Research Brief

Chip and System Trends for Mobile Handset Devices

Abstract: The way to a single-chip phone is paved with advances in design and silicon technologies. This will impact the price and success of data-enabled mobile handsets.

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Recommendations

- Semiconductor and other component vendors need to be aware of the new dynamics in the mobile handset market. They should try to get their components designed into wireless mobile device platforms or reference designs, as these will represent the highest volume opportunities for component sales.

- Semiconductor vendors should acquire or improve mobile handset systems knowledge. Mobile handset manufacturers are looking for suppliers that understand their problems and can offer economic and efficient component solutions.

- Modularization of the radio frequency (RF) portion of handsets is a continuing trend. Vendors in this space should make it easy for digital designers with limited RF expertise to use modules as "building blocks." RF semiconductors and modules will increasingly become commodity items in the next five years.

- Semiconductor vendors should be aware of additional opportunities for handset semiconductor chipsets in automotive telematics, hand-held devices, PC cards and modules. By 2005, these applications will increase in importance relative to mobile terminal devices. Mobile handset chipsets will then have a broader market base, allowing economies of scope for semiconductor vendors.
Introduction

The features and functionality of 2.5G and third-generation (3G) handsets are driven by the perceived need for data services for consumers and businesses. From the handset designers’ perspective, 2.5G and 3G handsets require more computing power than voice-only 2G handsets. Increased compute power normally comes with increased power consumption, everything else being equal. Even in today’s 2.5G implementations, power consumption is critical.

The use of color liquid crystal displays (LCDs) and application coprocessors for data-enabled handsets adds to the designers’ challenge by swelling handset sizes and adding power-hungry components. Smaller semiconductor geometries, increased integration and careful design for power management need to combine to make attractive and economically viable data-enabled handsets. This document discusses the major issues for semiconductor vendors and system designers in the new market conditions.

Business Trend

Over the past 18 months, wireless mobile device platforms (or reference designs) have been introduced by Motorola Semiconductor Products Sector (Motorola SPS), followed closely by Ericsson Mobile Platforms (EMP). Such platforms have become increasingly important in the mobile handset market. The idea of reference chipsets and designs for communications products is not new — some semiconductor suppliers including Siemens and Skyworks (Conexant) have been offering them for several years. However, the innovation is that the reference designs from Motorola SPS and EMP offer handset manufacturers complete system solutions, in other words, a complete kit of hardware and software for mobile handset design.

Popular applications and pricing that is acceptable to the consumer are the keys to success for mobile data. Revenue-generating applications such as messaging, entertainment and information services will become enhanced and have richer multimedia content as higher bandwidth becomes available. Mobile computing and location-based mobile commerce will also benefit from higher bandwidth and may prove to be the future revenue generators. As a result, operator service revenue will increase slowly from 2003 to 2005.

Developments in mobile handset design and semiconductor technology are vital to achieve the economies that are necessary to reach a consumer market. One development is the addition of applications platforms for multimedia that will work in tandem with the baseband section of the mobile handset. Key components for the baseband section include high-performance digital signal processors (DSPs) and central processing units (CPUs) with improved architectures and very low power consumption. Also important are improvements in RF design and materials, and the ability to integrate more functions on a single piece of silicon or multiple dies in a small-footprint package.

Gartner Dataquest Perspective

Technology Overview

Handset architectures for mainstream 2G technologies have, in essence, remained the same for a long time. The evolution has been toward increasingly higher levels of component integration. The drivers for this evolution are cost reduction by minimizing power consumption, while retaining or enhancing the handset’s functionality. The targets for designers of 2.5G and 3G handsets have not changed in this respect, but fulfilling these criteria is becoming harder to achieve.
Figure 1 shows the generic layout of a handset and the main subsections it contains. Three main areas can be identified: the baseband stage, the RF stage and the intermediate frequency (IF) stage. The RF and IF blocks (IF is omitted in direct conversion architectures) bring the relatively high radio frequencies down to those that can be handled by standard complementary metal-oxide semiconductor (CMOS) devices. The relatively complex encoding and decoding functions can then take place within the digital domain. The baseband also performs the other functions identified in the diagram, such as control and power management. Separate processors and visual media and computing applications are normally only found in high-end smartphones and personal digital assistant (PDA) devices with 2.5G or 3G data-enabled connectivity.

The basic structure of 3G or 2.5G handsets is not very different from that of the 2G handsets now in production, apart from the introduction of additional connectivity and high-end applications processing. However, the challenge for designers of 3G and 2.5G handsets is to cram in more functionality and keep power consumption and size within acceptable limits. The problem is worse in areas served by Global System for Mobile Communications (GSM) technology, because 3G wideband code division multiple access (W-CDMA) must retain backward compatibility with GSM. Figure 2 shows a more-detailed diagram of a W-CDMA handset.

**Figure 1**
Generic Layout of a Data-Enabled Handset

Source: Gartner Dataquest (October 2002)
Toward a Single-Chip Handset

RF

Within the past four years, mobile handsets have evolved from single-band transceiver to multiple-band transceiver capability, while still achieving increased levels of integration. 3G and GSM handsets require triband capability. This capability is being achieved through modularization.

Modularization has become more popular as a way of reducing the component count and space required for the RF stage in the mobile handset. Although this approach reduces the component count for the equipment manufacturer, it does not actually reduce the total number of components in the system. Instead, it moves the assembly process from the equipment manufacturer to the component manufacturer.

The move to modules containing more components in the RF stage is a significant trend. Formerly, the design of any mobile handset equipment required the skills of an RF designer — a scarce resource. Today, higher-level building blocks are available that do not require these skills — semiconductor companies are making RF modules that are impedance-matched to 50 ohm. These modules incorporate more of the RF subsystem.

The trend to put RF passive and active components in modules is firmly established. Agilent Technologies plans to introduce modules that will include power amplifiers (PAs), filters and low-noise amplifiers (LNAs) along with the associated passive components. RF Micro Devices has introduced a receiver module that includes surface acoustic wave (SAW) filters, mixers and LNAs for CDMA applications.

These are steps toward a single-chip handset. It is probable that as CMOS technology becomes more RF-capable, the function for external RF components will be reduced to passive filters and an RF PA.
Baseband and Applications Functions
A key reason to own a 3G handset is because it will offer enhanced data services as well as voice services. This development has profound implications for the complexity of the baseband section of 3G handsets. This section must decode more-difficult air interfaces in addition to dealing with data and voice. Because of this, the baseband section will form a higher proportion of the semiconductor value within the handset.

The difficulty is that this increase in function and complexity must meet size, cost and power consumption constraints. The radio and multimedia functions can consist of separate chips, but they share similar architectures (that is, the combination of DSP and CPU). In fact, some silicon vendors and equipment manufacturers are proposing to use the same processors for both functions because they believe there is sufficient additional processing power, especially for lower-end handsets.

Texas Instruments' approach to the applications function in high-end handsets is to have a separate applications platform or chipset. The chipset combines a low-power DSP and an ARM925T CPU to achieve the necessary combination of signal processing functions and control or operating system functions. Other semiconductor vendors may follow this approach, but this is not the only solution. Philips Semiconductors, for example, in its Nexperia Application CoProcessor (ACP) uses a hardware/software solution to minimize power consumption and implements many of the key media decodes such as MPEG Layer 3 (MP3) audio and MPEG-4 video in hardware.

As the baseband section becomes more complex, there is an interim stage of development when the number of chips increases before further integration happens and the number decreases again. These additional chips may add on W-CDMA capability to a GSM chipset or add to the applications processing power of the mobile handset as discussed above.

The Final Hurdle
The ultimate level of integration is to have all the handset functions and RF and baseband sections on a single chip, with the exception of the RF PA and a few passive components. Much integration can be achieved on a single CMOS chip, and Cambridge Silicon Radio has demonstrated this with its single-chip Bluetooth solution. Bluetooth operates in the 2.4GHz band, which is higher than current cellular frequencies and is close to that allocated for 3G. Developments in CMOS process technology and new RF CMOS design techniques have made it possible to operate CMOS at a higher frequency.

A single-chip handset is possible and it is only a matter of time before it becomes a reality. Texas Instruments has set itself the ambitious target of achieving this during 2004. This means that today's handset comprising four to five chips, an RF PA plus about 140 other components will be reduced to one chip and an RF PA. Consequently, the component bill-of-materials (including case connectors and so on) for a handset may be less than 100 parts.

Integration of the total handset system on a chip is not a trivial task — it requires process innovation and new design techniques. Analog design, especially at very high frequencies, requires skilled RF designers and careful layout. Simulation is problematical and, as a consequence, redesigns are common. However, those companies that can overcome these difficulties and accomplish a single-chip solution economically are extremely well placed to supply a commodity silicon product to established and new mobile handset manufacturers.
Gartner Dataquest Conclusion

Mobile handset design is undergoing some fundamental changes to meet the function and performance requirements for 3G and 2.5G mobile voice and data. The specification of the handset has an effect on the semiconductor components and these, in turn, determine the viability of mobile handset architectures. Opportunities exist for semiconductor vendors that can provide components that can support or enable these new architectures economically, either through highly integrated stand-alone chips or modules.

The mobile communications market will become the mobile communications and computing market. A whole new array of products will become wireless mobile devices, including notebook computers, PDAs, smart phones, handheld consumer devices and automotive telematic devices. These developments will broaden the market for semiconductor components, as cellular wireless communication technology becomes more pervasive.

Key Issue
What impact will emerging chip technology have on system trends?

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