Multi-rate systems: Decimation

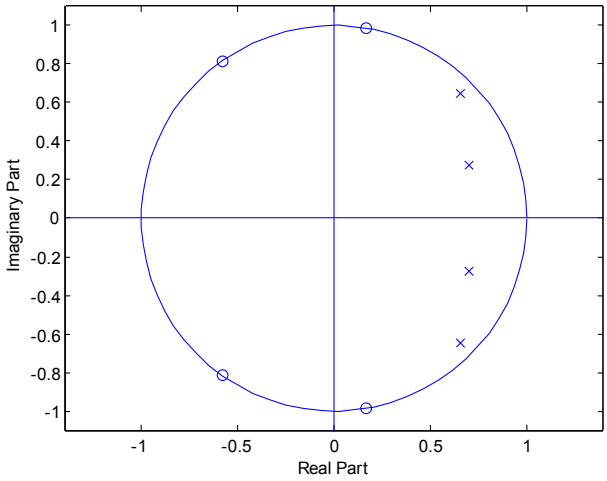
A multi-rate system is a system that has different sampling frequencies at various stages. For example, if you are transferring data between systems with different sampling rates such as a CD system with a 44.1 kHz and a professional audio sampling system using 48 kHz. This is 44.1/48=0.91875. This is equivalent to 147/160. So in practice you will interpolate (up-sample) by 147 and then decimate (down-sample) by 160. Decimation involves reducing the sampling rate. For example if you decimate by 2 you skip every 2nd sample. If you decimate you must also put the signal through a FIR digital low-pass filter 1st to avoid aliasing.

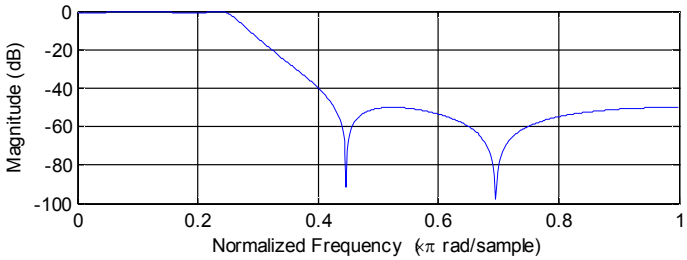
We can design a high order filter in Matlab as follows:

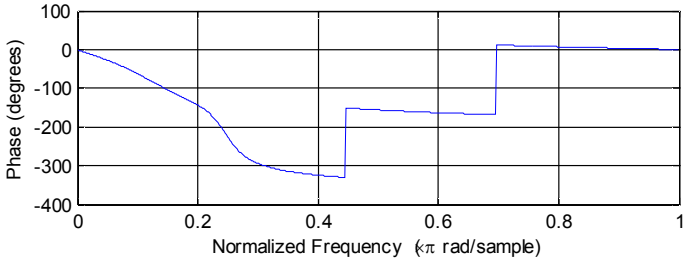
```
>> fs=8000
>> [b a]=ellip(4,1,50,1000*2/fs)
```

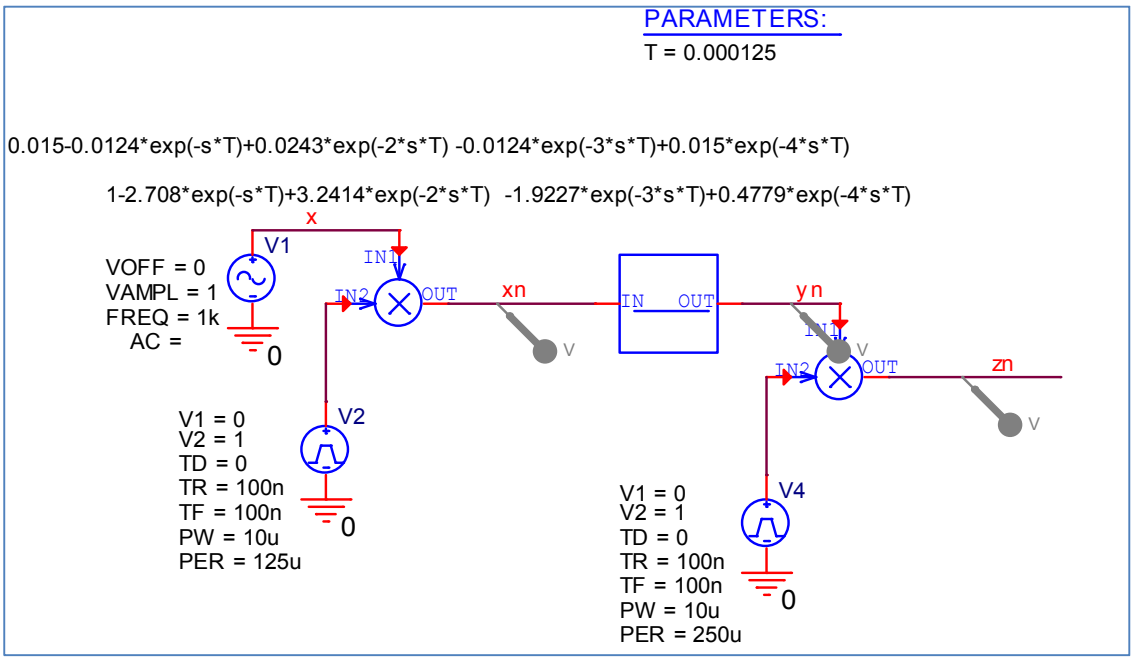
b = 0.0150 0.0124 0.0243 0.0124 0.0150
a = 1.0000 -2.7080 3.2414 -1.9227 0.4779

```
>>zplane(b,a)
>>freqz(b,a)
```



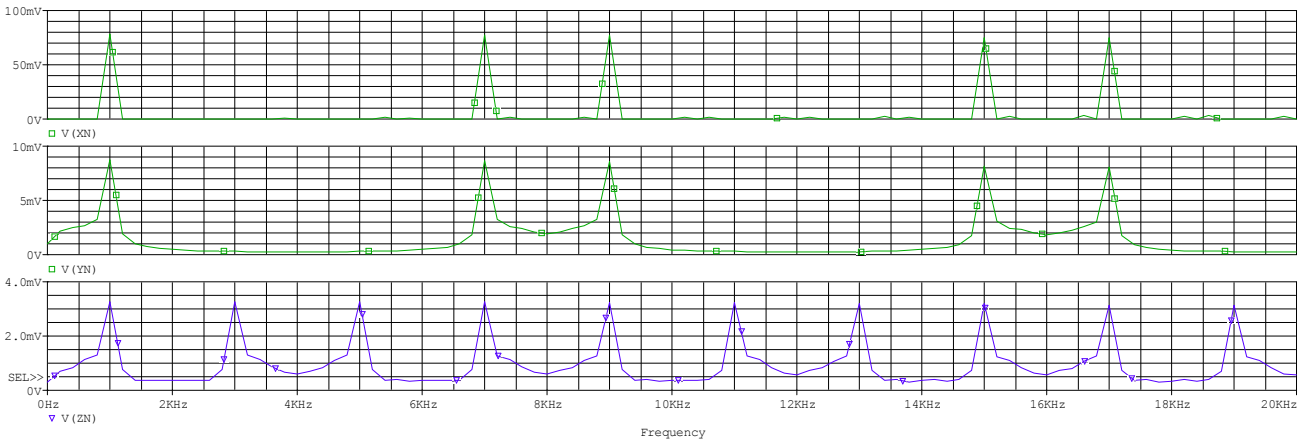


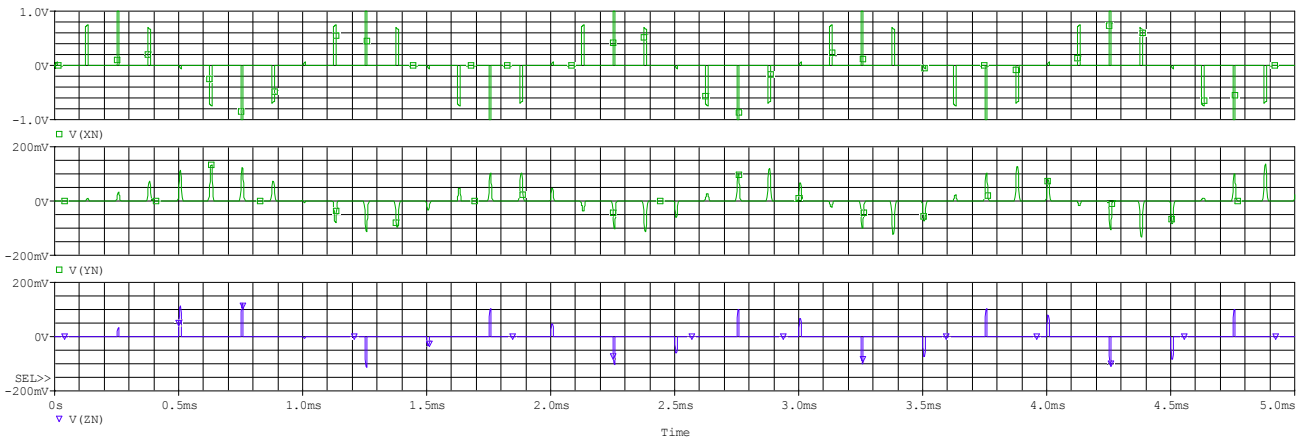




Decimation System in Pspice:

Note that the decimator sampler using a period of 250 us skipping every 2nd sample.





The above shows that as long as the input is filtered below the new nyquist (2k) the reduced sampling is fine. No aliasing with repeats at 4k.

Without decimation, the anti-aliasing filter has a cut-off frequency of fs/2. With decimation, this is now fs/2M, where M is the decimation factor. For example if fs=16000 and the decimation factor is 2, the FIR filter must cut-off at 1600/4=4 kHz.

Multiplications per second (MPS) and total storage requirements (TSR)

Consider the following problem:

A 2 stage decimator reduces a sampled signal from 240 kHz to 8 kHz. The sample rate for the 1st stage is 16 kHz and the 2nd stage is 8 kHz. The FIR filter order of the 1st stage is 45 and is 43 for the 2nd stage. Determine the number of muliplications per second and the total storage requirements of this system.

MPS=45x16k+43x8k=1064k instructions/sec.
TSR=45+43=88.