

## Some Thoughts Regarding GPR/ UWB and True Multi-frequency (impulse) GPR

Reading some of the marketing literature out here on the web, I recalled a discussion I had with my buddies as a child. We were jumping from trees, roofs, and whatever we could climb up on, as kids normally do, rubbing our knees and elbows. Now, jumping from high heights caused more pain, that we found out swiftly. So, we discussed at length why people who died in aircraft accidents didn't just jump when close enough to ground. The tricky thing, we reasoned, would be to time the jump.

Now, believe it or not, we have similar, impossible ideas floating around in the GPR/UWB community. I'm referring to the claims of creating multi-frequency systems based on frequency domain filtering techniques. Sometimes people are just careless with the wording; in other cases, it's more subtle, e.g., when the digital processing part is hidden altogether. You cannot have the benefits of multiple antennas, without having them!

The following is not rigorous, and I don't think I have to be, to prove what is obvious.

Assume that we have one pair of antenna flares, Transmitter (Tx) and Receiver (Rx) and that we get a certain frequency spectrum from this GPR antenna unit, which may look something like that in Figure 1. This GPR is then characterized by where the -10dB points cut across the spectrum from which one can derive the center frequency and bandwidth ( $f_c$  and  $f_h$  in figure 1).

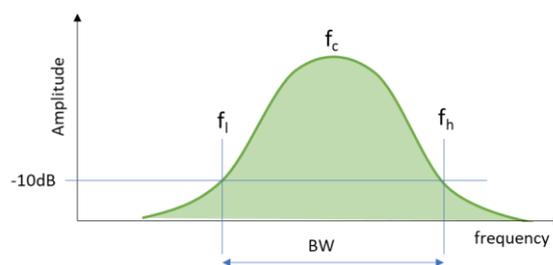


Figure 1, Frequency of original signal

Now we apply three filters with frequency response, as shown in Figure 2. Note that the bottom and top filters have responses outside the spectrum of the original signal. That means the output from these filters will be further narrowed and squeezed because there's nothing outside the original signal from which to draw results. We cannot create information from nothing.

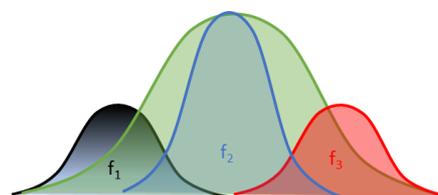


Figure 2, frequency response of filters overlaid on original spectrum

The result may be as presented in Figure 3, from which one can make an inverse fast Fourier transform (FFT) to present three separate radargrams. One may now claim to have three separate frequencies, with bandwidths and center frequencies calculated as in Figure 3, but how true is this?

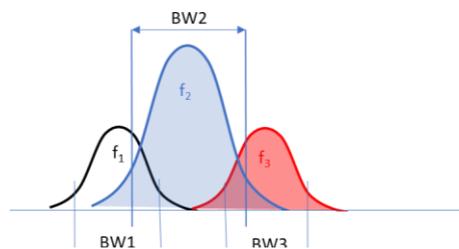


Figure 3, resulting spectra, now 3 separate radargram may be created by inverse fft!

Now, do the combined bandwidths and center frequencies in Figure 3 carry any more information than what's present in the original signal? If we believe so, we may as well believe that humans can fly! We cannot simply create something from nothing, and while people might have done so during the superstitious dark ages, today, we should know better.

Frequency-domain filters are effective for their intended purpose, but I think we should be honest with our clients and explain that providing them with tools for manipulating the frequency is NOT a multi-frequency GPR, as long as we have no more than one Tx-Rx pair.

That's just a fact and all GPR manufacturers owe their customers an honest assessment of what is reality and what is an attempt to create something out of nothing.