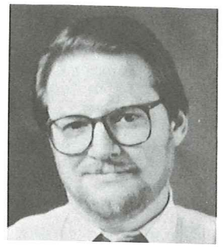

FDMA-TDMA-CDMA-HEDY HERE'S ANOTHER 4-LETTER WORD

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I bet you didn't know that for the last 30 or 40 years you have been using something called FDMA. The standard All-American way of operating radio systems has been by taking the entire spectrum from DC through light and dividing it into pieces. The acronym then translates into Frequency Division Multiple Access. This was a simple and straight forward plan and has worked ever since the 1934 Communications Act.

Now we have so many new technologies hitting us so quickly, we are having to learn some new acronyms. Most everyone is aware of the Fleet Call announcement and their plans to do massive digital things to the trunking industry. There, we got exposure, for the first time, to a new acronym. That is TDMA (Time Division Multiple Access). TDMA is not really new. This has been used for quite some time in the telephone industry to smash more conversations into their wires.

Now to make things worse (just when you thought the airwaves were safe) Qualcomm and others are pressing for a CDMA standard to be used in two-way technology. CDMA is Code Division Multiple Access.

This jungle of acronyms can really bog you down if you let it. However I would like to take a few columns and try to explain each of these and how they could impact the SMR industry. This will not be a highly technical undertaking. The goal is to simplify these terms to their lowest denominators. If you would like a technical overview of CDMA, and particularly TDMA, I would suggest that you pick up the February 1990 issue of *Communications Magazine* and read an article written by Fred Baumgartner on the subject. I would also suggest ordering a tape or two from our last ASNA Technical Symposium in San Antonio. We had two sessions in which the speakers dealt with TDMA and CDMA as it will relate to the SMR industry.

Now into the classroom and here we go . . .

FDMA

When radio had its beginnings, it used the entire spectrum to communicate. The first Morse code ever sent was done with a spark gap transmitter. Crude and difficult to call it a transmitter, nonetheless it transmitted a raspy signal over a broad range of frequencies and a short distance. These kinds of thing still exist today. If you have ever driven your car near a neon sign that may be faulty, you may have heard a buzzing sound on your car radio. This is generally caused by a spark somewhere. This spark transmits its signal over the lower end of the radio spectrum. Scientists got smart and were able to tune these spark transmitters to a specific range of frequencies. And then finally, of course, we developed into transmitting with a particular frequency as its target center frequency. From then on, the entire spectrum was split up in a orderly (some would argue against that) fashion where every user or group of users could operate on a unique frequency.

There is a parallel world to ours in the telephone industry. Telephone realized that all of the single pairs of wires floating all over carrying one conversation could actually handle a little bit more than one conversation per wire. They put more than one conversation on one wire by putting a carrier on that wire (similar to the carrier frequencies we know today).

TDMA

Then the telephone world realized that there were some problems with putting carrier frequencies on copper wires that were strung all over. These carrier frequencies began to interfere with other conversations that were being carried on other copper wires. Investigation into TDMA began.

A real simple way of understanding this is to picture a pump pumping fluid. This pump has one output but it has many pipes coming into it. For the sake of argument, lets say it has four fluid lines coming into this pump. Each fluid line has a different color fluid in it. Our goal is to pump each of these fluids through the pump, into a pipe line and at the other end of the pipe line, take these fluids and separate them back out again. I have no idea why anyone would want to do this, but it applies as an example!

If we let all four of our input lines into this pump at the same time, we would end up with mud color fluid going down the pipe. However if we opened up a valve to the yellow and then closed it and then opened up a valve to the blue and closed it and then opened up a valve to the green and then closed it and then opened to the red and then closed and then went back to the yellow fluid, this fluid would travel down the pipe in its own unique sections. If then at the other end we had a "smart" device that could sense the color of each group of fluid coming down the pipe and it could switch a valve to make sure the fluid got out to the proper buckets, we would have a pretty efficient system for equally transporting these four colors of fluid.

This method of opening up valves on the input and closing them and then opening up valves on the output and closing them, is what we call "clocking" in the TDMA world. The one pipe line going from the pump to the buckets is similar to our frequency on which we are operating. Four separate conversations can be clocked onto the one frequency and when they are received they can be decoded into their individual buckets and distinguished.

It is not a real simple thing to do all of this. First we have to take the voice which is analog, and we have to digitize it into ones and zeros. We must realize when we talk about this, that the brain is an analog device. If we try to feed 1's and 0's into the brain it would sit there and do nothing except say "huh?". So, to accomplish this, we have to split it back out at the receiver into the buckets, turn it back into analog so it can come out of a speaker to be heard by the end user. This is done by what we call A to D and D to A converters. (Not too novel but that is what it is called.)

With current technology, our industry is talking about putting three conversations on a single RF channel. I have been told that Motorola has shown six conversations on one RF channel-type TDMA system. In the telephone world they can achieve ratios much higher than this because they are dealing with a fixed hard wire medium over which they are transporting the conversations. Remember in the RF world we add complexity by the fact that the mobile is moving and there is interference. This can play with the timing of our clock and there are compensations that need to be added to take care of this.

TDMA is a tried and tested mode of conversation transportation and that is one of the reasons that it is well accepted as a coming standard in our industry.

CDMA - HEDY LAMARR ?

Code Division Multiple Access is a relatively new concept to the general radio public, although it has been around for quite some time and in use by government agencies. Believe it or not, it had its beginnings in 1940 when sex goddess Hedy Lamarr and composer George Anthiel invented and patented a frequency hopping scheme. In 1937 Hedy Lamarr, then married to Fritz Mandl (an arms manufacturer) fled her luxurious Austrian estate because she could not morally handle how her husband acquired his wealth by selling weapons of death to Mussolini. That same year she was discovered by film mogul Louis B. Mayer. Her film career was haunted by the thoughts of war and the role that armaments played.

At a cocktail party in 1940, Lamarr was making small talk with composer Antheil. They both had a disgust for the Nazi domination of Europe. The next day they met in private to discuss what they later patented as a "secret communications system" to prevent jamming of radio controlled torpedoes. The system devised by Lamarr and Antheil was known as frequency hopping. It works like this: A signal is broadcast over a seemingly random series of radio frequencies, hopping from frequency to frequency at split-second intervals. The signal could carry spoken words or commands for a torpedo. A receiver, hopping between frequencies in synchrony with a transmitter picks up the message. Would-be eavesdroppers hear only unintelligible blips. Attempts to jam the signal succeed only in knocking out a few small bits of it. This is the basis that the US Government built its $25 billion Milstar defense communications satellite system. This is also the basis for the Qualcomm CDMA system.

Antheil's part in this story came in the method for causing frequency hopping to be accomplished. In 1926 he scored a bizarre ballet for 16 synchronized player pianos, two electrically driven airplane propellers, four xylophones, four base drums and a siren (when the first notes were struck, the wind from the propellers nearly blew listeners out of their seats!). Antheil proposed 88 frequencies be used and the transmitters and receivers be synchronized with player piano rolls.

Why 88 frequencies? That's the number of keys on a piano.

We now call this spread spectrum. Rather than player piano rolls to synchronize the pattern of frequency hopping, we use digital codes to determine the frequencies that will be used. These are generally frequencies in a contiguous 1.5 to 2.5 megahertz block of spectrum.

As a side light, neither Lamarr or Antheil received any money for their patent. Frequency hopping was never implemented by the War Department until 1962 when Sylvania installed it on ships sent to blockade Cuba. That was three years after their patent expired and the rights to the invention fell into the public domain.