Introduction
Designing wireless local area networking (WLAN) capabilities into stationary consumer electronics (CE) systems is most successful when certain design issues are considered early in the development cycle. Doing so at the front-end of design will improve WLAN and host system performance. This white paper lists some of the most critical design considerations for integrating Texas Instruments (TI’s) WLAN solutions into host systems based on the DaVinci™ and digital media (DM) processors.

Every application has certain design considerations that are particular to it. Because of the size of the enclosure or the nature of the application, stationary CE products usually stay in one place for long periods of time. Examples include media adapters, personal video recorders, certain high-end gaming consoles and IP (Internet Protocol) set-top-boxes (STB). These types of systems operate off of power supplied by the power grid, and not batteries. The design considerations outlined here reflect the way stationary CE systems are installed and how they function in the typical home.

References are made throughout this paper to the comprehensive design support that TI provides. Drawing on its years of experience in wireless technologies and embedded subsystems, TI has assembled the industry’s most complete support programs and design documentation for WLAN applications. This level of support vastly accelerates the integration of effective WLAN capabilities into stationary CE products, allowing manufacturers to concentrate on developing differentiated functionality for their products, which makes these products more competitive in the marketplace.

System-Level Considerations
WLAN implementations should optimize certain basic performance parameters within the context and constraints of the application. These parameters include the reach or range of WLAN signaling, the data throughput rate supported by the WLAN implementation and its robustness when it comes to overcoming various sources of interference in the environment. In addition, the selection of a WLAN chipset solution as well as the software environment and tools supported by the WLAN solution are also important considerations.

Reach, Rate and Robustness
The effective reach or range of WLAN signaling is often determined by the specific requirements of the application. Some stationary CE systems require “whole house” coverage, while others do not. The effective reach of WLAN signaling is affected by the system’s transmit output power and the sensitivity of the WLAN receivers. For stationary CE systems, which usually have access to a constant supply of power, output power can be adjusted upward somewhat to achieve greater range. Receiver sensitivity is an inherent capability of the WLAN chipset, and so careful attention should be
paid to this feature. A general rule of thumb is that for every 6 dBm increase in receiver sensitivity, there is roughly double the linear range in free space. For example, a WLAN subsystem that has a sensitivity of -76 dBm at 540 FDM has roughly twice the linear range and 4 times the coverage area (in free space) as a chipset that has a sensitivity of -70 dBm at 540 FDM.

**G++ Technology**

High data throughput speeds are certainly important for some stationary CE applications, as is the ability to connect at large distances. System-level design decisions and the throughput rate of the WLAN chipsets have a decided impact on these factors.

Robustness of a WLAN implementation can be of particular importance in stationary CE systems which are often subjected to several sources of adjacent channel and in-band interference. The sources of interference commonly found in homes include microwave ovens, cordless telephones and other WLAN networks in close proximity. The inherent capabilities of the WLAN chipset as well as antenna placement and other design considerations can increase or decrease the robustness of a stationary CE product with WLAN capabilities.

**Chipset Selection**

The processing requirements of the host processor demanded by the WLAN chipset will have significant effects on the overall performance of the stationary CE system. Some chipsets require very little intervention on the part of the system’s host CPU, but others involve host CPU processing cycles in the execution of WLAN operations. “Stealing” processing cycles from the host CPU for WLAN operations effectively removes those cycles from other tasks that may be more essential to the functionality of the CE product. By doing so, the performance of the primary function of the product in the eyes of users is diminished.
**Software Environment**

A comprehensive and flexible software environment will accelerate development time and free programming resources for application-critical projects. Such a software environment should include a full-function driver and the flexibility to port the driver to another operating system (OS) should it be required by the manufacturer, an easily integrated driver architecture that can be quickly customized, standard APIs to ease application-specific integration as well as software development in general, security capabilities and a well-defined interface to the networking stack.

To ensure acceptable performance of a host system with a WLAN subsystem, interference between the two must be minimized. This requires adequate forethought and planning in the design of the motherboard and the placement of the WLAN daughtercard. The overall objective is to minimize the effects of noise sources from the DaVinci or DM-based system board on the WLAN subsystem and to optimize the WLAN subsystem’s performance within the application. Because the sensitivity of the receivers in TI’s WLAN chipsets is very high, steps should be taken to minimize radiated and conducted emissions from the motherboard that might otherwise degrade the performance of the WLAN subsystem.

**Antenna Considerations**

To minimize the pickup of the WLAN antenna or antennas of emissions from the system motherboard, these layout practices should be considered:

- Adequate spacing should be provided between non-thermal ground vias
- All signals and especially high-speed signals should be placed in an inner layer of the system board
- High-speed signal traces should be as short as possible
- Antenna location should be determined after characterizing the strength and location of the radiated spurious emissions on the motherboard

**General Layout Guidelines**

In general, the layout of a DaVinci or DM system board should reflect the following considerations:

- Consider moving signals into an inner layer, if possible
- Provide a ground pour in the top and bottom layers
- For high-noise and high-temperature areas, consider multiple ground vias for the ground return path
- If possible, design in multiple non-thermal ground vias after routing
Specific Considerations

Several specific aspects of system board layout should receive special attention from designers. These include the following:

- The number and placement of power supply and ground traces as well as related components such as capacitors and resistors
- Length and positioning of traces leading from the system’s oscillators
- Length and positioning of traces for any high-speed digital address/data bus
- The presence of ground pour and vias around the system’s clock, address bus, data bus and control bus
- The placement of resistors around memory devices to block noise from the memories
- The stackup layout of the printed circuit board’s layers
- Layout of TI’s VLYNQ™ interface, which provides a high-speed, low pin count serial connection between the WLAN chipset and the system board
- Design considerations for the power plane and bypass capacitors which reflect the characteristics of the power supplies utilized by the system
- The characteristics of the traces carrying 50-Ohm RF signals
- Overall placement of components on the system board to partition emission-producing components from the WLAN subsystem antennas
- Maintaining clearances around pins and traces that lead to the RJ45 connector
- The proper placement of ground vias when the power connector is located some distance from the switching power supply

Other hardware design suggestions can be provided by TI through a design review procedure.
Antenna placement and the need for antenna diversity in some applications should be taken into consideration early in the design of a WLAN daughtercard. The connection between the WLAN daughtercard and the motherboard also must be carefully designed to minimize emissions.

TI provides a reference design of a WLAN subsystem, the PCA-171, for stationary CE applications. Implemented on a MiniPCI daughtercard, the PCA-171 WLAN offers several antenna configuration options, including single, dual and triple antenna architectures should additional antenna variations be needed. TI stationary design guides define the pin-outs for the MiniPCI connector to the motherboard. This interface includes TI’s high-speed serial VLYNQ interface for a direct connection between the WLAN chipset and the host system’s DaVinci or DM processors.

The software environment is critical for bringing new stationary CE products with WLAN capabilities to the marketplace quickly. Some important considerations for software developers include the following:

- How fast and simple is software integration?
- Does the WLAN driver have a flexible architecture so it can be easily re-configured?
- Does the WLAN driver have an effective development environment including an OS and programming tools such as an application programming interface (API)?
- Can the WLAN driver be easily ported to other operating systems?
- Is there an efficient way to implement the level of security dictated by the application?
- Is the software infrastructure modular and easy to work with?
TI’s Consumer Electronics Station Development Kit (CE-STA-DK) for WLAN integration has been assembled to address all of these issues. Some of the major benefits and capabilities offered by the kit and its component parts are:

**Flexible WLAN Driver Architecture**

A flexible and full-featured WLAN driver architecture shortens the development cycle for integrating the driver into a host system. The TI WLAN driver architecture consists of the following four main modules:

- **Inter Process Communications (IPC)** – The IPC, which is also referred to as the User Space, facilitates communication between a developer and the WLAN driver’s kernel.

- **Utility Adapter** – The Utility Adapter supports an API that simplifies interaction with the driver for developers. This API can be used to configure the WLAN driver’s security mode.

- **Supplicant/Security** – The WLAN driver’s Supplicant contains the security engine that controls the various security modes and protocols. Depending on the needs of the application, the API can be used to configure the WLAN driver with any of several different security modes, including the most advanced methodologies.

- **OS Abstraction Layer** – The OS Abstraction Layer (OAL) implements functions that cross over various modules in the driver platform. In addition, the OAL simplifies the porting of the WLAN driver to other OSs.

**Development Environment and Tools**

Tools are essential so developers can easily modify the WLAN driver to blend it into the host system’s software environment and to add customized capabilities such as security options and protocols. TI’s driver for its WLAN chipset solutions comes with several tools for developers, including the previously mentioned API, a Configuration Utility (CU) and several utilities for porting the driver to other OSs besides Linux and for porting TI’s high-speed VLYNQ interface to the host system. The VLYNQ interface is present on the DaVinci and DM processors, providing a direct high-speed connection between the WLAN chipset and the host processor.

- **Application Programmers Interface (API)** – TI’s WLAN driver’s API simplifies several functions, such as establishing a security mode for the platform, configuring the driver to work with the latest security protocols and defining general connection settings.
Configuration Utility (CU) – Underlying the WLAN driver’s API is the Configuration Utility. The CU enables the development of applications based on a graphical user interface (GUI) or a command line interface (CLI).

Porting Tools – The TI WLAN driver has been developed on the Linux® kernel, but it can be quickly and easily adapted to other OSs. A closed virtual API is used to attach the driver to the new OS. In addition, the OS porting facility also includes a management API and a memory manager.

A second tool reduces the time and effort required to interface a TI-based WLAN daughtercard with a system motherboard based on TI’s DaVinci or DM processors. This utility quickly ports TI’s VLYNQ interface to the host system’s processor. VLYNQ is the high-speed interface for direct connections between a TI WLAN chipset on a daughtercard and the TI processor on the motherboard.

Choosing the WLAN Leader

Besides the basic design considerations and the various tools provided by TI to ease and simplify the design process, TI’s WLAN technology has consistently led the industry in key characteristics, providing benefits such as a fast time-to-market and a market-leading price/performance ratio across all performance parameters.

For example, TI’s innovative G++™ technology can enable “whole-house” coverage and high-performance throughput rates. To double the typical signaling range of WLAN networks, G++ technology supports transmit output power up to 23 dBM along with industry-leading receive sensitivity. Network robustness is substantially improved with G++ by minimizing interference from household appliances and other nearby wireless networks. An enhanced 125 Mbps mode supports throughput as high as 36 Mbps in real world stationary CE applications.

In addition, one of TI’s leading WLAN chipsets features the TNETW1350A, a single-chip media access controller (MAC) and spread-spectrum baseband processor for WLAN processing. Implemented in WLAN chipsets with a RF transceiver and power amplifier, the TNETW1350A provides unrivaled price/performance in addition to its unmatched combination of reach, rate and robustness.
The highly integrated TNETW1350A is compliant with all current 802.11 standards, including 802.11i for security and 802.11e for quality-of-service (QoS). The device has two interfaces to TI’s high-performance serial VLYNQ as well as internal power conversion and regulation. The TNETW1350A has hardware-based accelerators for Advanced Encryption Standard (AES) MAC encryption. It also supports next-generation WLAN security, including Wi-Fi Protected Access™-2 (WPA2) and Wi-Fi Multimedia.

References

DaVinci System Board with TI WLAN: CE Stationary Design Guidelines
DM System Board with TI WLAN: CE Stationary Design Guidelines
CE-STA-DK 1.0 – DaVinci Processor – Getting Started Guide
CE-STA-DK 1.0 – DaVinci Processor – Preliminary Release Notes
CE-STA-DK 1.0 – Configuration Utility Developer’s Kit – Programmers Guide
CE-STA-DK 1.0 – DaVinci Configuration Utility – CLI User’s Guide
CE-STA-DK 1.0 – DaVinci OS Porting Guide
CE-STA-DK 1.0 – DaVinci VLYNQ Porting Guide

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