Steve's Scanner Shop

Understanding Speech Inversion

By Steve Donnell

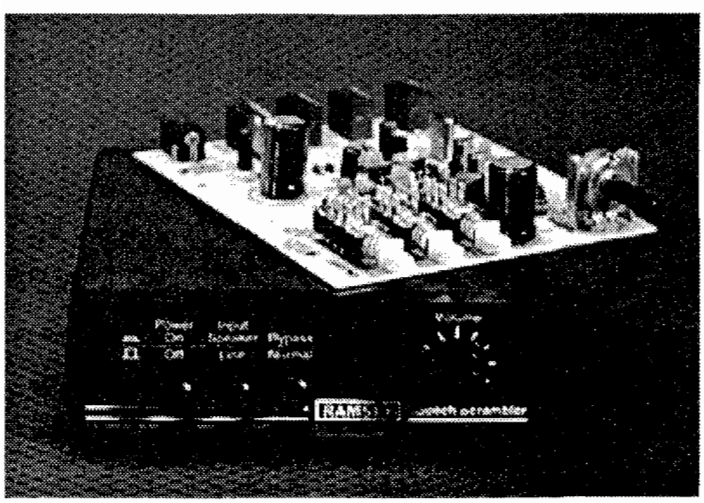
Way back in the days prior to DVP and digital-narrowband encoding one of the first(if not THE first) forms of speech scrambling was a technique known as "speech inversion". This provided a way for Police and some Business radio users to obtain some degree of privacy in their radio communications. As radio technology enters an increasingly digital-era, it is interesting to see that speech inversion remains a common means of achieving, albeit lo-level, security on different types of radios. If you've tuned across various parts of the VHF/UHF spectrum, you may well have already heard speech inversion scrambling being used. Inverted speech is transmitted using the same type of radios that carry "normal" speech. The phrase used by many people to describe what inverted speech is that is sounds like "Donald Duck talk". Another way of putting it is that it sounds like a mis-tuned Single Sideband radio signal.

In order to understand the process of how speech inversion works, you must first realize that human speech consists of a wide range of possible audio tones. Each spoken syllable consists of a wide band of sound energy. As seen used in two-way radio, the frequency range(band width) is intentionally limited to between 300-3,000 Hz. this is done in order to limit the band width(channel size) needed. Other radio services such as FM and TV broadcasts are permitted a wider bandwidth so as to accommodate the more complex sounds of musical instruments.

When speech is inverted, it is mixed with an audio tone called a "pilot carrier". The is an audio tone in the 2,800 - 3,600 Hz range. Typically either 3,300 or 3,500 Hz. If you recall what happens when two AC signals(radio or audio) are mixed together; They add and subtract with respect to their original frequencies, resulting in (product)signals on entirely new frequencies. Voice audio energy that was originally at say, 2,800 Hz is now shifted down to 500 Hz, and voice audio the stated out at 500 Hz becomes 2,800 Hz. If you look a this process in the form of a spectral graph of the audio voice band, you would effectively see the spectral arrangement of original audio signal to become flipped around or "inverted", hence the name: Speech inversion.

The use of different pilot carrier frequencies effectively creates a primitive form of access "key code"; Speech inverted using one pilot frequency, can't be decoded by anyone that has the same type of inversion scrambler, unless their equipment is also set to use the same pilot carrier as well. This can be a handy way to provide (voice)privacy between several different user groups on a shared UHF Business repeater or on a local Police frequency where you might want to have different scrambling codes(tones), where one is for Detectives and one for sensitive Dispatch matters.

Early designs of speech inversion scrambling equipment usually consisted of rather bulky add-on pieces, often these were not all that stable or reliable, particularly in harsh mobile usage conditions. Even very small shifts in the frequency of the pilot tone would cause the decoded audio to sound distorted. However in past several years, advances in integrated circuit technology, particularly in the area of what is called 'mixed signal' where analog(audio) and digital signals can be handled on one IC, has lead to the development of specialized ICs that permit speech inversion based scramblers to be produced on tiny modules not any larger than a book of matches, making them possible to install in even the smallest of the newest portable radios. Additional design improvements include the use of quartz crystal as pilot tone frequency references and the use of digital audio filtering techniques.



In reality, inversion scrambling offers very little in the way of "real" voice security, primarily because of how easy the format is to break. Many years back, a friend of mine discovered the he could acceptably decode inverted audio used on the local Police channel by simply injecting the correct audio tone from a signal generator, to serve as a the pilot carrier, into a scanner directly at the volume control. Despite the technical limitations, besides some of the technical improvements that we mentioned along with decreases in costs which enable speech inverter modules to be priced in the area of $100.00 a piece, has continued to keep speech inversion scrambling alive and well.

One additional factor that may play a part in promoting the growth of inversion scrambling in recent years is that if you recall, any encrypted form of radio communications to be included as one of the specific categories of the original ECPA(Electronic Communications Privacy Act). In theory at least, this gives some degree of extra protection to any type of scrambled transmissions, even those done using a low-level technique such as speech inversion. Speech inversion can at least serve to limit "casual" monitoring of communications that are encoded using this technique. This is why inversion scrambling capability as a designed-in feature has shown up in a variety of products such as cordless phones along with some Marine band and even FRS radios.

Some of the same technological advances that helped fuel the growth of "simple" speech inversion has also lead to the development of much more advanced variants of speech scrambling: One example of this is a technique called "split band". This works the same way as regular inversion scrambling, except that the original audio signal is broken down into two separate bands. Each using different pilot tone frequencies. Although we can't

verify this, it is reported that this type of scrambling can be effectively broken, using some of the same equipment that will work on "single band" inversion scrambling. An even more sophisticated form of inversion scrambling is called "rolling code". This technique has a continuously changing pilot tone that changes in a seudo-random pattern. It can be recognized by hearing a chirp or click every couple of seconds. This is a synchronizing pulse that ensures the receiving radio(s) stay in step with the signal being transmitted. Rolling code is most often employed by high-end Business radio users or Police that realize the security limitations of "simple" inversion scrambling. While rolling code scramblers cost about $400 - 500.00 a piece, this is much less than the $thousands that top of the line digital scrambling equipment can cost.

Although most speech inversion descramblers specifically intended for use with scanners have largely disappeared from the market due to legal concerns. These decoders can sometimes be spotted at Ham fleamarkets; Be on the look out for any small boxes that bear the name "Capri" or "Don Nobles"(DNE). Currently one rather sophisticated unit that is available for the experimenter/builder is a (scrambler/)descrambler kit from Ramsey Electronics. The Ramsey SS-70A scrambler/descrambler is a high performance circuit. One possible drawback is that it's pilot tone is fixed at 3,300 Hz. Check out their Web page at www.ramseykits.com . You can also check over some of the tiny scrambler/descramlber modules from MX-Com at their Web site:www.mxcom.com . One company that still has inversion descramblers available is CTP. Their DS49 uses a design similar to the old Cpari/Don Noble units. While these are not the most advanced in design, they can reportedly descramble the so-called "split band" form of inversion scrambling. The DS49 is small enough to install inside many types of scanners and they also have one that operates from a 9 volt battery and has a case which includes a belt clip, making it compatible for portable operations. Check out CTP's Web Page at: http://members.aol.com/ctpds49/index.html .