Weird & Wireless: Signals getting weaker in free space

Welcome again to the wonderful but sometimes weird world of wireless comms, written by Joel Young, CTO of Digi International

I get the inverse square law, but how does frequency factor into the mix when it comes to a signal getting weaker in free space?

In a **previous blog** we discussed the impact of the inverse square law on an isotropic transmitter. As such we came up with the observed power per unit area was related to the inverse-square of the distance from the transmitter, commensurate with the surface area of a sphere, or $1 / 4\pi r^2$, where r is the distance.

The problem here is that we are told that lower frequency (or longer wavelength) signals "go farther" in free space than higher frequency (or shorter wavelength) signals. This inverse square law says nothing about wavelength or frequency.

So what gives?

The trick here is to look at the receiver side. This is one that is always difficult for me to visualize. The key here is to remember that whatever happens on transmitting a signal, the INVERSE must happen on receiving side.

So, when we visualize our isotropic transmitter, we think of the wave coming out of a point a radiating equally in all directions or a sphere. On the flip side, we should think of our isotropic receiver the same way, as a point which is "listening" equally in all directions, also a spherical pattern.

Now, going back to basic geometry, we know that the intersection of two spheres is a circle. Hence we define this circle as the opening or aperture by which the transmitted wave is captured.

Next is the hard part from a visualization perspective. In our ideal, isotropic receiver, the opening or aperture should be perfectly sized for the wavelength we are receiving.

Hence, since the opening is a circle, the circumference of this circle would be exactly one wavelength - commonly referred to by the Greek letter lambda (λ). So for a given circumference λ, the radius of the circle is $\lambda/2\pi$ and the area of the circle (remember πr^2) is hence $\lambda^2/4\pi$. This is the size of the ideal catching area of our isotropic receiver.

Notice that the longer the wavelength, the bigger the net for catching the transmitted signal.

Now of course our goal should be to collect as much of the power as possible. Since our transmitted signal is spreading out, the bigger the net, the more power we can collect. When we couple them together, the power received is $(\lambda/4\pi r)^2$ times the power transmitted.

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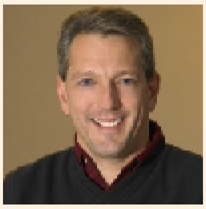

*Joel Young, VP of Research and Development and CTO at **Digi International**, has more than 22 years of experience in developing and managing data and voice communications. He joined Digi International in June 2000 and in his current role he is responsible for research and development of all of Digi's core products.*

Prior to joining Digi, Joel was VP of Sales & Marketing at Transcrypt International where he was responsible for sales, marketing, and product development for all information security products. During his tenure at Transcrypt, he also served as VP of Product Development and VP of Engineering where he was responsible for engineering, research and product development for wireless communications products, cellular telephony, wireline telephony and land mobile radio, data security and specialized digital radio products.

He also served as District Manager for AT&T Business Communications Services where he was responsible for the creation and implementation of voice processing and network database strategies, including deploying new voice processing platforms into the AT&T switched network for private network and other outbound calling services.