# New method for detecting frequency shifts in a digitized signal

**A new method for detecting frequency shifts in digitized signals has been investigated and developed during a bachelor thesis at Lund University. A real-time version of the method has been designed and implemented on a FPGA-platform with a high-speed digitizer.**

Standing waves has long been used in different applications such as in instruments. The strings on a guitar or the air passing through cavities and holes in a flute causing sounds with different frequencies, are typical examples of this. The same principle is used in radio applications where cavities of different shapes and sizes give rise to different resonance frequencies based on constructive or destructive interference. In this bachelor thesis, this principle, and its applications, has been investigated for usage in the digital domain. This has been done by sampling the signal of interest signal with a fast digitizer and then folding it back onto itself with a delay, as shown in figure 1, and thereby mimicking the behaviour of a cavity. If the frequency of the sampled signal corresponds to the length of the digital cavity (number of slots used by the cavity) constructive interference will form (shown in figure 1a). By investigating the values of the resulting signal in the cavity after a pre-determined number of fold backs, it is possible to determine the frequency of the sampled signal based on how well it “fits” the cavity.

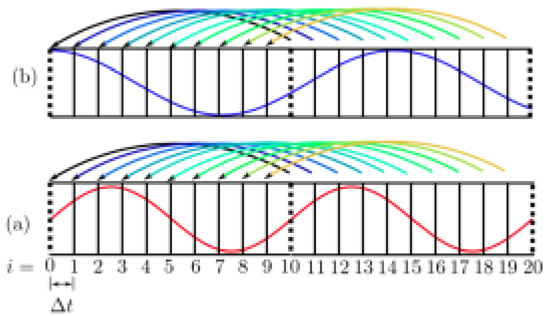


**Figure 1.** *A visual representation of a cavity length of 10. The fold back in (a) forms a constructive interference, while in (b) destructive interference is formed.*

By mixing the sampled signal with different mix signals, and then feed them in to different digital cavities of the same length and resonance frequency, it is possible, by looking at which of the mixed signals that “fits the best” in the cavity, to determine the sampled signal with even greater accuracy. This is done by calculating the root mean square value of each cavity after the fold back, resulting in a cavity response. The larger response, the better fit. The frequency estimation is done by interpolating responses, knowing the corresponding resonance frequency for each response, resulting in a polynomial with a specific local max. The local max of the polynomial corresponds to the sampled signal’s frequency.
The concept of using a digital cavity to determine a frequency with very high precision was confirmed by making measurements on signals generated by function generators and a laser that produced pulses at a rate of about 70MHz.

By making further development, this new method could have substantial benefits as a new way of determining the frequency, phase and amplitude of a sampled signal with high precision.