SoC integration paths.

With the SiP approach, the radio is implemented as a single package (the SPR, described earlier) and combined with a companion baseband device to create a two-package phone. Especially in feature-rich mid/high-end phones, this eliminates the risks associated with a SoC solution that might drive premature and potentially incorrect architectural partitioning decisions as standards, technologies and feature requirements continue to evolve.

With SPRs, each functional block follows its own integration path, using the optimal mix of available product and process technologies. The ultimate goal is still the fully integrated single-chip phone, of course. But by combining silicon integration with advanced packaging strategies, handset designers benefit from the most flexible and risk-free development roadmap possible, while still realizing a good portion of tomorrow's cost, power and space savings by integrating at the package level.

Conversely, when the RF portion of a radio is implemented using SoC technology, handset designers must address a variety of issues that require significant RF expertise. This can lead to as many as three to five design turns, each consuming two- to three-months for a typical RF board. By eliminating these design tasks, SPRs significantly reduce engineering costs and can remove eight to nine months of design cycle time.

SoCs also constrain roadmap flexibility. SoC proponents have drawn a roadmap in which most of the functionality (including the RF and analog blocks) moves onto the baseband die. SPR advocates, on the other hand, break the handset design down into digital and analog functions. Digital moves to the baseband die and analog to the transceiver die, and today's mixed-signal device essentially disappears altogether (See Fig. 1).

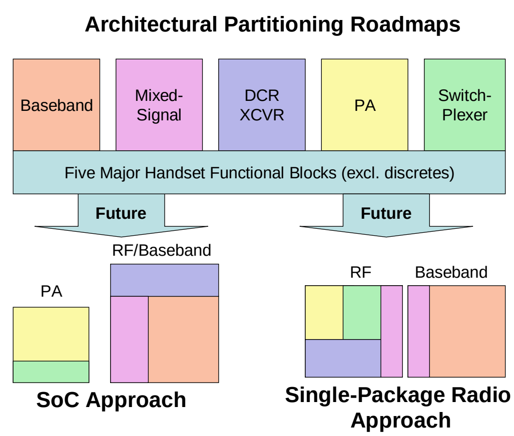

Fig. 1

This approach makes it much easier to quickly modify a design to support new capabilities and standards, as required, or to move to smaller geometries. The digital baseband die remains digital and can continuously shrink along the known roadmap of smaller geometries, while incorporating new features such as integrated wireless LAN modem capabilities, multimedia, cameras, video, satellite receivers for audio and music, GPS, color displays, Bluetooth, and so on. Similarly, the RF portion of the design then remains solely analog, and designers can focus on transceiver integration, discrete component reduction in the radio module, and smaller module sizes.

FULLY INTEGRATED SYSTEMS OPEN DOORS FOR NEW COMPETITORS

While SiP and SoC approaches are primarily being adopted by seasoned competitors, there is another option for handset manufacturers with little or no wireless design expertise. For these companies, the availability of complete, integrated platforms enables rapid market entry and the freedom to focus primarily on value-added branding, distribution and industrial design.

Today's system-solution vendors supply manufacturers with all of the devices from the baseband through the PA, as well as all necessary software. The system solution vendor and handset manufacturer then collaborate on board layouts, and the handset manufacturer has more available resources with which to focus on the form factor, MMI, plastics and feature/performance definition.

Time-to-market is greatly reduced as compared to the traditional model in which the handset manufacturer performs significantly more of the design work. In many cases, the typical two-year design cycle can be cut to as little as 12 or 18 months, while delivering an aggressive form factor and extremely rich feature set.

CONCLUSION

At the heart of today's cellular handset advances is a set of extremely powerful integration strategies and techniques that will continue to propel us toward even more exciting products and applications.

Designers will continue to leverage SoCs in standardized processes for digital-centric functions, driving further integration of additional functions when and where it makes technical and business sense to do so.

SiP, on the other hand, will continue to be the workhorse approach particularly in the RF front-end, where functional blocks can take advantage of the most effective mix of devices and process technologies to maximize performance and cost.

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ACRONYMS

DCR: Direct Conversion Receiver
EDGE: Enhanced Data GSM Environment
GSM: Global System for Mobile Communications
GPRS: General Packet Radio Service
MCM: Multi-Chip Module
MMI: Man Machine Interface
PA: Power Amplifier
RF: Radio Frequency
SAW: Surface Acoustic Wave
SiP: System-in-Package
SoC: System-on-Chip
SPR: Single-Package Radio
WLAN: Wireless Local Area Network