What's inside a silicon tuner?

Jacek Pawlowski

• a silicon tuner is a significant technological improvement that finds its way into nearly every new product in digital TV equipment

It is not only cheaper and much smaller but guarantees better performance if applied correctly - see our Feature Story in TELE-satellite 02-03/2011. Does this integrated circuit (which a silicon tuner in fact is) have innovative internal architecture that makes all this possible? Well, from the top level perspective, a silicon tuner has a rather typical front end architecture similar to a modern radio circuit. It is called the "direct conversion" or "zero IF" architecture and is quite popular especially in digital communication circuits. But, as usually, the devil is in the details.

Let's take as an example the simplified architecture of the AT810 chip of company Abilis Systems - see Figure 1. AT810 is a terrestrial TV tuner compatible with DVB-T/T2, ISDB-T, CMMB and DTMB/GB 20600-2006 standards. The first stage of AT810 is a relatively low gain radio frequency (RF) amplifier followed by a tracking bandpass filter. The filter attenuates the interfering signals originating for example from GSM, or WiFi devices by about 60 dB. That's a lot. The filter is automatically programmed by the on-board microprocessor depending on the currently selected TV channel.

The RF amplifier, except for amplifying the signal by approximately 20 dB, provides additionally a loop-through output – what is very desirable in double tuner TV receivers. For the best performance of the TV tuner, this amplifier not only must have a very low noise coefficient but it must be able to handle large signals without entering into the non-linear region of its characteristics. Technical people say that such amplifier has a large dynamic range.

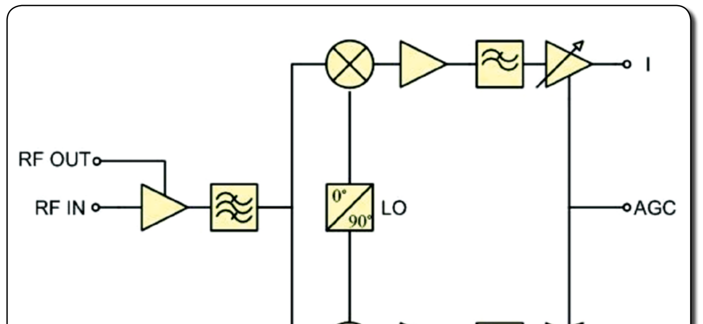

Fig. 1. Simplified block diagram of AT810 silicon tuner of Agilis.

After the RF amplifier and the bandpass filter we have the essence of a direct conversion circuit: two balanced mixers fed with local oscillator signals of the same frequency but shifted by 90°. It is sometimes said that those mixers are fed with sine and cosine signals because the cosine waveform is identical to the sine shifted by 90°. The frequency of the local oscillator (LO) should be equal to the frequency of the received TV channel. In this way, at the outputs of the mixers, we get the modulating signal shifted in phase by 90°. Such signals are called the I and Q vectors. The letters come from the "In-phase" and "Quadrature" terms. I and Q signals are then amplified and unwanted products of the signal conversion are removed in the low pass filters located in both signal paths. The filters need to be very sharp because otherwise we would get interference from the adjacent signals. After the filters, there are the amplifiers of variable gain that enable automatic gain control (AGC). Thanks to the AGC, both weak and strong input signals produce similar signal level at the output of AT810. If the signal is weak, the gain of the amplifiers is set high, and if the signal is strong, the gain is set low.

Once we have I and Q signals, the next step is to convert them to digital form in analog-to-digital converters (ADC's). However, the ADC's are part of a digital signal processor – not the part of a silicon tuner. Having digitalized I and Q vectors, we can do all the magic reserved for digital signal processing like: very good filtering, demodulation, moving from time domain to frequency domain (with the help of Fast Fourier Transform) and much more.

Perhaps it will be a surprise for some of the readers to learn that with the digitalized I and Q signals, we can quite simply demodulate also analog TV signals (classical AM modulation).

However, the very first step must be to achieve good quality I and Q signals. And this "good quality" was until recently posing real problems for the chip manufacturers. Except for having very good initial RF amplifier, we also need very good mixers. By very good, we again mean sub-circuits of high dynamic range. But that's not all. Both mixers and all the sub-circuits after them: amplifiers, low pass filters and AGC amplifiers must be identical in I and Q path. Even a small difference in gains or a small phase shift between them would ruin the performance of the direct conversion circuit. Such symmetry requires a very well controlled chip manufacturing process and is not so easy to achieve. Fortunately, the engineers from Abilis like their colleagues from a couple of other competitive companies succeeded in that. Thanks to them, the digital TV receiver designers got a new building blocks – silicon tuners - that enable them to develop better, smaller and cheaper set-top-boxes.

© 2011 www.Thai-D.com/sat-art