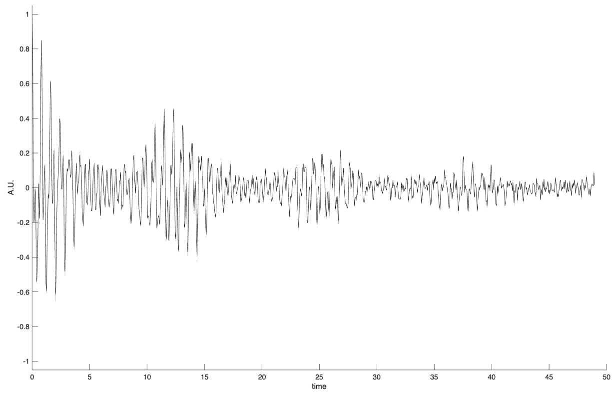
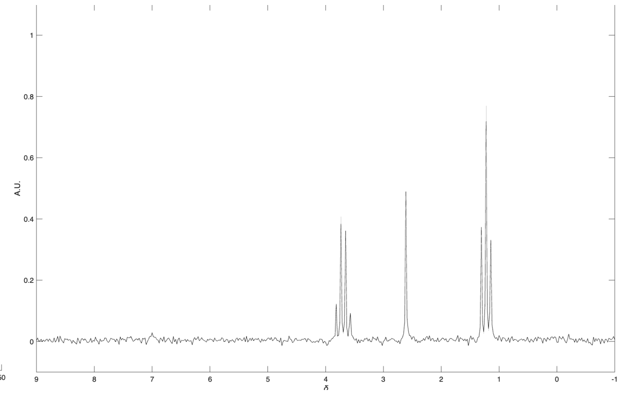
September 2025 NMR Topic of the Month: On Filters Part IV

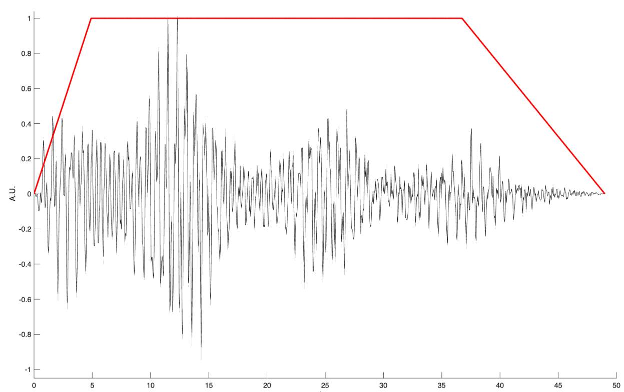
There are many other filters, but the remaining two that are available in TopSpin are discussed below. As always, we start with our straight FID and its Fourier transform shown immediately below for comparison purposes.

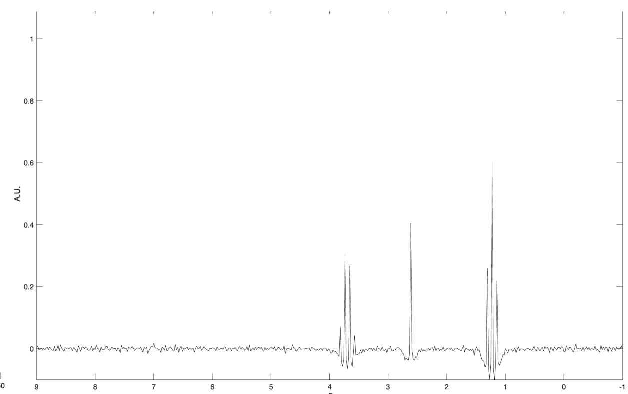




The Trapezoid Filter

This filter uses line segments to frame the FID. These segments are defined by two inputs (TM1 and TM2) that are fractions of the total length of the FID. (Note that 0<TM1<TM2<1). The trapezoid is created in the time domain starting at zero, rising linearly to one at the TM1 fraction of the FID, remaining constant at one until the TM2 fraction of the FID, and then falling linearly to zero at the end of the FID. It’s not commonly used, but it may be useful. The trapezoid filter below has TM1=0.1 and TM2=0.75.

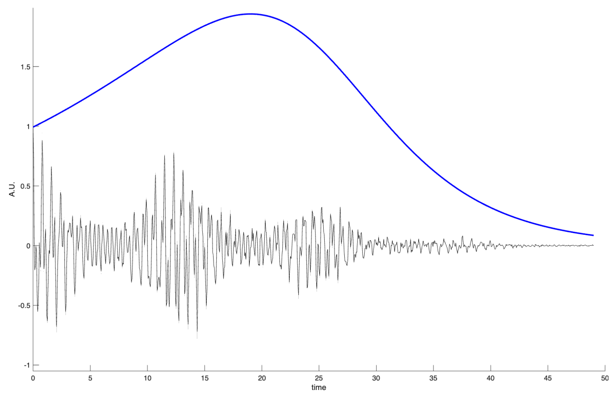


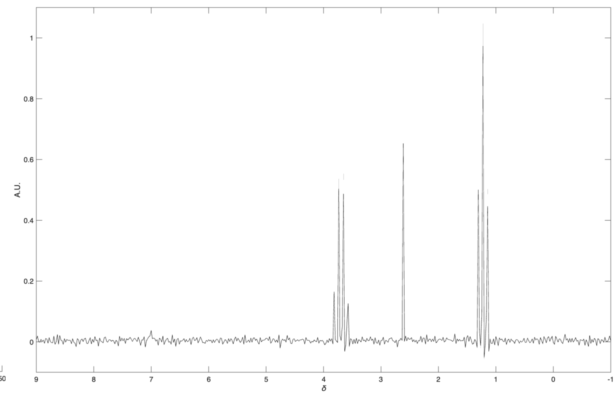


TopSpin very specifically indicates that TM1 cannot be zero, TM2 cannot be one, and they cannot be equal.

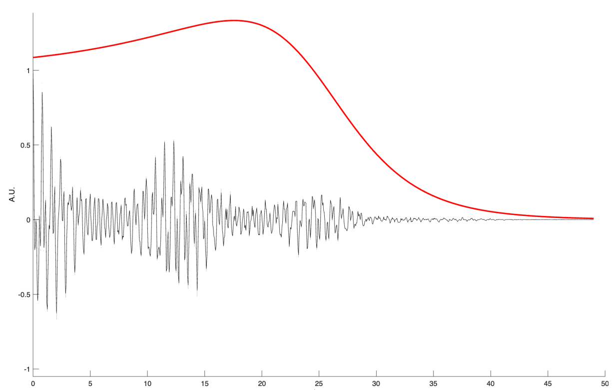
The TRAF Filter

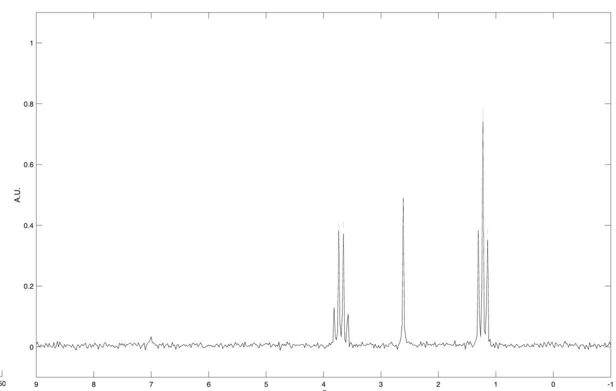
The **T**ransform of **R**everse **A**dded **FI**Ds (or TRAF) filter is built to maximize either the resolution or sensitivity of the spectrum without sabotaging the other (so to maximize the resolution but not at the expense of the sensitivity and *vice versa*). In TopSpin, the type of TRAF filter is distinguished by the resolution maximization being the traf filter and the sensitivity maximization being the trafs filter. These filters are built by re-imaging the signal as the FID both forwards and (flipped) backwards in time, applying a matched filter in both time directions, and then optimizing the filter to accomplish the desired effect. The resolution TRAF filter takes the form: $\frac{E(t)}{[E(t)]^2+[\epsilon(t)]^2}$ where $E(t)$ is the relaxation forwards in time and $\epsilon(t)$ is the relaxation backwards in time. This resolution TRAF filter is shown immediately below on the left in blue with its effect on the FID, and the resulting Fourier transform of that filtered FID is shown immediately below on the right.





The sensitivity TRAF filter takes the form: $\frac{[E(t)]^2 \cdot [E(t)+\epsilon(t)]}{[E(t)]^3+[\epsilon(t)]^3}$ where (again) $E(t)$ is the relaxation forwards in time and $\epsilon(t)$ is the relaxation backwards in time. This sensitivity TRAF filter is shown immediately below on the left in red with its effect on the FID, and the resulting Fourier transform of that filtered FID is shown immediately below on the right.





The TRAF filter works best on properly acquired data that consists of signals with narrowly-distributed relaxation parameters (typically T_2^*). In other words, if the signal consists of both sharp peaks and broad peaks or is acquired for too long/short a time the basic TRAF filter will not work well. Yes, you could do some fancier math to apply different TRAF filters optimizing each individual signal in the spectrum and then piecing a final spectrum together, but that task is left to the reader.

References

1. TopSpin: Processing Commands and Parameters User Manual Version 007 (H9776SA4_007), 57-58 (2023).
2. J.C. Hoch and A.S. Stern, *NMR Data Processing*, Section 3.10 & 3.11, Wiley-Liss, New York (1996).
3. R.N. McDonough and A.D. Whalen, *Detection of Signals in Noise*, 2nd ed., Academic Press, San Diego (1995).
4. D.D. Traficante and G.A. Nemeth, *J. Magn. Reson.* **71**, 237 (1987).