TECHNICAL BACKGROUNDER:
SOLVING THE TECHNICAL CHALLENGES OF DTV

BY JOHN NorrisWORTHY,
FOUNDER AND CHIEF TECHNICAL OFFICER, MICROtUNE, INC.
SOLVING THE TWO TECHNICAL CHALLENGES OF DTV
BY JOHN NORSWORTHY, FOUNDER AND CHIEF TECHNICAL OFFICER

OVERVIEW
Recently, there has been a great deal of industry comment about the adequacy of 8-VSB as a means to distribute digital television. There are clear reasons why the FCC has adopted 8-VSB, rather than its European counterpart, COFDM, as the modulation scheme in the United States. To provide some clarity to the discussion, I will review both modulation schemes and compare their merits/disadvantages relative to their end results. I will then offer an opinion on which scheme will ultimately succeed in the U.S. marketplace and why, as well as address an often-overlooked aspect of digital television reception: the tuner.

TECHNICAL OBSTACLE TO DTV: THE MULTIPATH PROBLEM
The issue identified by the Sinclair Broadcast Group in its ‘real world’ ATSC test case is the ‘old’ multipath problem. Multipath is the problem caused by a transmitted signal arriving at a receiver through multiple paths. These paths are reflections off buildings, airplanes, people moving around a room, etc. In analog video, multipath manifests itself as ghosts in the image, shadows of objects shifted across the screen. In really bad cases, the video breaks up. In digital video, which is either perfect or ‘off’, severe multipath interference can lead to loss of reception.

THE DEMODULATOR MUST SOLVE THE MULTIPATH PROBLEM

When a roof antenna is used, there is typically a line-of-sight path between the antenna and the transmitter. Furthermore, the roof antenna typically has directionality; it tends to receive signals from the direction in which it is pointed and rejects others. If the TV viewer is using a roof antenna, multipath is generally not a problem.

Unfortunately, the problems caused by indoor reception are not so easily addressed. The TV viewer may use a simple ‘rabbit ears’ antenna, or some other small, visually-attractive antenna that has virtually no directionality. In indoor applications, no directionality is required—it is impossible to know from where the signal is coming.
In a typical path in an urban setting, the signal will reflect off some buildings and enter the home through a window. The primary path may then reflect off walls and the like before arriving at the antenna. This is obviously a big multipath problem.

**WHY DIGITAL TV?**

Before addressing the solutions to these problems, I think it important to step back and review why the U.S. (and the world) is headed down the digital path in the first place. There are two main thrusts behind digital television. The first, and most important one, is more efficient use of the spectrum. The second is providing consumers with a better television experience. ‘Television experience’ can be expanded to include other classes of broadcast digital services, such as data broadcasting, on-demand programming and interactive television.

Spectrum is valuable. Until now, the television industry has enjoyed a prime, disproportionately large segment of our nation’s spectrum. More than half of this spectrum, ranging from 54 to 806 MHz, is left unused in any given locale. The decision-makers in Washington realize that a significant portion of the spectrum dedicated to broadcast television is currently unused.

**THE INTERFERENCE PROBLEM**

Would it surprise you to know that a primary reason for the inefficient use of spectrum is television tuner performance? In fact, the FCC, in granting licenses to broadcasters, specifically avoids, by mandate, the use of more than half of the available channels in a region. These channels, called taboo channels, consist of channels adjacent to an existing broadcaster and those at the so-called ‘image channel’ of an existing broadcaster. Channels that are harmonically related are also considered taboo. These taboo channels can potentially cause interference, manifested as lines or patterned noise on an analog TV set with a conventional television tuner. In digital TV, they can cause loss of reception. A diagram presenting the current analog television spectrum of Los Angeles is depicted below. It illustrates how much of the spectrum is ‘protected’ because of the taboo channels, a condition that is mirrored in major markets throughout the U.S.

**BEFORE DTV: UHF NTSC SPECTRUM FOR LOS ANGELES**

![Diagram showing NTSC and taboo channels](image-url)
In the UHF band, nearly three quarters of the spectrum is unused. Almost every channel has an image channel. If the allocation scheme also excludes use of adjacent channels and image channels, more than half of the spectrum is unavailable for use.

With higher-performance television tuners, those that offer the higher selectivity needed to reject the taboo channels, the spectrum could be more efficiently utilized. This would lead to a richer set of broadcast media and/or a reclamation of spectrum for other uses.

Recently, the new DTV broadcasters have been granted licenses to broadcast in the taboo channels. The chart below depicts the Los Angeles spectrum once DTV signals are added.

**AFTER DTV: UHF NTSC AND DTV SPECTRUM FOR LOS ANGELES**

DTV broadcasts within the NTSC spectrum are being permitted under the assumption that digital signals will not cause interference problems for existing analog channels. This view is based on the nature of a digital signal. A digital signal does not possess a strong picture carrier and it distributes its signal energy evenly across the channel. It is believed that these characteristics will prevent interference. Many experts are doubtful of this. In fact, broadcasters, the FCC and TV manufacturers are beginning to realize that advances in tuner technology are required to prevent interference in the reception of both analog and digital signals.

**THE INTERFERENCE PROBLEM**
SPECTRUM EFFICIENCY AND DEMODULATION

Spectrum efficiency also impacts the issues of 8-VSB and COFDM. 8-VSB has more bits per hertz of bandwidth than COFDM, and consequently it uses spectrum more efficiently. According to the Australian DTTB Report, COFDM needs an extra megahertz of bandwidth per channel (7 MHz for COFDM versus 6 MHz for 8-VSB) to get 19.3 Mb/s of data, the amount required for HDTV. The idea behind COFDM is to provide immunity to multipath. It does this by taking a bit stream and breaking it up into several concurrent bit streams. Additional complexity is incurred in the COFDM demodulator by dividing the streams into several isolated (orthogonal) channels. The bits are coded into symbols, and because symbols are now placed in several parallel channels, the symbol rate can be low (1/256us), so low in fact that the time between symbols is very long, relative to the time difference of arrival of the multipaths.

This is not the case for 8-VSB. The symbol rate (1/93ns) is such that typical multipath delays are a meaningful proportion of the period between two symbols, resulting in intersymbol interference. However, 8-VSB is much simpler because it is only one channel.

Proponents of 8-VSB point out that the intersymbol interference issue can be handled by sophisticated equalizers. These equalizers sense the secondary path or paths, invert them and subtract them from the signal, thus removing the offending multipath(s). Some multipaths are harder to remove than others since they are caused by moving objects rather than stationary ones. These objects could be airplanes or, even, people walking around a room. This is the dynamic multipath problem, and requires that the equalizer adapt to changing conditions. In the Sinclair tests, latest and greatest equalizer technology was not used, and as a result, the results are not alarming.

Another important issue is the power level required by each demodulation scheme. The Australian DTTB Report also found that an additional 4 dB of power was required for DVB-T (COFDM) to achieve the same coverage as ATSC (8-VSB). Considering both spectrum efficiency and power, 8-VSB appears to be a good choice, assuming that advanced equalizers will solve the multipath problem.

ROLE OF ADVANCED ICs IN SOLVING THE DTV TECHNICAL PROBLEMS

Engineers, in solving a technical problem, generally follow a simple rule. Determine what is fundamentally important and place the burden for making the solution work on complex digital signal processing algorithms and advanced integrated circuits. In the case of DTV, the fundamental issues are spectrum efficiency and power. There are two critical pieces of technology necessary to make the system work. They are the RF tuner and the 8-VSB demodulator. Much has been written recently about two new demodulator devices, the NxtWave Communications NXT2000 and the Motorola MCT2100, which are good first steps in addressing the vexing static and dynamic multipath problems. I believe that these problems will be solved quickly.
Because of the high industry visibility surrounding the multipath/demodulation problems, little attention has been paid to the performance of the RF tuner and its role in digital TV. The tuner is the critical device in the system that connects to the antenna and the broadcast world. From all of the channels present, whether digital or analog, it must select one and down-convert it to a standard intermediate frequency (IF) and filter out everything else. ‘Everything else’ consists of other channels and RF interference. The role of the demodulator is to take the standard IF, digitize it, and convert that to a bit stream suitable for an MPEG2/ATSC decoder. The role of the tuner and demodulator in solving the two technical challenges of DTV is presented in the chart below.

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Multipath Problem</th>
<th>Interference Problem</th>
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</thead>
<tbody>
<tr>
<td><strong>Problem/ Source</strong></td>
<td>Transmitted signals arrive at receiver from multiple paths</td>
<td>Strong analog or DTV broadcast in taboo locations causes interference</td>
</tr>
<tr>
<td><strong>Consumer Impact</strong></td>
<td>Creates ghosting in analog; Loss of signal in digital</td>
<td>Creates patterned lines in analog; Loss of signal in digital</td>
</tr>
<tr>
<td><strong>Solution</strong></td>
<td>Better digital demodulators</td>
<td>Higher-performance tuners</td>
</tr>
<tr>
<td><strong>Market Dynamics</strong></td>
<td>First wave of demodulators did not solve the problem</td>
<td>Attempts to turbo-charge existing analog TV tuners fall short</td>
</tr>
<tr>
<td></td>
<td>New players emerging with advanced solutions</td>
<td>Higher performance cable</td>
</tr>
<tr>
<td></td>
<td>Major chip vendors getting into the game</td>
<td>STB tuner not optimized for DTV</td>
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<td></td>
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<td>MicroTuner combines best of cable and TV tuners at low cost</td>
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**Digital Tuner**

The digital tuner will differ from conventional tuners used in analog television sets. It must possess the selectivity to handle a packed spectrum, while not sacrificing performance in other areas. It must address the interference problem, which in the digital era means handling strong image and adjacent channels. Traditional tuners lack this level of performance. The digital tuner must offer improved performance across all parameters, including

- Sensitivity (noise figure),
- Dynamic Range (the ability to receive strong and weak signals)
- Distortion
- Phase Noise (important in distinguishing symbols in digital transmissions)
- Selectivity (such as image and adjacent channel rejection).
This level of performance can be achieved by making more expensive discrete tuner designs or by taking an entirely different approach. At Microtune™, the approach was to leverage the advancing state-of-the-art in integrated circuit design to produce a tuner with the performance necessary for digital television, while not injecting extremely high cost burdens on it. Microtune’s tuner, the MicroTuner™, is the industry’s only single chip broadband tuner and it is based on patented technology and all-silicon design to achieve new levels of performance, quality, and reliability optimized for digital TV.

**CONCLUSION**

The key to making the DTV system work at an affordable price is new and improved technology. The source of this technology is the inexorable advance of integrated circuit technology. It can be expected to bring the cost in-line for the high-end signal processing required to overcome the prickly current technical issues. It always has, and soon, we will be able to enjoy the best digital broadcasting system in the world.

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