

Indoor Noise Conditions in the FM Broadcast Band

Steve Johnston
Director of Engineering and Operations
Wisconsin Public Radio

Abstract

The impact of indoor noise on AM broadcast reception is well known, but less so for FM thanks to the receivers' ability to hide the noise. My hypothesis was that the growing levels of indoor noise from modern electronics may be masking weaker FM signals – and probably digital HD Radio and HDTV as well. I also suspected this noise increase creates the impression that HD Radio and HDTV have difficulty with "building penetration" and subsequently led to the effort to increase digital power.

To get a sense of the noise present in the FM band in a variety of indoor situations, and see if it might explain the trouble these listeners were having with digital reception, I made measurements with a portable spectrum analyzer and antenna. I studied several urban apartments, suburban houses, and urban offices. All were found to have higher noise levels inside than outdoors on the same property. I also pinpointed some common sources of this noise.

Introduction

Radio hobbyists - ham radio operators, short-wave listeners, broadcast DXers, and other enthusiasts - are usually quite aware of the growing radio noise issues in our modern world. Less-technical listeners seem unaware of the increasing "noise pollution" problem, however.

AM broadcast listeners may be more conscious of the impact of noise on reception, thanks to the audible buzzes, growls, or pops. On the other hand, the FM receiver's ability to hide the noise has resulted in reduced awareness of the problem. Even if not directly heard, noise can mask weaker FM - and probably digital HD as well - it just isn't as apparent to the listeners why the signal is "weak".

Observations

I suspect that all broadcast engineers have heard reception complaints. Such complaints are completely normal, but I've noticed a new trend: long-time listeners describing deteriorating reception: "I used to get good reception here, but not anymore..."

In the past five years, WPR Audience Services "Listener Logs" show a 37% increase in email and telephone complaints related to reception.

At the same time, FM's new digital HD Radio indoor reception is simply not as good as predicted – both at WPR **and** industry-wide. Could these phenomena be related?

Hypothesis

Growing levels of indoor noise may be masking fringe FM analog signals. Likewise, the growing noise may be impacting digital HD Radio (and HDTV?) as well. Such noise troubles might be mistaken for a “building penetration” issue.

Measurements

I recently made an informal study of some Wisconsin Public Radio listener and staff homes using a battery powered spectrum analyzer (a radio receiver with visual display of strength versus frequency) and a loop of stiff wire about one-quarter wavelength in circumference on a short length of coaxial cable as a pickup antenna. My goal was to get a better sense of the noise encountered in the 88-108 MHz range in a variety of indoor situations and see if it might explain the reception troubles.

It is important to note that I did not try to put numbers on the signal strength of the noise, but rather made a comparison of outdoor to indoor reception at the same location.

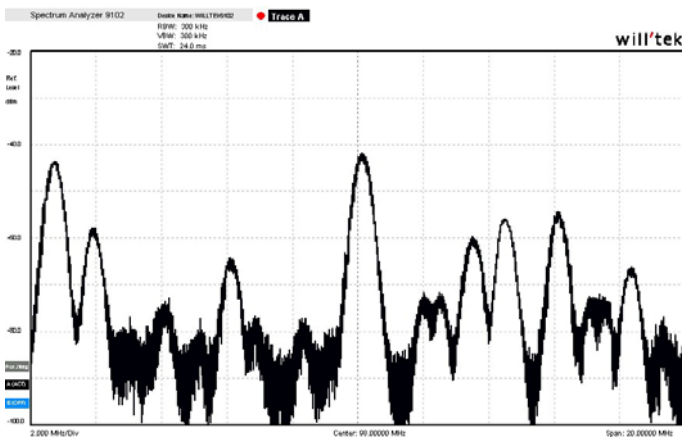
I visited several examples each of three types of locations: urban apartments, suburban houses, and urban offices. In each location I inspected the signal-to-noise conditions (as shown on the spectrum analyzer) first just outside the premises, then I stepped inside and captured the same conditions indoors.

Test Results

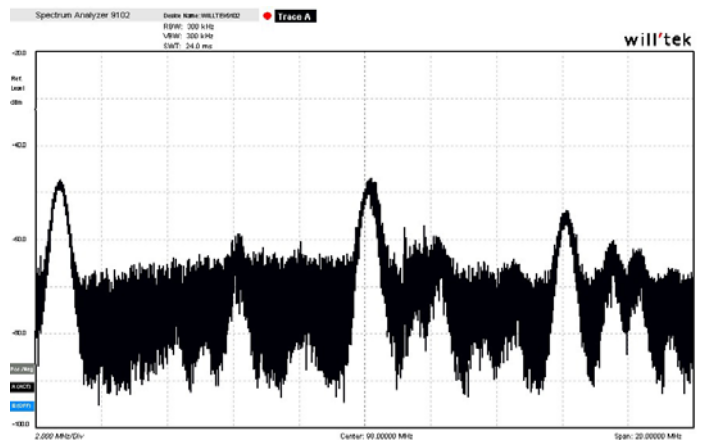
Suburban homes had much more noise in the FM broadcast band indoors than outside in the driveway – see figures below. Note that my spectrum analyzer configuration was optimized to show conditions across the whole band in a very broad manner and would not be appropriate settings to measure an individual signal.

The strongest noise sources I found inside the home were recently-manufactured “wall-wart” switch-mode power supplies used for charging batteries in cellphones and digital cameras. Some made a broad “hash” while others produced a series of noise peaks on discrete frequencies through the band, probably related to the switching frequency. Some HDTV sets and DVD players were also very noisy in the FM band, maybe from their power supplies as well but with their internal supplies it was impossible to be certain. Some personal computers and digital clocks and telephones were quite noisy in the FM band too.

An example of the suburban homes I tested – this one in Fitchburg, Wisconsin:



Outside a suburban house

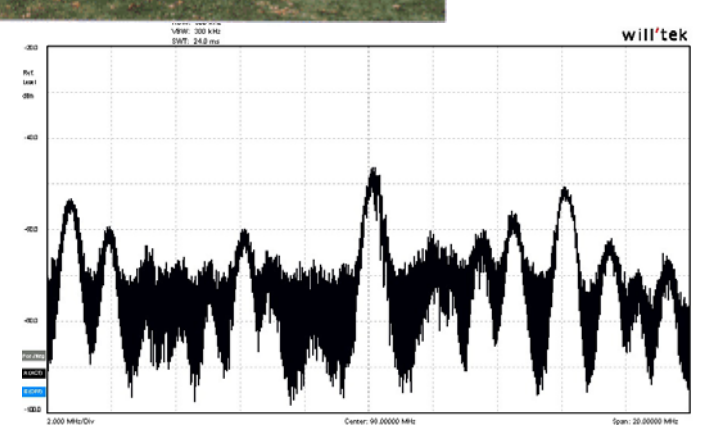
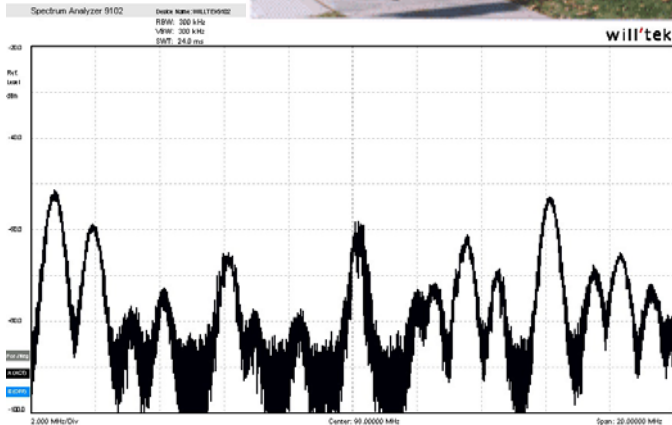


Inside a suburban house

The urban apartments I checked were also awash in noise, much higher than the background level in the parking lot outside. Fewer square feet of space meant the noise

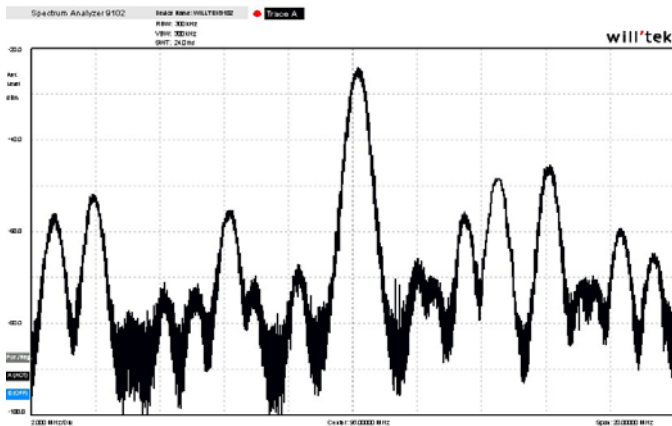
sources were more “concentrated” than in the single-family home. I encountered a similar array of noise sources, though, and a similar increase in the overall noise from outside in the driveway to indoors.

An example of an urban apartment building I tested – this one in Madison, Wisconsin:

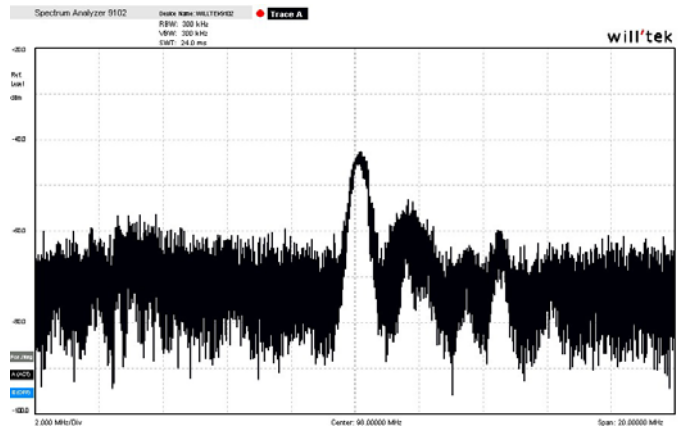


Several urban office structures on our University of Wisconsin campus in Madison were checked as well. They all suffered a bad combination of significant attenuation of the desired FM signals and high noise levels indoors. I found it harder to find specific causes of the noise in this environment. Some computers were noisy, as were many of the telephones. Printers with their switching-mode power supplies were cranking out the noise as well. But some of the noise in the office areas was harder to pin-point – I’m thinking there are more sources in this environment, on various floors and rooms, with more reflection and multipath propagation on the noise signals from the metallic structures, all of which tends to “blur” the source.

An example of an urban office building I tested – this one in Madison, Wisconsin:



Outside an Urban Office Building



Inside an Urban Office Building

Typical Noise Sources

Using the loop antenna as a probe, I swept many rooms in the test buildings. Switching power supplies, consumer electronics, and office equipment like computers, printers, and monitors were among the worst culprits. Noise was pouring out of some of these devices at alarming levels. It seems impossible that they every met existing specifications for radiated or conducted RF noise.

One cellphone battery charger was so noisy that when it was unplugged I could see a change in the noise outside the building!

Conclusion

All locations visited showed a dramatically higher noise level indoors. Putting numbers on this noise is difficult, as moving the antenna around even a bit greatly varies the absolute strength of the noise. Stepping back and thinking of my overall experience, across the whole band, in all the locations, it would be fair to say I saw as much as a 20 - 30 dB increase in overall noise going from outside to indoors. But even without hard numbers it is very clear that the modern indoor environment is much noisier in the 88-108 MHz range than nearby outdoor locations.

In the situations in which I was assisting a listener with a reception problem, I was able to find places to put the listener's radio and antenna to get better radio reception. In most cases the listener had installed his or her radio on a shelf or table quite close to other electronics, some of which were spewing out noise. I moved the radio out from among the noise sources and reception was naturally better. But of course we cannot expect all the listeners to have a broadcast engineer with test equipment come to their home and help position their radio for best reception.

Why the increasing noise problem indoors? My research seems to show that electronic devices are being manufactured without adequate concern for their incidental RF radiation. I contacted five engineers working in the field of switch-mode power supplies. Four of the five indicated that radio frequency interference was not a major priority for their companies – especially if improved RFI performance would result in **any** increase in manufacturing cost. The fifth engineer said his work was on devices for the medical electronics market, and RFI specifications had some importance for his company.

One of these engineers also said that further cost cutting may occur when products are contract-manufactured at a distant factory. For example, shipments of a battery charger built in China were found to be lacking the specified metallic shielding paint applied to the inside of the plastic cabinets.

I also heard from several engineers who said the third-party switching power supplies that had been specified and tested for their products were later replaced by less expensive products that had not been tested for RFI compliance. The replacement power supplies had the correct mechanical form-factor, and made the right voltages at the right currents, but were probably not as RF-quiet.

The fact that these manufacturing abuses can happen indicates to me that the regulatory agencies involved may have lost control of the situation.

As interference from these incidental noise emitters increases, all radio and “wireless” systems are at risk. We can expect our signal coverage to decrease and user complaints to rise. And new technologies, such as HD Radio and HDTV, may not perform as predicted due to the increasing noise levels.

In the face of intense competition for attention of listeners, broadcasters cannot afford to ignore this problem. Today's listeners and viewers have little patience with reception problems, and faced with any difficulty will go to other media for their news and entertainment.

In the short term, education about the noise pollution problem is helpful. Listeners can often reposition their radio and antennas, and/or disconnect offending noise sources, to get better reception. Radios tend to be placed on a shelf or table quite close to other electronics spewing out noise. Moving the radio out from among the noise sources and reception will naturally be helpful. But this is an example of "treating the symptom" rather than getting to the bottom of this problem. For the long-term health of broadcasting, better control of radio noise at the manufacturing end is necessary.

Brief Biography of Author

Steve started taking apart radios as a youngster and became a ham radio operator at age 13. A builder, repairer and restorer of electronic gear nearly all his life, Steve's been in broadcasting since 1981.

His professional career started at age 19 with Susquehanna Radio in Akron, Ohio. He became Chief Engineer in 1983 and stayed in Engineering Management with Susquehanna in Florida, Virginia and Pennsylvania.

In 2000, Steve shifted to Public Radio when he became Director of Engineering and Operations for Boise State Radio, a 20-station group in Idaho.

In 2005 he moved to Wisconsin Public Radio as Director of Engineering & Operations. WPR is a 30-station public radio group in Wisconsin.

Steve has a BA in History and, when not spending time with radio, is a writer and historian. He and his wife have two teenage children.

Company Description

Wisconsin Public Radio is a three-network, 3-station public radio group in the upper Midwest of the United States. It is one of the largest such groups, with complex interconnection systems serving AM and FM stations around the region. 13 of the 30 stations have been upgraded to include HD Radio multicast service. WPR has always taken a leading role in broadcast engineering since the founding of the flagship station, WHA, in 1917.