

# The Radio Hotel- AA0ST and Antennas 'Thru the Looking Glass'

by W5RH

So, the ever industrious and inquisitive Jeff, AA(zero)ST, sends me a link from [physics.org](http://physics.org) and suggests that I check out this rabbit hole – an article “**Chu’s Limit is No More**”. So I do. Suddenly, I find myself falling head over heels, deeper and deeper into the strange, underground caverns of modern antenna research. White Rabbit and Mad Hatter things I had never seen before, names I had never heard – Chu, Harrington, Foster, Wheeler, NIC--Negative Impedance Converters, “negative” capacitors and “negative” inductors – aka “**non-Foster**” Elements, DDIT -- Dynamic Dissipative Impedance Transformers to name a few. Totally unfamiliar territory, but with Google as my research friend, I was reading applicable material within minutes. I found items in the Google search that seemed to outline and explain it all. Understanding it, however partial, came after quite a few hours of reading (over and over).

The article claims that a Jabberwocky Scientist at the Navy Research Lab just broke thru “Chu’s Limit” on small antennas. *Who’s what???* In a nut shell, all antennas, but especially small antennas (less than  $1/10^{\text{th}}$  wavelength long), have a limited useable application bandwidth (Chu’s Limit). Along with that have physical properties, as we hams know them, of a greatly reduced and highly reactive Radiation Resistance  $R_r$  of 1 or 2 ohms, thus lowering the efficiency quite dramatically. Matching is possible, but very, very lossy with the familiar passive, or “Foster” capacitors and inductors. (**Google: Foster’s Reactance Theorem – 1924**) Getting the transmitter power into the smaller antenna structure is a big matching challenge, to say the least. Well...not anymore, it seems.

These cats are working on cell phone and other application related antennas in the 400+ MHz regions. They need small antennas so that they will fit inside a cell phone case and they need wide, wide bandwidth so that they can send and receive multi-Megabits of information over the RF channel(s). To do that takes usable bandwidth (**Google: Shannon’s Channel Capacity**). The key: applying low loss, “**non-Foster**” components to counteract the large feed point reactance and to enable efficient, low loss L networks to match the transmitter or transmission line  $Z$  to the small antenna’s very low Radiation Resistance.

What are “**non-Foster**” elements? They are NIC’s – Negative Impedance Converters, invented by Bell Labs in the 40’s. Negative capacitors and inductors, each made out of active op-amps (or equivalent transistor circuitry) and passive Foster components. The result of which is an active circuit that gives a reactance versus frequency curve that is the inverse of the Foster (passive) C or L’s. Plus, these active, negative capacitors and inductors can perform this inverse function with very little R loss. Great! The catch (other than operating at very low voltages) is that these active, non-Foster elements give a typical range of +/- 30n Henrys and the equivalent Farad delta. These nano-values are big numbers in the upper MHz regions, but in our Ham HF region they are but solder slag on the coils in our ATU’s. Now, there are folks wanting to take this applied technology and bring it down to frequency regions that we Hams (and the military) are more familiar with.

If they do succeed in applying this NIC technology at lower frequencies, how will it help us HF/VHF/UHF Hams? Other than being quite interesting to read about, I’m not sure it would even matter. We don’t send hundreds or even tens of Megabits on Ham Radio. At 400 Mhz, for instance, their record breaking 18 MHz is 4.5% of the bandwidth. At 14 Mhz, 4.5% bandwidth is 600 KHz...we can easily do that at under 2:1 SWR. However, it is not only bandwidth. It is available cycles per second to which to apply the modulation. **Nyquist** comes into play. You gotta be up in the MHz’s to have the faculties of the spectrum to do their kind of work. **Professor Nezar Bedhar, U of WI – Madison (Youtube)**, is working to apply these tunable negative reactance methods to small VHF and even HF antennas to make them more broadband and efficient. I’ll agree with more efficient – either in matching circuits or the antennas themselves. But in our Ham Radio, DX type world, it is not just about getting power into the ether. It is about sending our signals in a particular direction at a particular angle to allow us to “work the world”. So, I am not sure that a low voltage, active circuit NIC is gonna help us. Well, not on high power transmit, anyway. But the subject gives us plenty of **new words** to Google. So, please, Google away and have some fun reading about the new “Through the Looking Glass” antennas.

Thanks, Jeff, for the adventure! Enjoy your hobby. GL ES 73 DE W5RH

## Next Time – Tools for the Antenna Information Junkie

*The purpose of **The Radio Hotel** is to give you a practical kick start into exploring the workings of antenna systems. Google the buzz words and find out what they mean. Read up on antenna system theory to see how it all works together. You will be glad you did.*