WHITE PAPER

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TEXAS INSTRUMENTS

Integrated combo solutions

bring seamless mobile connectivity to wireless handsets

Introduction

Consumers are increasingly demanding greater connectivity from their wireless phone handsets. Bluetooth®, GPS, FM radio and mobile wireless LAN (mWLAN) technologies increase the utility of the cellphone by offering additional information, wider-ranging connections, or both. To meet the new expectations of end users, wireless handset manufacturers must look for ways to provide these enabling technologies in minimal space and at an affordable price. In addition, the quality of the user experience must not be compromised by shortening the usage time between battery charges or by degrading cellular service or connectivity performance.

System-on-chip (SoC) combo solutions that integrate one or more mobile connectivity technologies on a single device have proven their value in satisfying these requirements, and a new generation of combo chips is providing even greater functionality. TI is leading the migration toward combo connectivity solutions with its cellular-oriented connectivity based on DRP™ digital radio technology, true coexistence design, and advanced process technologies. In fact, TI is the only supplier to offer products that enable handset manufacturers to select different on-chip combinations of four primary connectivity technologies – Bluetooth, mWLAN, GPS and FM. New TI developments will bring even higher levels of integration saving manufacturing costs, reduce time to market and deploy additional technologies in the future.

Mobility and connectivity converge

The future of wireless communications lies in converged handsets that combine a variety of transmission technologies. Today, a wider range of wireless technologies is available than ever before, bringing personal- and local-area networks, navigation, broadcast radio reception, and a variety of other services to mobile users. As a result, consumers are demanding that manufacturers bring together different types of types of communication in a single convenient mobile instrument.

The phenomenal success of cellular phones, with more than a billion units sold worldwide every year, makes them the instrument of choice for ubiquitous connectivity. Cellphone users already have, or will have in the near future, options for hands-free remote conversation, music downloads and stereo playback through car speakers via *Bluetooth*®, emergency and location services via GPS (Global Positioning System), listening to FM radio and eventually viewing digital TV, and Internet access that can provide voice over LAN (VoLAN) as well as the wealth of content available though Web browsing, email, database access, interactive games and other programs. With these applications and others that are yet to come, wireless phone handsets are enabling connectivity for on-the-go consumers everywhere.

Market estimates reinforce the increasing importance of handset connectivity. By 2010 50 to 60 percent of wireless handsets will include either *Bluetooth* or FM reception, or both. Approximately half these will include GPS, and more than a hundred million units will offer mobile wireless LAN (mWLAN). Initially, these additional technologies were offered only by high-end feature phones, but statistics show that handset connectivity is rapidly becoming mainstream, and that cellphones with only voice transmission and reception will soon be in the minority.

Challenges for handset manufacturers

With enormous volumes of the wireless market at stake, handset manufacturers are continually looking for new solutions that will enable them to add connectivity features, yet keep the end products affordable. There are challenges, however. *Bluetooth*, GPS, mWLAN and FM all require different transmission and reception techniques. Adding one or more of

* (Sources include Strategy Analytics, In-Stat, i-Supply, Forward Concepts and TI internal information).

these capabilities to a handset requires enabling parallel communications by multiplying the phone's RF functions. Originally, connectivity technologies were added through multiple standalone devices, but now they are increasingly integrated in single-chip multiradio combo solutions that contain one or more connectivity functions. Just as silicon integration has traditionally been the key to reducing costs, space and power for the modem and other wireless capabilities, it is doing so again today with connectivity. Mobile multiradio combo solutions save space and reduce the phone's bill of materials, thus saving system costs and simplifying manufacture. Combos also serve to minimize power consumption.

At the same time, combo solutions require implementation of advanced technologies. Solutions providers face many challenges in creating devices that allow RF connectivity for multiple communication schemes to operate successfully on a single silicon die. Transmission-reception schemes can conflict, forcing innovations in order for on-chip RF functions to coexist or be multiplexed. Sharing the same antenna among different technologies compounds these conflicts and increases the need for enhanced design. Multiradio combos should also provide versatility, so that handset manufacturers can use the similar devices in a variety of systems with minimal redesign and qualification. The need for versatility is best served by a core approach that reuses the same connectivity technology across all combo devices. Platform-level integration that reuses the same software from drivers to applications also serves to simplify the design of multiple connectivity systems. How to implement these and other features successfully in combos is a challenge that requires leading-edge silicon and wireless technology.

TI's Mobile Connectivity Solutions product lines

For more than 15 years, TI has been a technology and market leader in providing silicon solutions for digital phone handsets, and its leadership extends into seamless handset connectivity. TI's multiradio combo solutions, suitable for systems ranging from voice-centric handsets to high-end multimedia smartphones, are used by the world's top five handset manufacturers and by a number of others as well.

In 2002, the company was the first to market with connectivity solutions that focused on a single technology for then-emerging applications. By mid-decade, TI's single-chip solutions integrated the RF and baseband for cost optimization while providing additional features for the growing market. Among the unique product offerings were mWLAN solutions that TI reduced from two chips to one in 2005. Having supplied multiple generations of *Bluetooth*, GPS and mWLAN devices, the company added FM reception in the first combo devices in 2007, and has recently made available FM transmission for connectivity to nearby receivers such as car stereos.

Today, with the introduction of multiradio combos, TI again is at the forefront of the connectivity revolution. TI's three multiradio combo product lines for handset connectivity are BlueLink™, NaviLink™ and WiLink™. Originally designed for adding *Bluetooth*, GPS and mWLAN connectivity, respectively, the lines have recently been enhanced with even greater functionality. Figure 1 shows the generations of these product lines, including recently announced products with multiple RF connectivities.

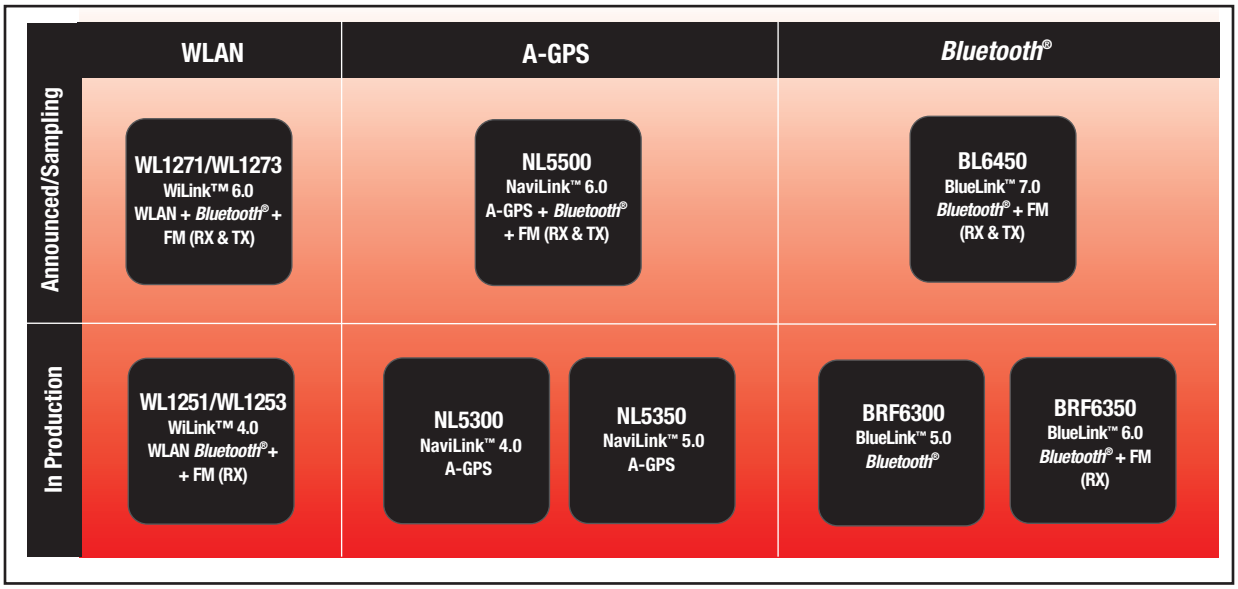

Figure 1: *TI's Mobile Connectivity Solutions*

The latest-generation – WiLink 6.0 – supports the Ethernet sub-standards commonly used for WiFi (802.11a/b/g/n), plus *Bluetooth* 2.1 and FM reception and transmission. NaviLink 6.0 adds *Bluetooth* 2.1 and FM transceiving capabilities to GPS, with assistance for GPS by the cellular network to help pinpoint the location of the user – a feature that is essential for emergency services. Previous-generation BlueLink 6.0 added FM reception on the same device as *Bluetooth* 2.1, and BlueLink 7.0 adds FM transmission. The current generation of all the connectivity offerings migrates to a more advanced 65–nm CMOS process, bringing additional power efficiency and die space savings that will help simplify the integration of new features such as *Bluetooth* Low Energy (BLE) communication with sensors in medical, sports and other equipments.

The multiradio combos are tightly integrated with TI's OMAP™ processors and OMAP-Vox™ solutions. The combos are designed to work with the applications and modem processors as performance-optimized, pre-packaged solutions in which the devices have been tested operating together in end use. For instance, WiLink 6.0 or NaviLink 6.0, with an OMAP-Vox solution, provides an optimized modem, applications processor and mWLAN/*Bluetooth*/FM or GPS/*Bluetooth*/FM solution for mid-tier handsets. BlueLink 7.0 is a cost-efficient solution to increase *Bluetooth* penetration in handsets by addressing the high-volume emerging market. With the seamless connectivity provided by modems, combos and host processors, manufacturers have a complete antenna-to-application solution with a fully validated software solution for a wide range of handset markets.

Designed to meet handset requirements

TI's new generation of multiradio combo solutions gives developers a wide range of connectivity options to support handset differentiation. All of the products are optimized for the small size and low power consumption requirements of wireless systems. The advanced CMOS processes used to manufacture the combos are designed with low-leakage transistors and integrated analog functions, keeping power consumption as low as possible in standby modes and supporting the on-chip integration of a large number of system functions. TI's SmartReflex™ technology, now in its second generation, is integral to the design of the devices. SmartReflex technology optimizes wireless handset performance and power consumption by leveraging advanced process techniques and employing intelligent, adaptive silicon design, advanced SoC architectural techniques and innovative software. These techniques, which are automatically included within the device design flow, address a number of power consumption challenges, including the difficult task of optimizing leakage at submicron process geometries.

Other power-reducing features are also used in the design of combo solutions including complete processors that provide media access control (MAC) and communications flow management, and are thus capable of handling the entire communications load for their respective connectivity technologies. The devices operate independently of the host processor except when communication with the larger system is necessary. As a result, the host and other functions in a handset can remain in low-power modes while a combo is handling communications tasks, saving power and extending battery life between charges.

The combo devices can connect directly to the handset battery, eliminating external power management chips, and the small-footprint packages require as little space as possible. DRP technology, implemented in all of TI's mobile connectivity solutions today, migrates to the digital domain much of the RF analog content, which often accounts for as much as 30 to 40 percent of a handset. Many functions implemented using digital components operate more power-efficiently than with analog components, extending standby and active usage times. In addition, DRP technology enables handsets to take advantage of the efficiencies and cost-reductions inherent in each new submicron digital process node, saving power and reducing the bill of materials.

Coexistence of RF connectivites

Signal interference between different RF technologies can cause difficulties for handset users, including reduced call reliability and even dropped connections. The greatest challenges are encountered in enabling the simultaneous operation of mWLAN and *Bluetooth*, which both use the same 2.4-GHz frequency band, though their transmission protocols are quite different. *Bluetooth* operation in a system cuts the available bandwidth for mWLAN by at least a third, which is reduced further by protocol overhead and timing, especially in modes designed for saving power. When a mWLAN router cannot establish a handset connection through acknowledgement, the link may time out and be closed.

Similarly, when *Bluetooth* scans for available devices on power-up, too much interruption can cause the link to fail. A design that uses the same antenna for separate RF technologies in order to reduce space and cost magnifies these issues.

TI's success in resolving these challenges through spectrum analysis and signal separation permits the integration and coexistence of *Bluetooth* and FM on the same die. TI's WiLink 6.0 solution provides intelligent, seamless coordination in the time domain at the media access control (MAC) layer, enabling mWLAN and *Bluetooth* to share the same antenna and antenna filter to reduce component counts and circuit board space. With effective simultaneous operations of voice and data, WiLink 6.0 devices achieve best-in-class ratings in signal range and robustness. Figure 2 shows a block diagram of the device, along with external functions in

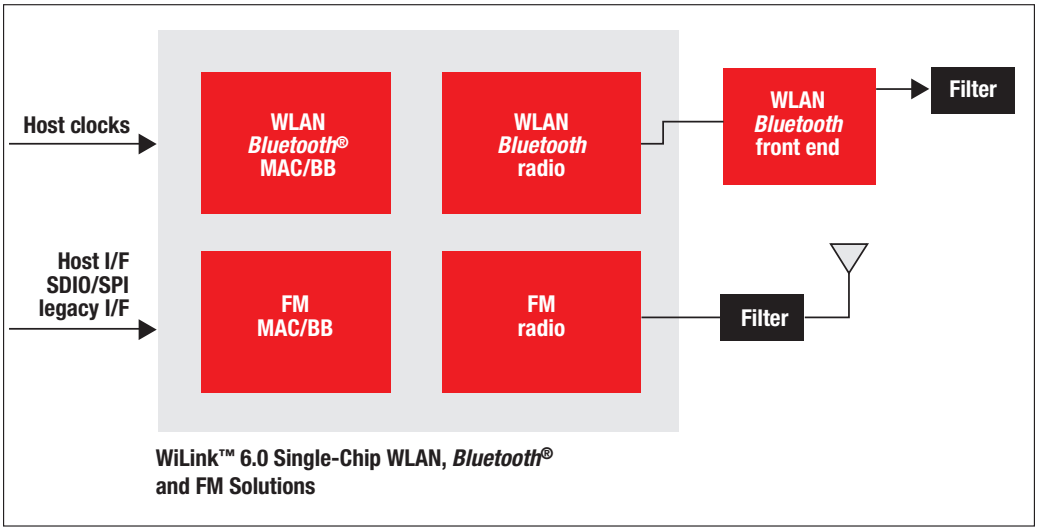

Figure 2: *WiLink 6.0 block diagram*

TI was among the first combo suppliers to achieve the integration of different RF connectivity technologies, eliminating many redundant components in the system. Continued development has led to the successful coexistence of even more RF technologies on the same die in the latest generation of combo products. TI's range of host processors means that RF coexistence operates successfully to provide a variety of new applications. Because the different combos are based on the same architecture, system developers can create a variety of end products with minimal redesign.

Complete hardware and software

TI's multiradio connectivity products are complete solutions, including both hardware and software to help simplify development and save time to market. TI is one of the few solutions providers with support for multiple operating systems, including Linux®, Symbian™, Nucleus and Microsoft® Windows Mobile®, giving developers flexibility in the type of system they choose to build. For multimedia systems, TI provides reference designs for the use of its connectivity products with various OMAP platform hosts. To simplify design and enable the developer to concentrate on adding value, the third-party software and application suites are pre-integrated.

The different Mobile Connectivity Solution product lines are fully software-compatible, so that developers not only have a choice of which platform to use for a specific handset, but they can also easily port their software to the other platforms. For instance, suppose a developer uses WiLink 6.0 to create a handset featuring mWLAN, *Bluetooth* and FM. The developer can directly port the *Bluetooth* and FM modules to BlueLink 7.0 for a less fully featured handset. The same modules ported to NaviLink 6.0, plus the addition of GPS software, yields a new handset with support for location and navigation services. All of the new products are also backward-compatible with older product generations, so that developers can reuse software they developed for earlier handsets. In this way, manufacturers have flexibility for developing a complete line of handset products quickly through reusable engineering.

Leadership in mobile connectivity solutions

Consumers are demanding increased services from their mobile devices that can only be provided by increased RF connectivity. Hands-free conversation, music downloads, stereo playback through car speakers, location services, FM radio reception, Internet access and VoLAN—these and applications that are yet to come are increasingly in demand not only on high-end handsets, but in all but the most basic cellphones.

To satisfy market expectations, handset manufacturers have to provide *Bluetooth*, GPS, FM and mWLAN options inexpensively, in a small space, and without unnecessary additional drain on the system battery. TI's combo solutions provide single-chip, small-footprint solutions that meet these requirements while supporting an increasingly greater variety of multiple connectivity technologies. By integrating most of the system components on one die, a combo reduces the system bill of materials and simplifies the board layout. Advanced CMOS processes and design techniques also serve to lower power consumption for longer active usage and standby times.

Among solutions providers, only TI offers multiradio combos selections among all four primary connectivity technologies. Depending on their needs, developers can choose among different on-chip combinations of *Bluetooth*, GPS, FM and mWLAN. With advanced processes, SmartReflex power reduction, DRP digital radio, and coexistence design techniques, TI can offer leadership combo products, and leading wireless manufacturers have chosen TI combos for development of their handsets. Complete hardware and software solutions simplify development, save time to market, and promote flexibility for manufacturers as they develop full lines of handset products. As manufacturers work to make their handsets smaller, lighter-weight and more affordable, as well as offering more features and operating longer on a single battery charge, they can turn to TI for leadership in multiradio combo solutions that make cellphones into the heart of mobile connectivity for consumers.

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