USM
Defining the Breakthrough Technology Which Will Redefine the Next Generation In Telecommunications

A Simple Primer

By

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In today's high technology world, innovation and creative ideas feed into a dynamic global market which is constantly searching for new breakthrough technologies which will allow us to improve our quality of life while presenting capital opportunities.

Earlier this year, Photron Technologies Ltd., a leading-edge wireless technology company and aeroTelesis Inc., a technology communication services provider based in Los Angeles, announced such a breakthrough technology. Ultra Spectral Modulation or USM ™, is a new and different modulation technology that will provide for wireless data transmission rates of 100bps/Hz (bits per second). This extraordinary speed far exceeds all current technologies (GSM, GPRS, EDGE, CDMA, etc.) which provide for rates of up to 4bps/Hz.

The implications of a breakthrough wireless technology which will result in a 25x increase in bandwidth efficiency are enormous. The potential lists of applications for such a technology is sure to rapidly grow while the performance of currently known applications, (voice, data, video, etc.); will certainly improve in dramatic fashion.

It is clear that this modulation technology, which represents such a fundamental shift in telecommunications theory while presenting unique opportunities for applications not previously possible, requires a simple and straight forward explanation.

The purpose of this paper is to provide a clear and straight forward explanation of USM from a semi non-technical aspect which has been requested by lay people. This paper is not intended as a technical presentation nor should it be considered as such.

In addition, in order to fully understand the basics of USM and its implications, a short discussion and simple overview of modulation is required.

What is Modulation?

To assist in the understanding of *Ultra Spectral Modulation*, USM™, it is beneficial to have a basic understanding of modulation theory.

Modulation is simply a number of different methods for adding information on to a "carrier signal". It is also referred to as "encoding" information on a carrier signal or simply impressing some recognizable intelligence onto a carrier.

The carrier itself can be a radio frequency, a beam of light, a sound wave, or any other medium that allows for the "transmission" of information that man or machine can receive and understand.

In the most primitive sense, if you were to in some set pattern, wave a blanket or cloth through a stream of smoke from a fire, you would be modulating information to someone visibly seeing the subsequent smoke pattern. In this case the stream of smoke is the carrier. The modulation method is the waving of the blanket. You have transmitted information via "Smoke Signals."

Certainly we have advanced well beyond smoke signals to other methods of modulation. Continuing on a technology timeline, Morse Code is a good example of modulating on an electrical carrier (actually an electromagnetic carrier). The carrier was miles of telegraph pole lines. An operator would key in a series of electronic pulses known as the "dash" and the "dots". This tapping a key up and down would send characters to the receiving end where another operator would read the message on a tape. (An early version of sending text messages).

There are of course other more well known and current modulation techniques in use today. The radio in your car probably uses two of these modulation methods: AM, (Amplitude Modulation), and FM, (Frequency Modulation). The carrier is a radio frequency signal which is "modulated" by either varying the "Amplitude" of the signal, (AM), or by varying the "Frequency", of the signal, (FM).

A third common modulation technique is PSK, (Phase-shift Keying). This method used in digital communications, modulates by varying the Phase of the transmitted signal.

Modulation and Bandwidth

The process of modulating requires what is known as "bandwidth". This is the width of the range or band of frequencies that the modulation signal uses to transmit the information. Bandwidth can also be thought of as the spread in frequencies.

Some simple analogies may be helpful in understanding bandwidth: In order for automobiles to travel from one point to another in some orderly fashion, we need roads that vary in width. The wider the road, the greater the number of possible cars. Likewise, for water to flow in some controlled fashion we can use pipes, the larger the pipe, the greater the amount of flowing water. Likewise in telecommunications, the wider the bandwidth, the greater the amount of modulated information that can be transmitted. The point here once again is that we need bandwidth to transfer information.

Mathematically, bandwidth is simply the difference between the highest frequency a signal uses and the lowest frequency it uses. This bandwidth is measured in Hertz, (Hz) and was previously referred to as “Cycles per Second”, CPS. The designation was changed from “CPS” to Hz during the mid 1960’s in honor of the German Physicist Heinrich Hertz who proved that electricity can be transmitted using electromagnetic waves. (This lead to the development of the telegraph and the radio.)

To designate a large number of Hz such as 10,000 Hz, we use the prefix of “Kilo” or simply its symbol represented by “k”. A kilo is a unit of measure meaning 1,000. Thus we would note 10,000 Hz, as 10kHz. For a larger number such as 10,000,000 Hz, (10 million Hz), we would use the prefix “Mega” or simply its symbol represented by “M”. Thus again we would note 10,000,000 Hz as 10MHz. There are additional prefixes such as “Giga” which is one billion and is noted by the symbol “G”.

We are now at the realization point where we know that different types of modulation, (AM, FM, PM, etc.), require bandwidth to transmit information and that this bandwidth is measured in Hz.

Bandwidth in telecommunications is a very important and valuable commodity. In the United States, the Federal Communications Commission, (FCC), controls the allocation of frequencies and bandwidth. This process basically gives a service provider the right to use those frequencies and associated bandwidth to provide communication services. Recently this year, a large National Wireless Carrier, (for the cell phone market) paid approximately $270 million for 10MHz of bandwidth in just one large city. (Known as a “Market”). This example shows just how valuable bandwidth can be.

How much bandwidth is actually needed to transmit information? This is dependent on the modulation technique. A basic voice signal has a bandwidth of approximately 3,000 Hz, or 3kHz. With AM, a radio station will use 10kHz of bandwidth while a FM radio station will use 200kHz. An analog television broadcast signal has a bandwidth of 6MHz. Current wireless technologies such as cell phone communications use different amounts of bandwidth again depending on the method used. The GSM family of technologies which includes “GPRS” and “EDGE” for data communications use 200kHz of bandwidth, the same as FM radio. With the various CDMA technologies developed by Qualcomm, the required bandwidth is 1.25MHz and 5MHz for “Wide-band” CDMA. For the short range technologies known as “Wi-Fi”, required bandwidth is 20MHz. The simple chart shown in Figure 1 below will summarize required bandwidths for the common wireless technologies used today.

Data Transfer Rates

The final piece of our puzzle has to do with data transfer rates or simply, data rate. Data rate, also referred to as "throughput", is the speed with which data can be transmitted from one device to another in a given amount of time. Remembering that we are now in a digital world, this data is in the form of "bits", the ones and zeros that comprise the digital world. So, data rate speed is measured in bits per second. (bps). Due to the fact that most of the information transmitted today is very large, the data rate speeds tend to be measured in "kbps" and "Mbps". (kilo bits and Mega bits per second respectively).

Because we know that the greater the amount of bandwidth available, the faster the data speed, it is important to examine the speed not only in terms of how many bits can be transmitted per second, but also, how much bandwidth is being used to achieve this speed.

Returning to our previous example of automobiles on a road, we know that with a wider road, we can pass more cars through a given point over a specific period of time. This analogy goes on the premise that all of the cars are traveling at the identical speed which is also their maximum possible speed. So, if all of the cars are traveling at their maximum speed down a two-lane highway, how do you get more cars past a given point over the same period of time? Simple answer is to increase the highway to four lanes; now more cars traveling at the same maximum speed can cross the point in question.

The aforementioned analogy on water through a pipe is also relevant; if you want more water to flow, use a bigger pipe.

So how do we measure data rate speeds while taking into account the bandwidth being used? We simply measure the speed in bits per second, (bps), per the amount of bandwidth used. Remembering that bandwidth is measured in Hz, we would now have a measurement indicated as "bits per second per Hz." (bps/Hz).

Today's common wireless technologies have the ability to transmit at rates of from 1 to 4 bps/Hz. Using the EDGE technology as an example, EDGE technology can transmit at the rate of approximately 2 bps/Hz.

It is important to note that most speed figures given by wireless carriers and other telecommunication providers do not indicate the bandwidth used for the advertised speeds. The reasons are many but basically speaking, the customers and other end users are concerned with only the speed that they will experience as they use the technology in their every day lives. The amount of bandwidth used to achieve the speed is transparent to most users and in itself is not important. If you pay for a "broadband" or "high-speed" connection in your home to use the Internet, whether it be cable or DSL, your concern will be; how fast is it? Can I download movies? You may know that the older technology of "dial-up" was 56kbps with a modem, so how fast will your "broadband" connection be? Perhaps 1 Mbps, 2 Mbps, or more.

?The EDGE technology previously mentioned which is used for data applications on hand held devices, achieves rates approaching approximately 384 kbps. (1.92bps/Hz multiplied by a bandwidth of 200kHz.)

Other examples include CDMA 2000 1X EVDO with rates of up to 2.4Mbps and "Wi-Fi" (802.11g) at rates of up to 54Mbps.

Figure 2 on left will show peak data rates for some of today's common technologies used in wireless communications. (Peak data rate may be thought of as "Maximum")

USM – Redefining Telecommunications

Technology is a dynamic science and evolving rapidly on an almost daily basis. Most communication technologies today present themselves as incremental improvements. They are in fact of the smaller, better, faster realm that appears to improve the way we communicate. These technologies may not necessarily put us "leaps and bounds" above our current state but rather provide an improvement that may be perceptually better.

Case in point is the announcement earlier this year by a large technology hardware company that they are abandoning the development of a new and marginally faster technology for cell phones. The stated reason was that the market for this technology, the market being the cellular carriers, did not have an interest due to the fact the "latest and greatest" that they currently provided for their customer base was just fine. The point is, improvements that are simply incremental or small marginal improvements may not hold any viable value for the intended markets in terms of cost-benefit.

What is USM and how is it so dramatically different from current technologies? What is it that makes this technology a "breakthrough" and so far above all other technologies?

The name itself, *Ultra Spectral Modulation*, gives a starting answer to the questions posed. We understand modulation and we know that spectral refers to the continuous spectrum of radio frequencies. With the help of Merriam-Webster, we learn that Ultra is defined as "going beyond others or beyond due limit: EXTREME.

So what is it that makes USM such a breakthrough technology? What have the innovative Engineers at Photron Technologies done that creates this Ultra Modulation that goes beyond the others?

The true breakthrough is the ability of USM to transmit data at phenomenal speeds through a very narrow band compared to other technologies. The explicit fact that USM has functionally shown the ability to transmit data at rates of 100 bps/Hz is the “Ultra”. The transmitting of random data at speeds of 5 Mbps through channels as narrow as 50kHz, further characterizes this new modulation technique as a redefining of the next generation in wireless communications.

Most conventional thinking encompasses the idea that you need a wider band, a broader band, in order to transmit data at the required fast speeds. Everyone wants “broad-band” so they can experience the fast delivery of information and data as well as minimizing the bottlenecks. When you want a high speed connection in your home or office for “surfing” the web at high speeds, you install a “broad-band” connection. No one would order and install a “Narrow-band” connection.

USM has shown that a very large amount of bandwidth IS NOT required for high data rates. The fact that USM can transmit at 100bps/Hz compared to the 4bps/Hz with other technologies, translates into a 25x improvement in spectral, (bandwidth), efficiency.

USM – Method of Development

The development of USM encompasses many years of research and design performed by (RF) Scientists and Engineers. USM is the culmination of ground-breaking innovative research in simulation and modulation technology.

This concerted and combined effort by the USM development team was dramatically enhanced by the use of the latest simulation models. The progress made over the last few years regarding the accuracy and strict correlation of mathematical models and associated technology tools, enabled the development to progress at a faster pace.

Specifically the design models indicated that by using the correct mix of electrical characteristics within Phase Modulation, (PM) and Amplitude Modulation, (AM), the resulting newly designed waveform would increase the technical feasibility of faster data transfers.

The next step entailed the design and implementation of the “Ideal” Digital Filter that could not be produced utilizing conventional process techniques.

By combining this new “Hybrid Modulation” technique with Photron’s new Digital Filter containing certain and specific electrical characteristics, the engineering team was able to achieve and independently confirm, the results of Ultra High Speed data transmission through a very narrow bandwidth.

USM – Beginning of a New Era

Although over the many years, narrow-band technologies have been studied and evaluated, the narrow-band performance of USM is without question, contrary to conventional thinking. The initial concept and subsequent results of USM fully challenge long-standing assumptions and many mind-sets of the Engineering Community.

It is this very challenge raised by the developers of USM regarding long standing assumptions and theorems on the Science of Telecommunications that has brought us to this redefining point. I believe this fundamental shift in modulation technique, shows that technology does not have to continue on the sole path of incremental and marginal improvement, which may be fine for those who choose such a path, but can travel on a revolutionary road containing leaps and bounds. This is the road that USM has chosen.

Applications-Present and Future

- Mobile-to-Mobile real time streaming video
- Satellite to Mobile real time streaming video
- Terrestrial High Speed Data Transmissions
- Wireless Internet Protocol for Internet Data Services
- Satellite video, data, and voice communications
- Voice and video delivery in legacy paging infrastructure
- VSAT applications at up to 50x current data rates
- Increased capacity for emergency and safety channels
- Video conferencing fixed and mobile
- T3 data rates for hand-held applications
- Wireless local loop with video conferencing