EDUCATION UPDATE

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AM Can Sound Good

While some may say AM really doesn't matter today, I beg to differ. AM still attracts large rating shares in many markets and it's very important in rural markets. It is my opinion that AM remains viable and important. It is often neglected technically. Listener disgruntlement with the on-air product becomes a self-feeding engine of decline. It does not need to be. Many are leaving considerable coverage and audio performance on the table through neglect. Comparably, FM is generally easier to "get right" than AM is.

Why are bandwidth and symmetry of sidebands important? AM is fundamentally a double-sideband, full-carrier system. If the sidebands are symmetric, one tenet of quality has been met. If one sideband is attenuated or removed by means of incidental phase modulation or by phasing and/or matching networks, distortion will occur in most receivers. Without going deep into the math, looking at phasor diagrams or understanding undesirable quadrature terms, suffice it to say that the end result of most sideband asymmetry is undesirable distortion. Fact: If you remove one linear sideband from an AM transmission, the resultant envelope distortion for a single, 100% modulated tone is 33% and, for a two-tone signal, you can add up to 50% intermodulation distortion! I learned decades ago working with Ampliphase and Doherty transmitters, as well as poorly neutralized plate modulated transmitters, that sideband asymmetry caused by incidental phase modulation can make the radiated signal sound very bad!

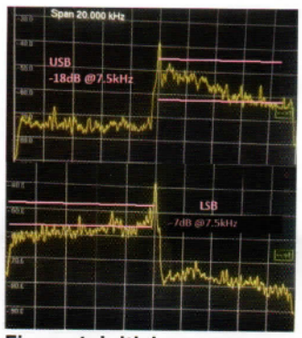

Figure 1. Initial spectrum tilt; lower sideband vs upper sideband

We used to run proof of performance measurements, and it often became difficult to keep envelope distortion below 5% at higher frequencies. The envelope would not be sinusoidal; rather, it would have a skewed trough of modulation that presented itself as distortion to the listener. Worse, the large amounts of IM distortion also produced fold into the lower audio spectrum and pass through the receiver untouched while the higher frequency terms are attenuated by filters in the radio. It still occurs today and the problem is made much worse because of the poor audio response characteristics of many of today's radios!

Enter the example of WION in Ionia, MI: It's a non-directional at 4.7kW daytime and 330W directional using a three-tower array at night. During the day, the station has crisp, clean audio and a good on-air presence, but during night operation, remnants of IM could be heard in the signal. Upon investigation, it was found that the phasor consisted of a resonant power divider (often referred to as a jeep coil). The power divider was tuned to present a near 50 ohm real component at 1430kHz with some residual reactance. A tee network was used to fine tune the common point to 50+j0 at the transmitter output. While the transmitter was matched at carrier, the network was not actually tuned to resonance. It was simply adjusted to present a usable load at the carrier frequency through the rest of the network. This is not uncommon.

The first thing we undertook was to modulate the transmitter to 90% at 5kHz and above. We found considerable distortion and skewing present in the envelope. The transmitter then fed bandlimited, 10kHz white noise. Spectral images indicated more than 11dB of sideband tilt at 1437kHz! Next, we swept the common point using the conventional method: OIB and RF generator. The resulting sideband impedances confirmed our spectrum observations. The resonating capacitor had been tuned to obtain a carrier match with no consideration of sideband impedances. The power divider was not actually resonant; resonance occurred well below carrier frequency. This left us with two choices: (1) Rebuild the entire network at considerable expense and time required plus the great possibility of requiring at least a partial proof afterwards, or (2) get creative.

Removing the resonating capacitor across the power divider, I found the impedance dropped to 11.2=J8.5 Ohms. Using a single tee network to transform that impedance would result in considerable bandwidth limiting: It may be symmetric but it will likely be narrow as well leading to the possibility of detuning during certain weather conditions and other issues; something WION had already observed. I considered more complex networks but I decided to resolve it with a simple autotransformer. Some were skeptical.

Linear transmission lines and transformers are inherently wideband. A section could be used to match the power divider to the transmitter, but this was not practical. I settled on a 4:1 UnUn approach: An unbalanced 4:1 toroid to transform the low impedance presented by the untuned power divider to a resistance close to 50 ohms with some minor reactance present. The toroid we developed was overkill: I used three large 2.4" cores stacked. I chose to use #77 ferrite. Broadband transformers from 500kHz to well over 10MHz may be made with this material. There exists a commercially available balun for use up to 5kW at 1 to 30MHz, but don't use it. It contains #43 core ferrite and will get quite hot. We tested it to confirm its performance and, at 330W carrier and 1500W peak envelope power with modulation present, it soon reached the Curie point temperature from core loss heating and all magnetic properties were lost. Thankfully, the transmitter protected itself. The

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Education Almanac

Webinars by SBE

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Aug. 17: HD Radio Monitoring: What Has Been Done and What Can Be Done With Modern Monitoring Equipment
Aug. 31: Basic RF for IT Module 3
Sept. 21: Basic RF for IT Module 4

SBE Ennes Workshops

ENNES WORKSHOP

Aug. 21: Nashville, TN
Sept. 16: Jekyll Island, GA
Oct. 23: Kansas City
Oct. TBD: New York City

Contact the SBE to arrange an SBE Ennes Workshop in your area.
sbe.org/ennes_workshop

Member Spotlight: Greg Schmitke

Member Stats
SBE Member Since: January 2014
SBE Certifications: CBRE, CBT
Employer: Northwestern Media - KFNW/KLBF, owned and operated by the University of Northwestern - St. Paul
Position: Chief Engineer
Location: Fargo, ND
Chapter: 17 Central Minnesota
I'm Best Known For: Being a listener for someone who may just need a sounding board or encouragement or a word of advice.

Q. *What do you enjoy or value most about your SBE involvement?*

A. The SBE stands with us, supports us, and offers education to not only keep us up-to-date with engineering and the high standards we're expected to maintain, but to also help us prepare for the future and the new technology.

Q. *What got you started in broadcast engineering?*

A. As a kid I'd pretend to be an announcer. I'd introduce records, or I'd do play-by-play of a game and record it all on my cassette recorder. I attended Brown Institute in 1986 for radio and TV broadcasting and realized a boyhood dream when I started working for WTCN in Stillwater, MN.

Greg and his wife on his motorcyle.

Q. *Who was your mentor or who in the industry do you admire?*

A. An incredible engineer, a great brother, a natural teacher, and from my hometown: Gary Ellingson. He was chief engineer of KFNW when I started here. Gary helped me join the SBE and was my mentor and teacher as I studied for my CBRE exam.

Q. *What do you like most about your job?*

A. I really enjoy the hands-on of engineering, sometimes you're into a transmitter up to your shoulders or more. Two years ago, we moved our entire AM array to a new site. It was a lot of work, and a lot of fun too!

Q. *When I'm not working I...*

A. ...I really enjoy fishing, flying, and riding motorcycles. Living so close to MN Lakes Country is great for fishing, and there's beautiful scenery for riding. Over the last 30 years my wife and I have been very involved with The Christian Motorcyclists Association. I have my private pilot's license, but haven't had the opportunity to fly in quite a while.

Q. *What's something people don't know about you?*

A. I've visited Hawaii over a dozen times. The laid-back lifestyle is appealing, and of course the incredible weather and tropical scenery doesn't hurt either.

Q. *What's your favorite gadget?*

A. My motorcycles. Riding with the Christian Motorcyclists Association allows us to minister to other bikers and meet them with the love and message of Jesus at the point of their need.

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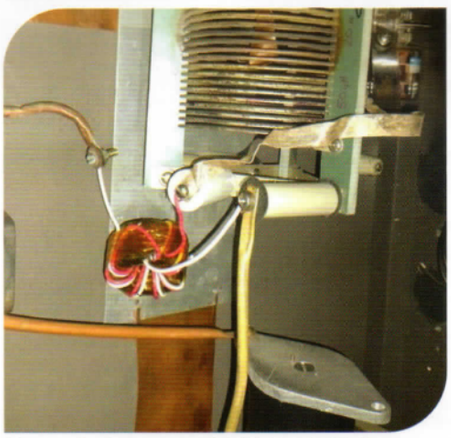

Figure 2. Prototype 1:4 UnUn 2.4" diameter type 77 ferrite core

three-stack, Type 77 material runs very cool.

Figure 1 shows the sideband tilt we observed, Figure 2 shows the prototype toroid utilized for testing purposes, and Figure 3 shows the (no longer) resonant power divider. I have since replaced the toroid with an encased version and cleaned up the installation.

From a quantitative standpoint, an initial 17% 1:1 IM at 7/8kHz and 12.5% 4:1 IM at 60Hz/7kHz dropped to 1.4% and 1.3% respectively (80% modulation). Harmonic distortion dropped from 8% at 7.5kHz/80% modulation to 1.2%. Furthermore, the broad match obtained removed nearly all sensitivity to weather and icing this past winter. From a qualitative standpoint, the station sounds much cleaner and intelligibility at night has increased substantially. Denser processing is now utilized, with no degradation in day vs night audio quality yielding significant coverage increases. Because the power divider taps to each tower were unchanged, the ratio of power, and phase, was also unchanged. Superposition held. The antenna monitor indicated no change in readings and monitor points confirmed no change in field strength values. This was a huge Win-Win; technically and operationally.

This approach can work for many applications at the 1kW and below power levels using readily available materials, and I now have special order toroids obtained to do a similar modification at the 5kW level. One must carefully engineer the matching, though. Each situation presents different constraints and one must carefully choose where lumped elements are also utilized to achieve the final match while presenting low reactive terminations to the toroid. Since WION still uses a stereo exciter, we have other tools to further improve sideband matching, but I'll save that for a future article.

AM can sound good. Improving performance, gaining better sound quality and often increasing coverage as a result do not always incur large expenditures. It's time we look at AM again.

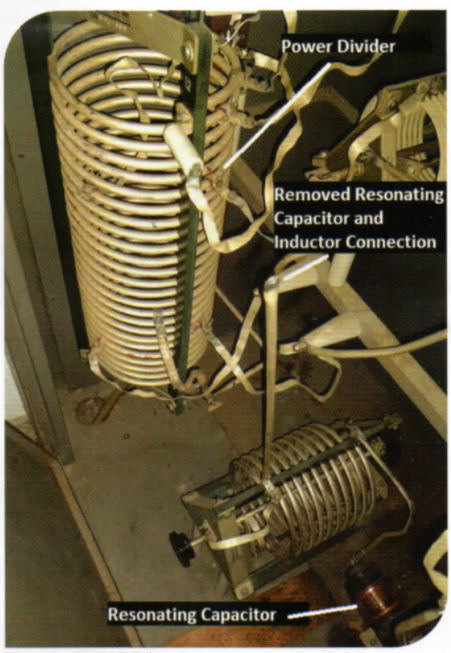

Figure 3. WION phasor power divider; resonating network removed