

# Silicon TV tuners poised to replace cans

While the evolution of TV receivers has accelerated on many fronts in the last decade, fully integrated silicon tuner design has lagged behind this evolutionary wave. The silicon TV tuner is now perfected and will rapidly replace traditional can tuners, just as transistors replaced vacuum tubes during the mid-1960s.

By Alvin Wong and Jordan Du Val

The past decade delivered an unprecedented and multifront evolution of TV broadcasts and receivers. These advances include stereo audio, HDTV, flat-screen technology using LCD and plasma displays, and TV receivers integrated into personal computers. The ultimate goal for TV receivers is a fully integrated solid-state TV with a flat-screen LCD or plasma display.

While significant progress has been made toward this goal, tuners have fallen behind in the evolutionary development. This lag, however, is in the process of rapidly changing. Demand for smaller and lower-power televisions, flat-screen miniaturization, and even government standards are driving the development of silicon tuners to the razor's edge. In fact, the Federal Communications Commission (FCC) has set standards requiring all new televisions to incorporate digital tuners within the next two years.

## Tuner history

The traditional tuner design for decades has been the "can" tuner, appropriately named because they are housed in metal enclosures to minimize RF interference and cross-talk. Despite the long history of use, can tuners have some major deficiencies.

First, the requisite use of tunable and fixed coils has virtually dictated discrete transistor designs for the tuner. This results in poor temperature characteristics and a physically large, power-hungry module—some as large as two inches by four inches. Perhaps the primary deficit with can tuners though is that each must be tuned individually as part of the manufacturing process. Not only is this a time-consuming step, the tolerance of the passive components results in a relatively broad acceptance standard for can tuner quality control.

As the disadvantages of the can tuner become more evident in today's modern devices, the silicon tuner is poised to unseat the can tuner in virtually all applications, in the same vein as transistors replaced vacuum tubes. Silicon tuners have the potential to offer a number of advantages and capabilities that the can tuner lacks.

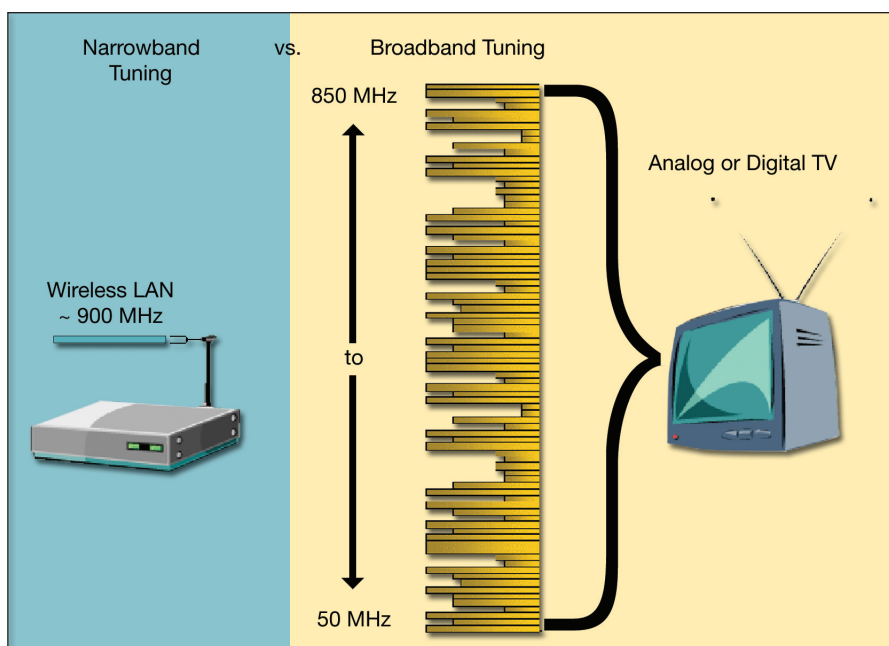


Figure 1. Narrowband vs. broadband tuning.

Highly integrated silicon tuners are much easier to manufacture, and no tuning is required, reducing the overall cost of the tuner. The tuner can also be made extremely small compared to the can tuner because of the high level of integration.

Another notable advantage of silicon tuners is that a single tuner can receive TV signals using any of the several worldwide transmission standards. This means that an international manufacturer need only stock a single, meets-all-standards tuner, instead of one or multiple can tuners for each disparate standard.

Other advantages of silicon tuners include:

- integrated analog and digital tuners;
- multiple tuners in the same package for picture-in-picture and other applications;
- greater reliability;
- superior thermal stability;
- tighter quality control standards; and
- quicker channel lock: ~5 ms vs. ~150 ms.

These advantages, coupled with recent IC design rules and techniques have enabled

practical silicon tuners. New IC techniques being used include enhanced BiCMOS processes, silicon-germanium (SiGe) transistors, and 0.18  $\mu\text{m}$  design rules. This design evolution, when added with government dictates, will result in a rapid and universal transition to silicon tuners.

## Overcoming physical and integration problems

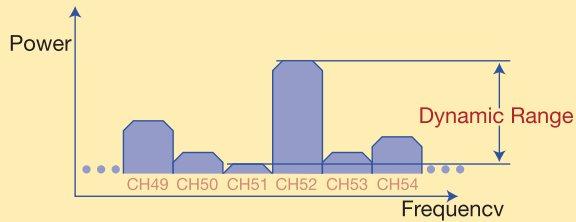
The fact that development of silicon tuners has lagged behind virtually all other TV developments clearly identifies that silicon tuner technology had difficult challenges to overcome in order to realize a producible tuner. And indeed, a number of difficult hurdles had to be crossed before a practical, manufacturable silicon tuner could be produced at a reasonable cost.

An obvious question at this point might be 'why are tuners even necessary? Why not do it all digitally?' Ideally, such a tuner would be produced with a simple (in concept...extremely complex in design)

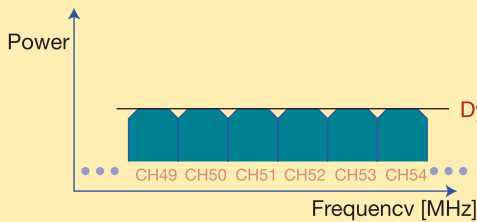
### Terrestrial Broadcast



Chips for terrestrial broadcast reception must be more complex to handle a potentially large dynamic range difference between channels.



### Cable



Supporting only cable reception does not require the same design complexity.

Figure 2. Broadcast signals vs. cable signals.

analog-to-digital converter (ADC), whereby analog TV signals would be directly converted to a digital datastream without tuned circuits, including input and output filtering.

Even a cursory look at TV bandwidths reveals the magnitude of the ADC problem to be overcome. The Nyquist theorem requires nearly two billion samples per second using an ADC converter to sample the analog input across the entire 860 MHz TV bandwidth, and with enough bits of resolution to reproduce an HDTV-quality picture.

ADC converters with that kind of sampling rate and resolution currently are expensive.

This extreme sampling speed and resolution is necessary because of the very large bandwidth associated with broadcast television. However, if a tuner is used, this broadband input can be tuned to a single, baseband signal that is significantly easier to process with ADCs. Because the tuner simply pushes the difficulty of handling this very large bandwidth from an ADC converter to the tuner, problems dealing with the large bandwidth

tional analog designs to facilitate broadband capability with new silicon tuners.

An even bigger obstacle in the realization of silicon tuners was designing highly integrated circuitry to accommodate the enormous dynamic range required for broadcast TV signals. Signals reaching the receiver are affected by the variable and arbitrary distance from the transmitter. It's not unusual to have signal strength variations of several-thousand-fold.

Cable signals are of relatively uniform signal strength and integrity, which al-

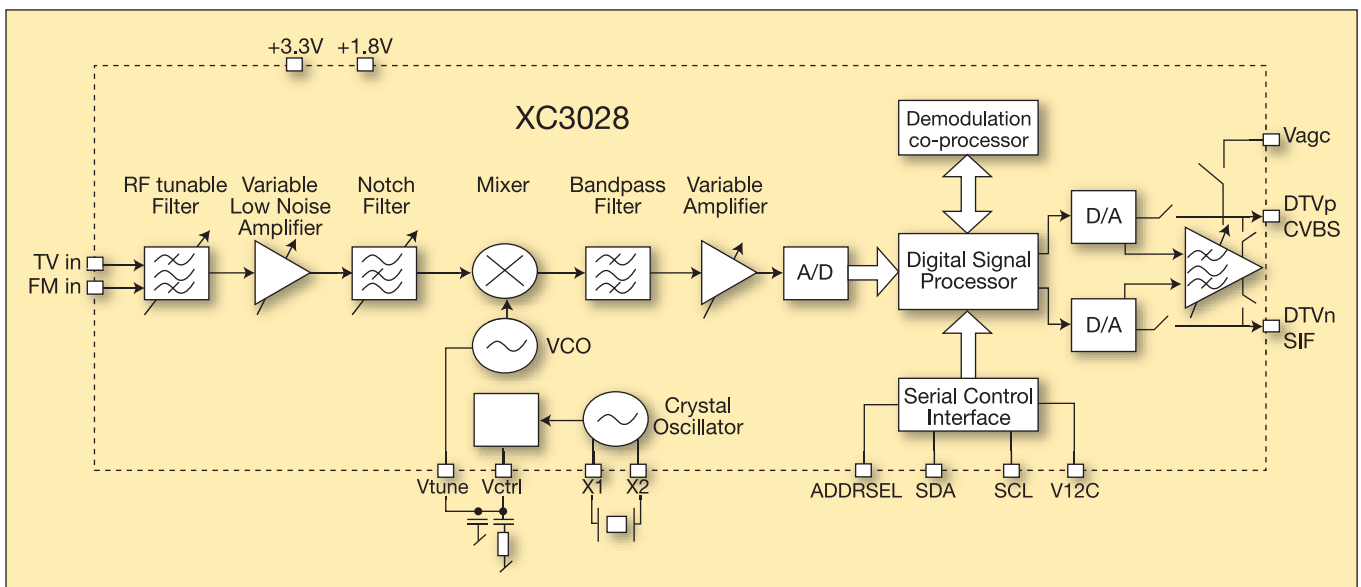


Figure 3. Block diagram of XC3028 analog and digital silicon tuner.

still had to be solved. Most receiver designs cover a relatively small frequency range. A couple of examples include 802.11b wireless LANs and cellular phones. The tuner in a cellular phone tunes about 500 kHz of bandwidth. A TV receiver, by comparison, must tune about 860 MHz—three orders of magnitude more bandwidth. The extreme difference in bandwidths results in many proven narrowband design techniques not transferring to TV's wideband requirements. Figure 1 illustrates the magnitude difference in the two receiver applications. New techniques have replaced tradi-

lowed some early silicon tuner designs to work in that environment. However, only recently have silicon tuners achieved the dynamic range required to reliably reproduce a quality TV picture and audio (Figure 2). Silicon tuners, such as Xceive's XC2028 and XC3028 have a dynamic range of 80 dB, more than enough to handle the challenge of broadcast signal quality.

The large dynamic range also demands that the receiver be extremely sensitive to receive very weak signals—yet not prone to front-end overload caused by very strong signals.

New active filter designs have produced the sensitivity required, while remaining immune to overload induced by strong, local signals. This results in a superior sensitivity of  $-83$  dBm or better.

### Silicon tuner solutions

Several manufacturers have full or partial silicon tuner solutions. We have produced a one-design-fits-all-TV-standards analog tuner IC. While XC2028 is a complete analog RF-to-baseband tuner, the XC3028 is a complete analog and digital RF-to-baseband tuner.

Both these chips are based on a systematic, iterative design approach to optimize highly integrated functions in traditional and non-traditional ways. The basic block diagram of the silicon tuner is shown in Figure 3. This design is significantly more sophisticated than a can tuner, incorporating substantial digital processing circuitry in addition to the RF signal conditioning and tuning front end. For instance, the XC3028 integrates on-chip wideband tunable filters, image rejection filter, programmable channel filter, and wideband voltage-controlled oscillator (VCO).

Not only are silicon tuners a significant improvement over can tuners in the areas outlined above, they have a much tighter QC acceptance tolerance due to eliminating high-tolerance passive components. Figure 4 shows the frequency response of two individual Xceive EVK4 silicon tuners vs. two high-quality can tuners. Note how little variation exists in the silicon tuners compared to can tuners.

To further illustrate this point, several can tuners were tested separately. It was observed that 1 dB to 2 dB of variation across the frequency range is normal. In addition, each tuner has a slightly different transfer characteristic, resulting in slight variations in the picture quality of the completed TV receiver.

In addition, the designers have extensively analyzed the sources of non-linear signal degradation to further enhance dynamic range over the full TV bandwidth. Each non-linear degradation was cancelled with an inverse-acting non-linear source. Another advancement is that no external low noise amplifier (LNA) is required with Xceive's silicon tuners. Other solutions may require external LNAs to achieve the  $-83$  dBm sensitivity of the Xceive design (ATSC signal).

A final factor in physically being able to integrate the full tuner function was the fabrication of the IC itself. The fabrication took advantage of improvements in the BiCMOS process, as well as benefiting from small,  $0.18\ \mu\text{m}$  architecture. Both factors contribute to speed and low power consumption.

Perhaps even more important in the fabrication process is the use of SiGe transistors. These active devices are faster, more power efficient, and more important, have improved noise characteristics compared to traditional silicon transistors. Incorporation of this leading-edge technology also significantly impacts the ability to incorporate the silicon tuner in a package smaller than a dime.

### Applications

There are many obvious applications for silicon tuners—they will replace can tuners in virtually every consumer TV set within just a few years. Beyond that, however, the reduction in size and power requirements opens a new and diverse universe of applications.

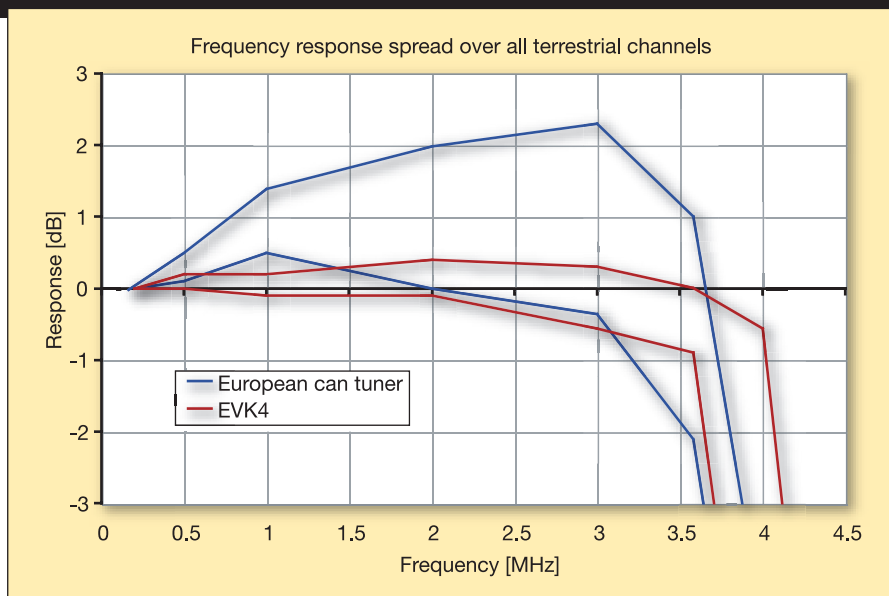


Figure 4. Superior tolerance of silicon vs. can tuners.

■ **Tuners for PCs:** The demand for TV receivers integrated with PCs already exists. New silicon tuners will make them significantly more practical. For example, Compro has designed a USB 2.0 compatible TV receiver based on the XC3028. This tiny device (VideoMate U880) is about the same size as a USB flash drive.

■ **Flat panel TVs:** Another market that

will get a boost from silicon tuners is picture-in-picture. Because of the low-power design and adjacent-channel interference rejection, multiple silicon tuners can be incorporated into a single design, allowing instant access to several broadcasts.

■ **Cellular phone/PDA:** The size of silicon tuners, with their stingy use of battery power, allow for TV reception in a cell phone or PDA.

The TV broadcast industry has been in the midst of sweeping changes over the last 10 to 15 years. One of the last components to experience this sweeping evolution is the tuner.

Only recently have tuner designs caught the innovation wave. Newly designed silicon tuner chips, integrating the full tuner function have performance, packaging and power advantages over traditional can tuners. **RFID**

#### ABOUT THE AUTHORS

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