Thin air: ATSC reception isn't always easy

Brian Dipert - May 14, 2009

An admitted tightwad when it comes to television content, I'm unmotivated to pay for a cable, satellite, or IPTV (Internet Protocol-television) subscription, and I can ignore—and, for shows I've recorded, skip— commercials. These characteristics explain my long-standing interest in obtaining OTA (over-the-air), “free,” advertising-supported reception at my home. The technology's potential translates to reality only in robust reception environments, however. As anyone who has lived through the analog-to-digital cellular-telephony transition can attest by analogy, the all-or-nothing approach makes the digital version of OTA TV problematic in settings with sketchy signals.

The FCC (Federal Communications Commission) has stated that, in less than a month, all full-power NTSC (National Television System Committee) transmissions will cease in the United States. Many broadcasters have already gone to ATSC (Advanced Television System Committee)-only setups with FCC approval, citing motivations such as the desire to retire archaic analog-broadcast equipment and to avoid costly redundant analog and digital transmissions. Will the remaining stations follow the trendsetters' lead on June 12, or will the FCC further delay the transition, citing unacceptable numbers of consumers still unready to make the changeover to digital? A previous TV-themed article predated by a few weeks the original NTSC shutoff date of Feb 17 (Reference 1). I hope this article doesn't yet again jinx the FCC's plans, and I suspect that AT&T, Qualcomm, Verizon, the White Spaces Coalition, the Wireless Innovation Alliance, and other entities with plans for the freed-up spectrum would agree.

The signal source

I live in the Sierra Nevada Mountains, northwest of Lake Tahoe on a ridge at an elevation of 7000 feet, southwest and about a 30-minute freeway drive away from Reno, NV, and I tune in stations whose broadcasts originate there (Figure 1). The signals I can reliably receive come from two sources: Peavine Peak to the northeast and Slide Mountain to the east (Table 1). I can't see Slide Mountain from my house because its summit is more than 1000 feet lower than—and on the opposite side of—an intervening chain of mountains. Topping this mountain chain is 10,776-foot-high Mount Rose, the second-highest peak in the Lake Tahoe Basin. However, thanks to single- and double-edge diffraction effects, I can usually receive with adequate strength the digital transmissions originating from most of the towers at Slide Mountain—specifically, the equipment operated by CBS (Columbia Broadcast System) affiliate KTVN and NBC (National Broadcasting Co) affiliate KRNV. To get a fuller sense of the geographic challenges involved, visit Google Earth and peruse the vistas from my starting-point location with GPS (global-positioning-system) coordinates 39.372025, -120.249603.
ABC (American Broadcasting Co) affiliate KOLO’s tower is also on Slide Mountain, alongside its competitors, but the signals originating from it don’t arrive at my location with sufficient noise margin. The same KOLO tower originally handled both NTSC transmissions on Channel 8 and ATSC beacons on Channel 9. Although KOLO shut off its analog signal in early January, it hasn’t yet moved the digital signal to Channel 8. The fact that KOLO plans to move at all suggests the root cause of my reception woes. Although station engineers decline to provide specifics, KOLO’s Web-site documentation implies that KOLO designed the antenna and other equipment for Channel 8 and that its operation on Channel 9 is suboptimal. Competitors suggest that the ATSC broadcast “footprint” isn’t currently as omnidirectional as it should be.

Fortunately, this area is rife with “translators,” low-power rebroadcasting equipment to fill in the “blank spots” that terrain issues cause and that are therefore common in mountainous regions. Such gear may also become common elsewhere in the future (see sidebar “A San Francisco Bay Area equivalence”). KOLO, for example, has a translator on Peavine Peak serving the community of Verdi, NV, below and southwest of it. Fortunately, my residence lies in almost a straight line to the southwest beyond Verdi. I can also tune in a Peavine Peak-based translator for PBS (Public Broadcasting Service) affiliate KNPB, whose main tower on Red Peak is receivable only in optimal atmospheric conditions. Fox affiliate KRXI placed its primary tower on Peavine Peak, too, and it therefore provides on average the most robust transmission of any local broadcaster.

**Intermediary attenuators**

Under ordinary circumstances, airborne precipitation doesn’t appreciably degrade the OTA-TV signal traversing from a source tower to a destination antenna. Moisture tends to affect UHF (ultra-high-frequency) transmissions more than it does VHF (very-high-frequency) signals. The circumstances in this location are far from ordinary, however. The winter of 1938, for example, dumped 819 inches, or 68.25 feet, of snow on Donner Summit, just a few miles west and less than 300 feet higher than my home office. And Echo Summit in South Lake Tahoe holds the record for the second-heaviest 24-hour snowfall accumulation in the United States, at 67 inches, or nearly 6 feet, on Jan 4 and 5, 1982. Granted, recent years haven’t delivered such snowfall extremes, but the daily peaks and seasonal averages are still substantial.

Equally important, the snow originating from storms coming off the Pacific Ocean is notoriously known as Sierra Cement for its high water content. Even when the weather is comparatively balmy, cloud caps and snowstorms over the Mount Rose Range suppress signals to the degree that my equipment sometimes can’t reliably receive the transmissions. The precipitation attenuation potential is especially critical when you consider that ATSC broadcasts tend to be substantially lower-power than their NTSC predecessors, even more so for the translator-sourced weak signals that focus on the Verdi, NV, community more than 3000 feet below them. Although intermediary vegetation isn’t a substantial factor in my location, neighbors with moisture-rich aspen and pine trees between them and broadcast towers need to sometimes relocate antennas, vegetation, or both to optimize reception.

If it weren’t for the “bending” capabilities of VHF signals, the formidable hunk of intermediary granite known as the Mount Rose Range would obstruct any broadcasts I might receive from Slide Mountain beyond it. One other potential distortion source, Prosser Hill, has GPS coordinates of 39.375644, −120.225964 and is less than two miles away from my house, and its summit is approximately 100 feet higher than my house.

Prosser Hill straddles the straight-line paths from my residence to both Slide Mountain and Peavine Peak, although it doesn’t directly block the signals from either location’s towers to the house. However, those same signals also travel from the towers to Prosser Hill, where they’re reflectively...
redirected my way, thereby resulting in multiple time-shifted received copies of each transmission. Man-made “mountains,” such as tall buildings, also cause this phenomenon, *multipath distortion*. It can both degrade the incoming signal due to destructive interference and confuse the receiver. Counteracting multipath interference's effects through the use of multiple reception antennas and other techniques is a primary focus of the recently approved mobile-ATSC standard (reference 2 and reference 3).

**Antennas and orientations**

In searching for an antenna that could deliver adequate reception but that was also both diminutive and aesthetically attractive, I came across Antennas Direct at the 2008 NAB (National Association of Broadcasters) conference. The company subsequently sent me a ClearStream 2 unit (Figure 2). Antennas Direct promotes the ClearStream series as “designed and optimized for 2009 frequencies associated with the DTV [digital-television] transition.” With that description in mind, I initially believed that the ClearStream 2 handled 44- to 88-MHz, low-band VHF channels 1 through 6; 174- to 216-MHz, high-band VHF channels 7 through 13; and 470- to 698-MHz UHF channels 14 through 51. In attempting to receive all possible Reno-area transmissions, I “split the difference” between Peavine Peak and Slide Mountain, essentially pointing the antenna directly at Prosser Hill.

This first-pass strategy turned out to be flawed for several reasons. UHF signals are more receptive (pun intended) than their VHF counterparts to precise antenna orientations that point directly at the originating towers, no matter how wide the antenna's primary reception lobe may be (Figure 3). I also hadn't yet driven to Slide Mountain and therefore didn't realize that it wasn't visible from my porch (Reference 4). What I initially thought were the towers of ABC, CBS, and NBC were in reality microwave gear on Relay Peak, which is south of and on the same ridgeline as Mount Rose.

A reader of my blog had also pointed out that ClearStream 2 looked like a UHF antenna and that the published gain and voltage-standing-wave-ratio graphs cut off at 400 MHz, beyond the upper threshold of the VHF band. When I forwarded this feedback to Antennas Direct, Robert Schneider, company president, responded, “The TV engineer is correct that the tapered-loop element is optimized for the core-UHF frequencies and is almost flat in ... directivity and beam pattern between 470 and 700 MHz.” He also confirmed that, although the element has some nominal VHF performance, the graph doesn't show the high-band-VHF data. It was impossible, he said, “to incorporate a VHF element into the design without severe compromises to the UHF performance (electrical coupling and insertion losses).” So, the company's engineers redesigned the PCB (printed-circuit-board) balun to allow the feed line to act as a high-VHF radiator. Schneider claims that this approach provides “modest VHF performance” from 174 to 216 MHz. “We have found [ClearStream 2] to be a significant improvement over traditional UHF/VHF-combination designs,” he says.

For my reception needs, the ClearStream 2's claimed high-band-VHF capabilities were insufficient. So, I reoriented the ClearStream 2 directly at Peavine Peak, and I added an AntennaCraft Y5-7-13 to the hardware mix to handle the VHF broadcasters. Fortunately, the horizontal beam to which I mounted the Y5-7-13 points directly at Slide Mountain, resulting in a cosmetically acceptable end result. Even more fortuitously, the UHF broadcasts all originate from Peavine Peak, and the VHF signals all come from Slide Mountain, so I didn't need to install a rotor for either antenna. A notable downside to my chosen VHF-antenna location once again involves snowfall. Even with clear skies between Slide Mountain and my house, accumulated snow on the antenna notably attenuates the broadcasts. As soon as I sweep off the snow, however, the received-signal strength substantially improves.

**Cabling shortcomings**


The two antennas' outputs merge by means of a passive combiner before entering the house. Jack Antonio, KTVN's chief engineer, and members of his staff brought with them several useful pieces of measurement gear during several visits to my residence. With that equipment, I determined that the house's internal coaxial-cable topology further degrades the signal on a frequency-dependent basis ranging from a few decibels to nearly 10 dB of loss. In initially attempting to receive KOLO's primary transmission from Slide Mountain, I installed a Motorola model 484095-001-00 signal booster at the outside junction between the passive combiner and the exterior wall of the house (Figure 4). However, I was still unable to receive KOLO's broadcasts, and the Motorola device overboosted KRNV's already-strong signal, causing me to also lose reception of it. This regression was upsetting because I wanted to watch the Summer Olympics coverage on NBC, which was due to begin in a few hours, so I hurriedly disconnected the Motorola signal booster.

A few months later, with a better understanding of both the local broadcasters and my reception situation, I tried again. This time, I chose Antennas Direct's CPA-19 booster. Like the company's ClearStream antennas, it focuses its amplification on UHF and high-band-VHF spectra, which was fine because I wanted to improve ATSC reception and didn't care about NTSC reception. Unlike Motorola's unit, however, the CPA-19 didn't overboost signal inputs. According to Schneider, the CPA-19 has only slightly higher gain—17 to 19 dB—than the company's other preamps. That fact is incidental, however, because any gain greater than 10 or 12 dB in a residential application is almost overkill. He says that the goals of the CPA-19 preamp include lower noise of approximately 1.5 to 2.1 dB; higher resistance to overload, given that the signal ratio at the antenna between a high-power nearby station and a distant station can be 500,000-to-1; better filtering and rejection of signals outside the 174- to 216-MHz VHF and 470- to 700-MHz UHF bands, such as cellular, wireless-broadband, and public-safety frequencies; and improved RF shielding. “Often, amplifiers can do more harm than good when they either introduce noise onto the line or ... overload in the presence of a nearby transmitter,” says Schneider. “The CPA-19 amp should have noise levels and overload resistance comparable to commercial-grade amps, but, as with all amplifiers, it's not a magic bullet. It cannot create a signal that doesn't exist at the antenna to begin with, but, [in the] worst case, it shouldn't do any harm.” In contrast to my Motorola experiment, I installed the Antennas Direct CPA-19 inside the house on the other end of the long wiring run that originates above the front door, thereby enabling the unit to also counterbalance the coaxial cable's attenuation effects.

Receiver trade-offs

I have long used and enjoyed a time-shifting ReplayTV PVR (personal video recorder), so the conventional ATSC tuner in my 37-in. LCD TV felt like a substantial step backward. Because I own several Xbox 360 game consoles with built-in Windows Media Center-extender capabilities, I decided to turn a spare Windows Vista Ultimate-based laptop into my high-definition, digital ReplayTV successor (Figure 5). I had a Hewlett-Packard ExpressCard TV Tuner, and the ExpressCard slot in my Dell XPS M1330 notebook PC was empty, so I decided to use the HP device instead of a USB (universal-serial-bus)-based tuner. The driver CD that came with the unit was unreadable, but a Google search revealed the fact that the ExpressCard TV Tuner is an HP-relabeled twin of Hauppauge's HVR-1500, and this company provides downloadable drivers from its Web site. As with many products for consumers who are not technologically savvy, Windows Media Center hides technical details and advanced settings behind a slick, simple user interface. When everything's working as intended, it's an easy-to-use product, but, when glitches arise, finding and fixing them can be frustrating. For example, Windows Media Center, like much other DTV-cognizant software and hardware, reports only the virtual channel, not the physical channel it's tuning in. And, unlike some other TV-oriented software packages, Windows Media Center doesn't scan the VHF and...
UHF spectra for valid broadcast signals; instead, it relies on program-guide data that it downloads in response to a user's entered ZIP code. Thus, it was only by accident that I stumbled across the fact that Windows XP and Vista's Media Center database incorrectly reports that KOLO's primary ATSC transmission is on Channel 23. It's actually on Channel 9 and will be on Channel 8 in the near future. Because this primary beacon is currently too weak for my needs anyway, the impact of this error has no effect on me, but it would prevent anyone in the Reno, NV, broadcast region from receiving KOLO's signal.

Windows Vista's Media Center application unfortunately also doesn't comprehend that, based on a user's ZIP code, a local translator signal on a different channel might be more appropriate for reception than the station's primary transmission. And overriding the default program-guide-supplied physical-channel information is neither well-documented nor easy to accomplish. Ben Reed, a Microsoft spokesman, explains the discrepancy by noting that, until Windows Vista OEM-only TV Pack update (whose functions will become more broadly available with upcoming Windows 7), the company relied on FCC-sourced data to derive physical-channel information. A search of the FCC archives reveals that KOLO's original ATSC assignment was Channel 23, although the relocation to Channel 9 occurred many years ago. Reed also promises that Windows 7 will add a substantial number of additional ZIP-code-derived database entries that will, for example, better comprehend the presence of nearby translator beacons and that users will be able to more easily override suggested physical-channel assignments.

To evaluate the feasibility of netbooks as portable DTVs, I mated Pinnacle's USB-based PCTV (personal-computer-television) HD (high-definition) mini stick with my Micro-Star International Wind U100 (Reference 5). Because MSI based this netbook on conventional Windows XP, which doesn't include Media Center functions, I also installed Pinnacle's corresponding TVCenter Pro application suite. TVCenter Pro not only scans broadcast spectra so that you needn't rely on program-guide data, but also reports the physical channels it detects as either VHF or UHF values; online resources can easily translate these physical channels' frequencies into channel numbers. For example, TVCenter Pro let me determine the physical channels the translators on Peavine Peak use, whereas KNPB's Web site doesn't even document its translator. TVCenter Pro also provides more robust signal strength and quality feedback than the data from either Windows Media Center or my LCD TV's ATSC-tuner user interface.

I attempted to use the PCTV HD mini stick with the Dell XPS M1330, but this approach ultimately proved unacceptable. On the upside, the unit's built-in signal-booster feature noticeably enhanced the probability of receiving moderate- to marginal-strength incoming transmissions. After I put aside the PCTV HD mini stick and returned to the HP ExpressCard TV Tuner, I decided to experiment with Antennas Direct's CPA-19. Unfortunately, the PCTV HD mini stick injected random video artifacts into recorded shows—artifacts that I hadn't observed with the HP ExpressCard-based alternative. At first, I thought I was seeing degraded reception. After lots of experimentation across multiple stations and at various device settings and after noting that the artifacts were macroblock-based versus frame-wide, however, I concluded that the problem occurred after the ATSC signal reached the tuner.

The problem might have arisen from the hardware or a software driver, but I suspect that it came from occasional and inevitable USB contention and insufficient buffering to counteract the contention. Is Dell or Hauppauge, which recently took over Pinnacle's TV-tuner product, responsible for the fix, or do both companies need to make accommodations? Stay tuned to Brian's Brain blog to find out.

References
A San Francisco Bay area equivalence

The problems I confronted and surmounted while researching this article aren't unique to rural mountainous environs. Exemplifying that reality, the AntennaWeb Web site asks would-be users whether there are any buildings, steeples, towers, or other structures taller than four stories within four blocks of their location; airports within two miles of their location; or nearby trees taller than 30 feet. Natural and man-made structures in urban settings can also distort OTA (over-the-air) television transmissions by creating both direct-blocking attenuation and reflective-multipath-interference effects.

Take, for example, the San Francisco Bay area. Longtime EDN readers Lou Dorren and Noland Lewis recently completed an in-depth study of DTV (digital-television) reception in that area. You can find download links to both portions of their report at a post on EDN Technical Editor Paul Rako's Anablog. I question Dorren's repeated assertion that he and his partner have no ax to grind with respect to ATSC (Advanced Television Systems Committee) technology. I think, for example, that the two authors paint an overoptimistic picture of the viewer acceptability of the “snowy-picture, good-sound” yellow regions of the Santa Cruz Mountains and East Bay Hills in their analog-TV-reception plots (Figure A).

Nonetheless, the “RF-shadow” attenuation of signals originating on Mount Sutro by Mount San Bruno and vice versa is evident in the results. The “cliff effect” that transforms marginally acceptable analog transmissions into nonexistent digital presentations is also obvious. Mount San Bruno is particularly problematic because it is higher and wider than Mount Sutro and has a larger population residing behind it. I wonder whether Bay area broadcasters will end up installing translators to supplement the primary transmitters on Sutro Tower. Monument Peak in the South Bay near Fremont, CA, which already contains several stations' primary towers, would be a logical location for such translators if their power output were sufficient to reach all areas that Mount San Bruno's RF shadow affects.