

White Paper

Building a Digital-to-Analog Converter Box with Toshiba TC90407XBG-Based Solutions

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Highlights

- Examines the implications of the Congressional mandate to end analog TV transmission: fueling demand for digital-to-analog converter boxes that allow use of existing analog TVs with over-the-air reception
- Explains an NTIA-administered coupon program that lets U.S. households request coupons as subsidy for the converter boxes
- Provides technical perspective about the NTIA technical specifications and features to which converter-box manufacturers must adhere
- Describes the TAEC TC90407XBG single-chip solution and production-ready reference board specifically designed for this market; enables rapid adaptation to manufacturing

Introduction

The last major change in the way we watch television occurred in the 1950s when television broadcasting switched from black and white to color broadcasting. Currently, we are in the midst of another major shift, the transition from analog to digital transmission that will culminate with the end of analog transmission on February 17, 2009 per Congressional mandate. Digital TV always provides a crisp picture as it eliminates analog-TV artifacts such as snowy pictures or ghost images. In addition, digital TV encompasses a higher resolution format that is commonly known as high-definition TV (HDTV). High-definition (HD) pictures have five to six times the resolution of analog-TV pictures and thus provide a significantly higher quality viewing experience. Over the last few years, many TV broadcast stations started broadcasting digital TV and pay-TV services such as cable TV or satellite TV have followed suit with upgraded digital-TV/HDTV services. However, many U.S. households still receive over-the-air analog TV and, with the changeover, a considerable number are expected to require converter boxes to translate digital signals into analog equivalents. This paper examines the changing environment, the technical requirements to build a government-compliant converter box and describes Toshiba's production-ready solutions to enable ODMs and OEMs to take advantage of this attractive market opportunity.

Government Actions Drive Demand for Converter Box

In the Digital Television Transition and Public Safety Act of 2005, the United States Congress mandated that the Federal Communications Commission terminate licenses for all full-power TV stations in the analog television service and require the end of broadcasting in analog TV service by February 18, 2009.¹ The purpose of this conversion to digital TV service is to free up bands of the scarce, valuable broadcast spectrum for use by safety and emergency services as well as enable new advanced, innovative wireless services. This means that until February 17, 2009, TV viewers can receive TV services in both analog and digital format (depending on their equipment and TV sources). On February 18, 2009, many TVs that receive over-the-air analog broadcasting could suddenly go black. In order to prevent this misfortune, in the same act, Congress created a Digital-to-Analog Converter Box Coupon program. It funded a program through which households in the United States may obtain coupons that can be applied toward the purchase of digital-to-analog converter boxes. The act defined a digital-to-analog converter box as "a stand-alone device that does not contain features or functions except those necessary to enable a consumer to convert any channel broadcast in the digital television service into a format that the consumer can display on television receivers designed to receive and display signals only in the analog television service, but may also include a remote control device."²

The Department of Commerce's National Telecommunications and Information Administration (NTIA) will implement the converter-box program. NTIA announced that starting January 1, 2008, all U.S. households will be eligible to request up to two \$40 coupons to be used toward the purchase of up to two digital-to-analog converter boxes (subject to availability of initial funds).³ These converter boxes will connect to the rooftop or indoor antenna of the existing analog TV and will convert the digital TV signal to an analog signal which will go to the analog TV. With the purchase of this converter box plus a couple of cables, consumers can use their analog TVs, even after analog transmission ends. It is estimated that 22 million converter boxes will be sold in the next 2+ years.⁴ This high demand provides a rewarding opportunity for consumer electronics manufacturers and semiconductor manufacturers who can provide cost-effective solutions for this market.

Building a Converter Box that Meets the NTIA Specification

The basic specification and features for the digital-to-analog converter box were detailed by NTIA in March 2007.⁵ The NTIA document provides the minimum requirements for the converter box and some optional features that the converter box may support. Let's examine from a technical perspective the requirements to build such a converter box. The radio-frequency (RF) signal from the antenna is received by a tuner in the converter box. The tuner will tune to the required 6 megahertz (MHz) band and produce an intermediate-frequency (IF) signal. This signal is demodulated by an 8-level vestigial sideband (8VSB) demodulator, which outputs a Motion Picture Experts Group (MPEG) transport stream. Then this MPEG transport stream is processed by an MPEG processor which extracts the audio and video streams from the transport stream and decompresses them into audio samples and video frames. Since Advanced Television Standards Committee (ATSC)/HD transmitted frames may be in HD resolution, an included scaler must scale them down to the resolution that is accepted by National Television Standards Committee (NTSC) TVs. These scaled-down video frames are then converted to an analog signal, which can be transmitted to an existing analog TV. Some older TVs circa 1980 may only have

an RF input, in which case an additional RF modulator must be provided in the converter box. Similarly, stereo audio can be output from the converter box via the familiar red and white audio jacks. This signal also can be modulated with the video signal and go over the RF signal. In addition, the converter box can provide support for a remote control, graphics for menu display and an optional program guide.

TAEC TC90407XBG Single-Chip Solution Optimized for the Converter-Box Market

To address the converter box market, TAEC designed a highly integrated, cost-competitive ASSP solution, the TC90407XBG digital TV SoC. Fig. 1 shows a block diagram of the chip. TC90407XBG can perform VSB demodulation, MPEG transport, audio and video processing, video scaling and video-signal conversion to NTSC. This minimizes the number of external components required to build a converter box. This chip is specifically targeted to converter-box type applications where an ATSC signal is converted to an NTSC signal and the architecture was carefully optimized for these applications. Compared to other solutions on the market, the TAEC device further minimizes the amount of memory required for video processing operations.

TAEC designed a production-ready reference board based on the TC90407XBG (see Fig. 2). Comprised of a complete hardware and software solution, this module reduces the manufacturer's design-cycle time and engineering expense. This board incorporates all the features required by NTIA and most of the permitted optional features. This enables the manufacturer to determine the best combination of features vs. cost. In addition, Toshiba offers a software development kit with a documented application program interface (API). This allows the manufacturer to provide value-added functions and add its own look and feel to the user interface. Fig. 3 illustrates the software design.

An available software development kit can be customized by the converter-box manufacturer. For example, the graphics-user interface can be customized to make the look and feel similar to other products in the manufacturer's line up. In addition to the basic applications provided by Toshiba, the manufacturer can provide an electronic program guide and other

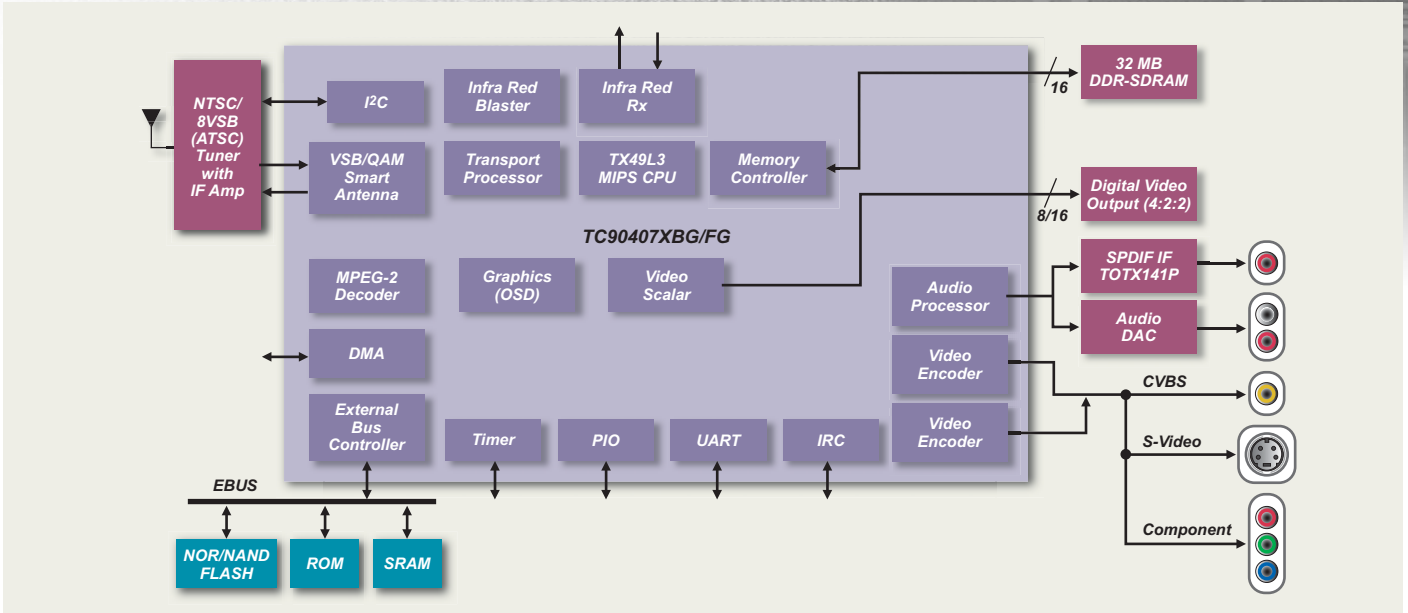


Figure 1. TC90407XBG Block Diagram

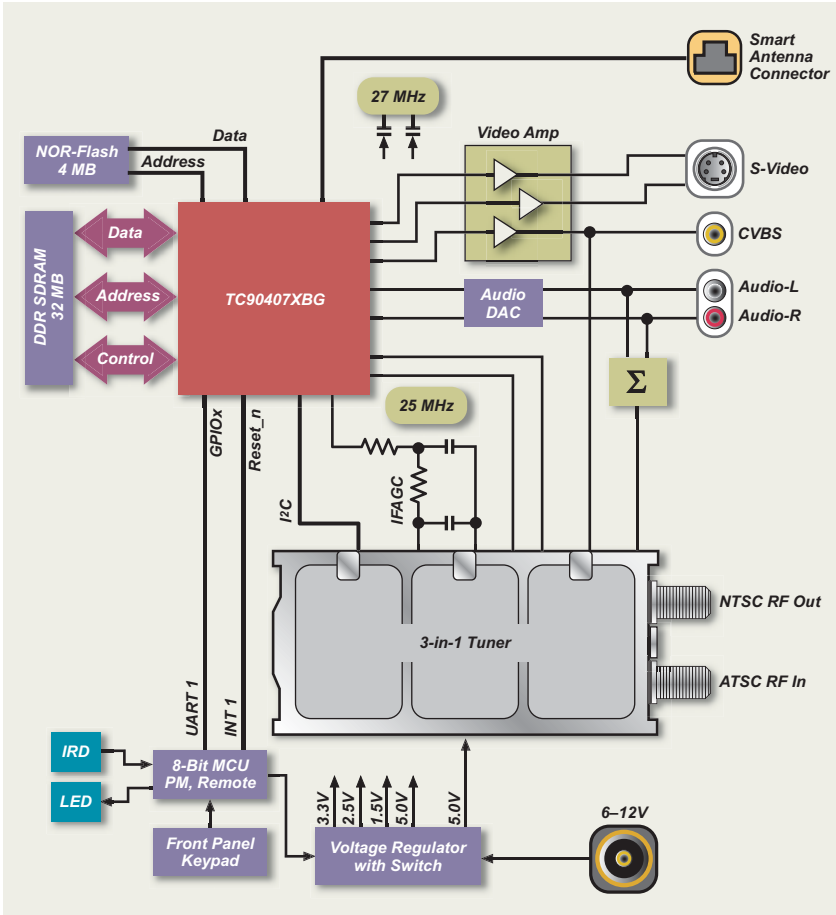


Figure 2. Converter Box Reference Design Based on TC90407XBG

applications as desired. As well, the manufacturer can customize the remote control and keys to its own purpose.

TAEC provides a total system-solution package with production-ready hardware and software. Toshiba provides customization assistance as desired in the United States or at several locations in Asia. After ODMs and OEMs add a box and remote control, they are fundamentally ready to go into production.

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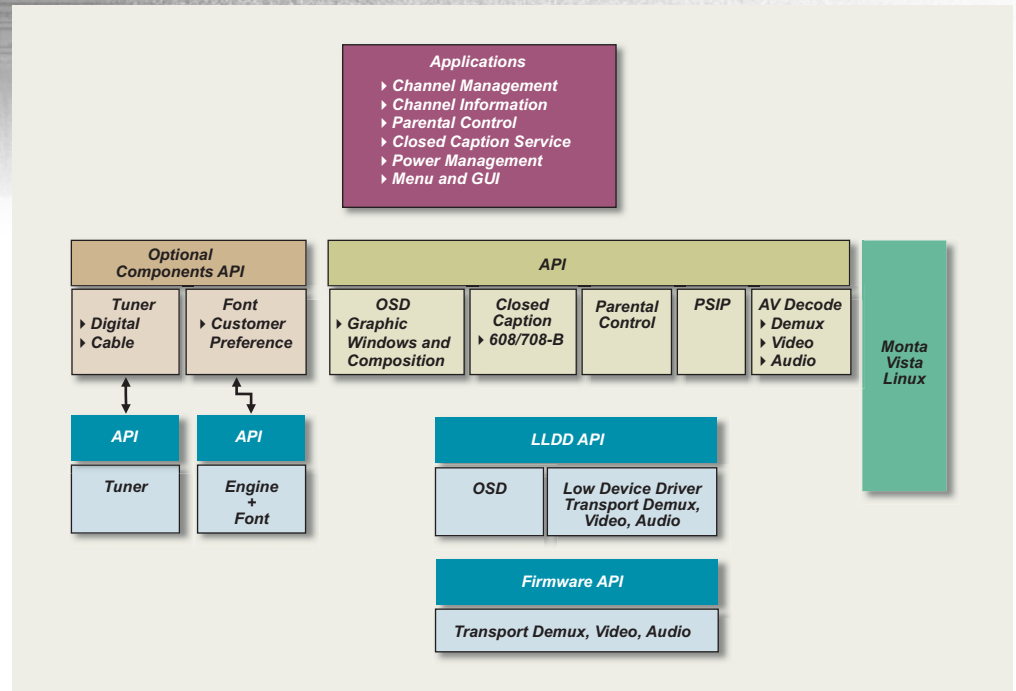


Figure 3. Software Design

- 1 One Hundred Ninth Congress of the United States of America, Digital Television Transition and Public Safety Act of 2005 (Washington, D.C.: GPO, 2005), 18-24.
- 2 Digital Television Transition, 21
- 3 "Commerce Department Issues Final Rule to Launch Digital-to-Analog Converter Box Coupon Program," National Telecommunications and Information Administration press release (Washington, D.C., March 12, 2007)
- 4 National Telecommunications and Information Administration, "Digital Television and Public Safety Request for Information: Market Research for Implementation of the Digital-to-Analog Converter Box Coupon Program—Question and Answers" (Washington, D.C., August 18, 2006)
- 5 National Telecommunications and Information Administration, "DTV Converter Box Coupon Program Information Sheet for Manufacturers" (Washington, D.C., March 2007)

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