



Developing Economical, Mainstream Television Designs with Next-Generation Silicon TV Tuner ICs

Introduction

Silicon TV tuner ICs are rapidly displacing legacy mixer oscillator phase-locked loop (MOPLL) CAN tuner technologies to reduce cost and size and improve performance. Silicon tuner IC adoption began before 2007 and gained real traction during 2010 when flat-panel TVs and set-top boxes (STBs) saw a significant increase in sales. Designing silicon TV tuners that matched MOPLL performance levels was the main hurdle for adoption, but once semiconductor suppliers met this performance standard the road was cleared for silicon tuner IC shipments to accelerate. Several suppliers now offer a wide variety of silicon TV tuner products. Navigating the competing options can be a complex process given the wide range of issues surrounding TV tuner IC selection. Putting these technical issues into perspective will help simplify the TV tuner selection process.

State of the Market

TV market demand has grown to an amazing 230 million units (Mu) per year across a wide range of regions. The broader TV market breaks down into two segments relevant to TV tuner ICs: integrated digital television (iDTV) platforms (approximately 160 Mu) and analog-only TVs (approximately 70 Mu), which consist of both flat-panel TVs and analog-processed CRT TVs.

Analog-processed CRT TVs employ an older image processing technology. In contrast, flat panel TVs incorporate advanced DSP-based image processor SoCs supplied by companies such as Broadcom, MediaTek, MStar, Novatech and Sunplus Technology. Some major TV brands also have their own internal semiconductor teams that build captive flat-panel SoCs. Analog-processed CRT TVs use less capable microcontrollers and cannot easily accommodate silicon tuner IC programming and configuration. These analog-processed TVs are likely to retain the older MOPLL CAN tuner implementations, which often require more than 150 separate components (see Figure 1). Flat-panel platforms employ modern high-performance processors that run a substantial amount of firmware so they are well positioned to configure modern digital devices such as silicon TV tuner ICs.



Top of PCB

Bottom of PCB

Figure 1. Example of MOPLL CAN Tuner, which Requires 150+ Components

Many TVs must support both analog and digital transmission standards to meet consumer demands. Examples of analog transmission standards include NTSC and PAL/SECAM. In this case, the word “analog” describes the transmission modulation format and not the specific processing technology used to decode it. Many countries are in various stages of executing their analog switch-over plans where the terrestrial analog broadcasts will be terminated and replaced with higher quality digital broadcasts. Yet even in countries that have theoretically made the hard cut over to digital, the analog transmissions remain active, and consumers continue to demand support for these transmissions. Japan is perhaps an exception, having achieved a true conversion to all digital, but TVs sold in virtually every other region are forced to retain analog reception capability to deal with low-power analog broadcasts, slow-to-upgrade cable networks and legacy consumer electronics devices. Tuner support for analog transmissions will be required by all major TV brands for TVs outside of Japan for at least five more years and likely for ten more years.

Numerous TV platforms accept content from both terrestrial and cable sources. As a practical matter, these platforms must support analog transmissions as long as the multi-subscriber operators (MSOs) continue to transmit analog content on their cable networks. Cable and terrestrial STB segments add an additional 175 million systems of demand per year.

A recent forecast of silicon tuner ICs from IMS Research (Figure 2) projects the market growth for the overall number of TV tuners for demand TV, STB, cable modem, satellite receiver and other segments. Several multipliers are applied to account for multi-tuner IC applications, generating the roughly 700 million units of overall tuner IC market opportunity shown. The rapid adoption of silicon tuner ICs is evident from this data and is even stronger when focusing on just the TV and cable STB segments where silicon tuner ICs have made deeper inroads.

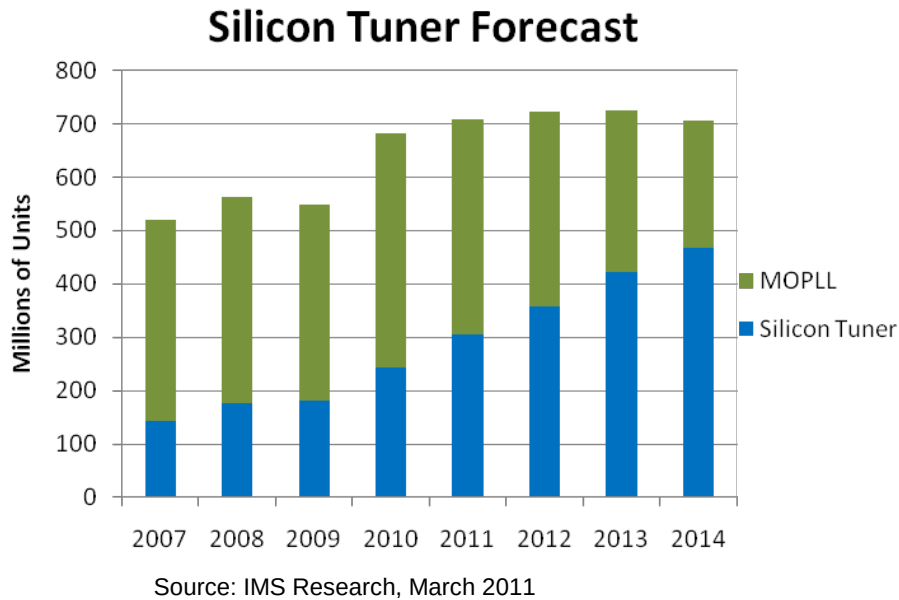


Figure 2. IMS Research Forecast Shows Growing Market Demand for Silicon Tuners

Opportunities Going Forward

The high-growth markets of mainland China and Taiwan are taking the lead in new silicon TV tuner IC opportunities. TV makers in China have rapidly increased TV production over the last three years, and cost-optimized silicon TV tuner ICs help them deliver high-quality TV models at competitive price points. According to the analyst firm DisplaySearch, China became the world's largest market for LCD TVs in 2011. DisplaySearch also predicts that flat-panel TV shipments (both LCD and plasma models) in China will nearly double from the 31 million units reported in 2009 to 59 million units in 2014, reaching a compound annual growth rate of 14 percent.

Top-tier TV brands are accelerating their adoption of silicon tuners to save cost, improve reliability, reduce component inventories and support thinner TV form factors. These same advantages are driving significant opportunities in the second- and third-tier TV brands where the adoption of silicon TV tuners is just starting. Because today's silicon tuner ICs must support all worldwide terrestrial and cable broadcast standards, these smaller TV brands benefit from the intensive work already accomplished by the top brands.

Connected TVs expand the range of program sources beyond just the antenna and cable, and are gaining significant traction as "apps" make their way to large screen TVs. New communication interfaces for TVs such as Wi-Fi, Ethernet and LTE (cellular) are delivering rich, diverse content beyond the traditional broadcast sources. These interfaces present special technical challenges for over-the-air (OTA) broadcast tuners. For example, a special Wi-Fi immunity circuit is needed to protect against this interference.

Silicon TV Tuner Selection Challenges

Tuners perform a complex task in that they must cleanly receive one low-power transmission in a crowded spectrum full of other content. This puts a great deal of pressure on the RF front-end of the silicon TV tuner IC. The complexities present at the geographic boundaries of two differing transmission standards add additional challenges. Add to this the architectural complexities of popular DTV and STB SoCs, and it becomes clear that a single silicon TV tuner IC cannot meet the needs of the entire market. Fortunately numerous tuner IC architectures are available today that address these varying platform needs. The challenge is to confidently select the right device for your application.

Channel Reception: The keys to achieving clear TV broadcast reception are sensitivity and selectivity. These characteristics in turn are based on low noise figure (NF), high RF front-end linearity and high-quality RF front-end filtering. Low noise figure means that the RF front-end adds very little unwanted noise to the incoming signal, while high sensitivity means that there is ample video signal-to-noise ratio (VSNR) even with weak input signals to correctly receive the broadcast. But TV tuners almost always need to receive a single broadcast in the presence of many other signals. This is where the silicon tuner IC's selectivity -- the ability to block or exclude content on nearby "blocker" channels -- is essential for clean reception. To achieve high selectivity in a cost-effective solution, a silicon tuner IC needs both high linearity and high quality filtering in the RF front-end. As a result, silicon TV tuner ICs with high sensitivity and excellent selectivity performance, as shown in Figure 3, add up to more channels received under real-world conditions.

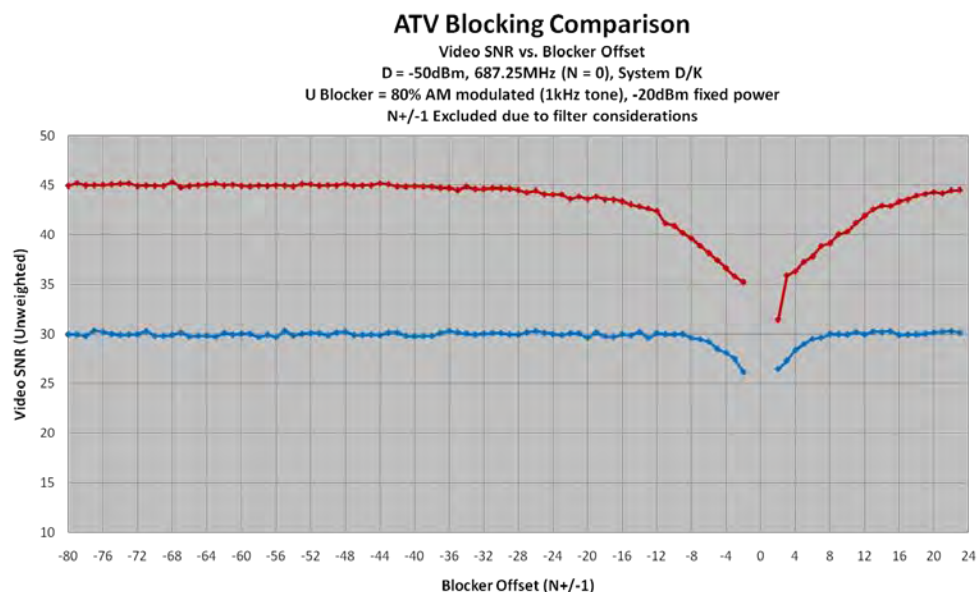


Figure 3. The Si21x6 TV Tuner Demonstrates Exceptional VSNR Performance in the Presence of a Blocker (Red Trace) Compared to Alternate Tuners (Blue Trace)

Field Testing: Major TV brands deliver products adhering to the official broadcast standards, but they also must address the many real-world exceptions to these broadcast standards or face consumer complaints and costly product returns. Unusual broadcast conditions and exceptions occur more frequently than you might realize. This is especially true at the geographic boundaries between one broadcasting standard and another where issues can get very complex. For example, in Europe numerous analog and digital standards can be received across international borders by a single TV. To address these non-standard reception conditions, the TV tuner and demodulator must first detect and then compensate for the non-standard transmissions. These conditions are corrected on a case-by-case basis and require extensive field testing to perfect. Without the extensive control and configuration capabilities of the silicon TV tuner ICs, these increasingly challenging requirements could not be addressed. TV manufacturers put TV tuners through rigorous field testing, highlighting both standard performance as well as performance to anomalous broadcasts. TVs destined for cost-conscious regional markets may choose a lower cost TV tuner, but TVs destined for broader export markets will certainly require robust worldwide performance.

Flexible Architectures Reduce Cost: Greater choice in TV tuner architectures has been a positive development for iDTV and STB suppliers. Several silicon tuner IC variations are now available to meet the specific architecture needs of iDTV and STB platforms. Modern TV and STB platforms have three main circuit functions: the silicon TV tuner (see Figure 4 for example), the demodulators and the audio/video and processing graphics SoC. The output of the tuner drives the input of the demodulator, and the output of the demodulator drives the input of the audio/video processing and graphics SoC.

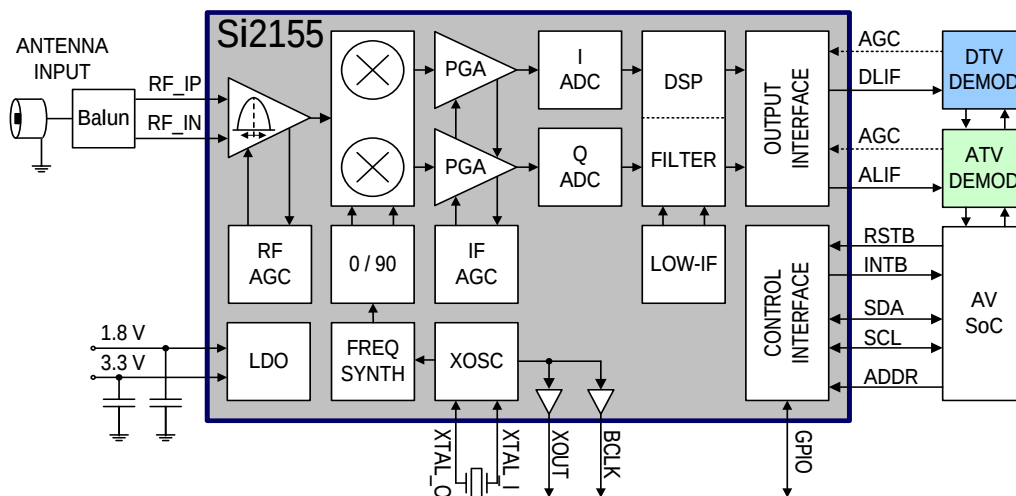


Figure 4. Example of State-of-the-Art Silicon TV Tuner Architecture

TV and STB platforms have varying needs for analog and digital tuners. For example, a simple narrowband cable access box (cable STB) may need a single digital-only tuner. In contrast, a high-volume mainstream iDTV will likely support analog and digital terrestrial broadcast as well as cable input sources. For the larger TV brands, these tuners must support all analog and digital transmission standards worldwide. TV tuner ICs are now available supporting numerous architectural configurations such as digital only, multi-channel digital only, analog and digital tuners, analog and digital tuners with analog TV demodulator, as well as various receiver configurations with a tight linking of tuner and demodulator.

Most modern TVs support at least one tuner that can tune both analog and digital channels. Separate demodulators for the analog and digital channels are needed. To support varying digital demodulator standards, there may even be multiple demodulators such as DVB-T and DVB-T2 within the same platform. Demodulators vary in complexity with ATSC (North America) and DVB-T (digital terrestrial broadcast for Europe and many other regions of the world) being relatively low complexity standards compared to DTMB (China's new digital broadcast standard) and DVB-T2 (a new higher density digital standard in Europe). In the case of digital demodulators such as DVB-S2, DVB-C2 and DVB-T2, the demodulator is typically contained in a standalone IC. Less complex demodulators can be found in the audio/video processing and graphics SoC, or they may be combined with other more complex digital demodulators.

STBs support a cable input and in some cases a broadcast antenna input. Unlike TVs, the SoCs used by many STB platforms usually lack an analog TV (ATV) demodulator and are not well suited to analog broadcast reception. In these cases, the ATV terrestrial broadcast demodulator will be external to the SoC, if such a demodulator is required for the STB.

Demodulators for analog TV (ATV demodulators for NTSC, PAL and SECAM) are especially prone to poor behavior when presented with the many real-world anomalous transmissions. In practice, actual demodulator performance is highly dependent on the experience gained from prior generations of effort. This experience is concentrated in specialized control firmware running on modern silicon TV tuner ICs and demodulators. Given the many nuanced interactions between tuners, demodulators and image processing SoCs, TV manufacturers must perform extensive field testing to validate specific combinations of tuners, demodulators and SoCs. This means that in some cases, a tuner with a higher performance internal ATV demodulator will be chosen even if the SoC integrates its own ATV demodulator. The key question for the designer is to determine which demodulator has been adequately field-tested relative to the TV's or STB's intended market and use. If field testing for a specific tuner/demodulator combination has not been completed, it may be necessary to adopt an integrated and more thoroughly tested tuner/demodulator combination to meet the development timeline and cost targets.

Cable STB applications can present a special challenge for tuner selection. In most cases, the demodulator will be supported by the STB SoC. Generally, the transmission environment for cable is considered less variable than that of terrestrial broadcast. Signal strength and other factors are reasonably well controlled within a cable network. Tuner performance metrics are generally relaxed for cable STBs applications using this reasoning. However, the ability to control the cable plant depends on the specific cable provider or multi-subscriber operator (MSO). In some cases a given MSO will have issues with “channel tilt” (differing signal strength across the channel spectrum), external signal ingress (most likely from local terrestrial broadcast stations that interfere with the cable transmissions) or a mixed transmission mode network that re-transmits an array of channels from different sources with different transmission characteristics. A lower performance silicon TV tuner IC may not be adequate in these situations, and a higher performance TV tuner designed for terrestrial TV broadcasts may be needed to receive the full range of channels.

What Should you Expect?

As a practical matter, what types of TV tuner options are available for use? A review of Silicon Labs’ latest generation of silicon TV tuner ICs can help answer this question. This new TV tuner family offers a range of architectures that combine easily with popular TV and STB system-on-chip (SoC) devices.

The Si21x6 TV tuner family includes the high-performance Si2176 silicon TV tuner IC with analog demodulator, as well as the Si2136 complete analog receiver. The Si2146 digital-only TV tuner IC is ideal for cable set-top boxes and multi-tuner HDTVs. The high-performance Si2156 TV tuner IC provides a popular configuration (with just the digital and analog tuners) with features similar to the cost-effective Si2155 tuner. The Si2155/56 devices easily combine with popular TV and STB SoCs. These devices apply equally well to iDTV, cable platforms and STBs. The entire Si21x6 family, including the Si2155 TV tuner IC, delivers exceptional RF performance and design simplicity offered by Silicon Labs’ current-generation TV tuner ICs that are in high-volume production at five of the world’s top seven TV brands.

The Si2155 TV tuner is designed to reduce system costs in high-growth regional markets such as mainland China and Taiwan where there is substantial variability in the technical requirements for TV and STB platforms depending on the needs of regional and export platforms. TV tuner architectural flexibility is especially important to reducing costs and simplifying designs in today’s rapidly growing TV markets.